# VETERINARY ENDOSCOPY



## for the Small Animal Practitioner

TIMOTHY C. McCARTHY

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*To our patients*

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# Preface

My first endoscope was a second-hand flexible gastroscope. When I purchased it for $500 in 1982, I did not think that it would ever pay for itself, but that it would be fun to use. I was right about the fun but very wrong about the profitability. I now own 33 endoscopes, and endoscopy generates over 75% of my practice income. Few cases pass through my practice nowadays without the benefit of endoscopic diagnosis or surgery in some form or another.

My passion for endoscopy grew as I learned that a multitude of diseases can be examined or treated more effectively and safely with an endoscope than with any other approach. In the early 1980s my focus was on diagnostic techniques, and I had no intention of developing an endoscopic surgery practice. Over time it became increasingly clear to me as a surgeon that a tool providing enhanced visualization and access to structures with minimal trauma would yield better results for my patients. The optics and mechanics of modern endoscopes—both rigid and flexible—provide us as practitioners with the ability to see, sample, and treat many diseases with markedly improved accuracy and reduced morbidity. When we consider the added advantages of reduced postoperative pain and accelerated recovery, it becomes obvious why endoscopy *is* better medicine.

I also realized that rigid endoscopes had many advantages over flexible endoscopes. Better optics, simpler design, reduced cost, and the rigidity needed to perform surgery in the abdomen, thorax, and joints all contributed to my inclination to expand rigid endoscopy. This is perhaps the most significant feature that differentiates this book from the authoritative text *Small Animal Endoscopy* by Dr. Todd Tams. My goal with this new work is to offer a complementary text with a greater emphasis on diagnostic rigid endoscopic techniques from a *surgeon's* perspective and to include minimally invasive *surgical* procedures currently being used in practice.

Gastrointestinal endoscopy is well established as a diagnostic and therapeutic entity in small animal practice, and it has completely changed our understanding of gastrointestinal disease and the approach to diagnosing and treating gastrointestinal disease. Rigid endoscopy is having the same effect in other areas throughout the body. Cystoscopy is the most underused endoscopic technique available to veterinary medicine today; when cystoscopy has realized its full potential in practice, its use will exceed the application of gastrointestinal endoscopy and will completely redefine lower urinary tract disease in veterinary medicine. Rhinoscopy is a highly effective diagnostic tool that has minimal morbidity and mortality and allows easy, direct access to the nasal cavity and frontal sinuses for examination, for diagnostic sample collection, and for therapeutic procedures, minimizing the need for traumatic surgical explorations. Laparoscopy and thoracoscopy are established as effective diagnostic tools, and application of minimally invasive thoracic and abdominal surgical procedures is being defined, from laparoscopic ovariohysterectomies to thoracoscopic lung lobectomies. The concept of laparoscopic- and thoracoscopic-assisted techniques is gaining favor, and these techniques combine endoscopic visualization with standard open surgical techniques, taking the best from both worlds. Video-otoscopy has revolutionized the practice of otology in small animal practice by providing better visualization of changes within the ear canal, in the area of the tympanic membrane, and especially within the middle ear. Furthermore, video-otoscopy allows the practitioner to demonstrate clinical findings to the pet owner, greatly improving client compliance. Arthroscopy is the most significant advance in small animal orthopedics that has occurred in my professional lifetime, providing more information about intraarticular pathology than can be achieved with any other diagnostic technique and



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facilitating operative procedures for greatly improved results with minimal operative trauma. It is redefining our understanding of arthrology in small animal practice.

This text is designed to be a *practical* guide to endoscopic procedures that can be easily incorporated into any small animal practice with proper training and instrumentation. I encourage readers to attend workshops and training courses, whenever possible, to supplement the information that can be gleaned from this text. No reading or observation can replace the valuable experience of hands-on training in endoscopic techniques. An increasing number of courses in each specialty area are available at all levels throughout the world.

The first three chapters provide general introductory information about instrumentation, anesthesia, and biopsies. Chapters 4 through 14 are organized anatomically, and each includes the basics of instrumentation and established technique as well as some of the most recently developed procedures. Whenever possible, illustrations have been included alongside endoscopic images to help orient the reader quickly to the endoscopic anatomy. The final two chapters look to the future, which, if human medicine gives any indication, will most certainly include *lots* more endoscopy!

**Timothy C. McCarthy**

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# Acknowledgments

A great number of people and animals collectively made this work possible; I simply put it to paper.

Thanks to:

First, my parents for bringing me into this world and for their unending support, encouragement, and love.

Dr. Don Bailey and Betty Bailey for introducing me to veterinary medicine and for getting me into veterinary school.

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My colleagues who referred the cases that provided me with the material for learning these techniques, and all the clients who entrusted me with their beloved pets.

Mr. Karl Storz and Mrs. Sybill Storz for their interest in veterinary medicine, and all the staff of the Veterinary Division of the Karl Storz Endoscope Company for their educational endeavors and instrumentation development for our profession, especially Dr. Christopher Chamness for his support, encouragement, and friendship.

And most important, my wife and son for their patience and for allowing me the time to complete this project.



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# 1 Introduction to Veterinary Endoscopy and Endoscopic Instrumentation

Christopher J. Chamness

The word *endoscopy* is derived from Greek by combining the prefix *endo,* meaning "inner," and the verb *skopein*, meaning "to view or observe with a purpose."[1] The result is an appropriate term for the procedure of looking into the cavities of the living body. Endoscopy was first introduced in veterinary medicine in the early 1970s. As veterinarians have become aware of the diagnostic and therapeutic indications, the use of endoscopy has increased dramatically.

## HISTORY OF ENDOSCOPY

The first recorded endoscopy procedure was in 1806 by Phillip Bozzini, who tried to visualize the urinary tract.[2] Bozzini used a tin tube illuminated by a wax candle with a mirror to direct the light (Fig. 1-1). In 1868, Adolf Kussmaul developed and used the first gastroscope.[3] The light source was fueled by a mixture of alcohol and turpentine. The first subjects were sword swallowers, which seems appropriate, in that this instrument was rigid. Nitze introduced the first optical telescope in 1879, which he used as a cystoscope to study the pathology of the urinary bladder.[4] In 1902, Georg Kelling reported visualizing the abdominal contents of a dog by using a cystoscope.[5] Approximately 10 years later, H. D. Jacobaeus proposed the term *laparoscopy* for visualizing abdominal contents and described thoracoscopy in human medicine.[6,7] The first report of laparoscopy in the United States was in 1910 by Bertram Bernheim, who used a proctoscope to visualize the gallbladder.[8]

Endoscopy in small animal veterinary medicine began in the early 1970s. O'Brien reported an endoscopic evaluation of the lower respiratory tract in dogs and cats in 1970.[9] The use of laparoscopy for the evaluation of liver and pancreatic disease was first reported in 1972.[10,11] In small animal veterinary medicine, the first reported use of gastrointestinal endoscopy was by Johnson and colleagues in 1976.[12] Initially, gastrointestinal endoscopy was used more frequently than any other endoscopic procedure in small animal veterinary medicine. Bronchoscopy was the next endoscopic procedure to gain wide acceptance. Gradually, other endoscopic procedures evolved.

Currently, small animal endoscopy includes many procedures. In addition to those procedures mentioned previously, rhinoscopy, cystoscopy, arthroscopy, vaginoscopy, otoscopy, thoracoscopy, and avian endoscopy are routinely performed in small animals by use of rigid or flexible endoscopes. This field is also rapidly expanding beyond diagnostic endoscopy, in that leading veterinary endoscopists are working in collaboration with endoscope manufacturers to develop a growing number of practical, minimally invasive *surgical* procedures.



**Fig. 1–1**
The first rigid endoscope, built by Bozzini in the early 1800s. The light source was a candle. *(From Tams TR:* Small animal endoscopy, *ed 2, St Louis, 1999, Mosby.)*



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## OVERVIEW OF ENDOSCOPIC INSTRUMENTATION

Endoscopes can be divided into two broad categories: *flexible* and *rigid* (Fig. 1-2). Flexible endoscopes can be advanced along tortuous paths and are therefore most commonly used in anatomic areas where there is a tube or lumen through which to pass the device around corners or bends (gastrointestinal tract, respiratory tract, male urinary tract). Rigid endoscopes are high-quality, medical grade telescopes. They do not bend; however, they are available in a variety of viewing angles and fields of view, allowing the operator to see in many different directions, depending on the model used (Fig. 1-3). Rigid endoscopes are required for endoscopy of body cavities without an orifice or lumen (abdomen, thorax, joints, oral cavity, coelom of birds and reptiles). Because of their superior optics and lower cost, rigid endoscopes are also commonly used in veterinary medicine for otoscopy, cystoscopy in females, rhinoscopy, colonoscopy, esophagoscopy, and gastroscopy. The optical quality of the rod lens–generated image of the rigid endoscope surpasses that of the fiberoptic or digital image produced by flexible scopes. Flexible endoscopes are considerably more expensive and require more maintenance than rigid endoscopes.

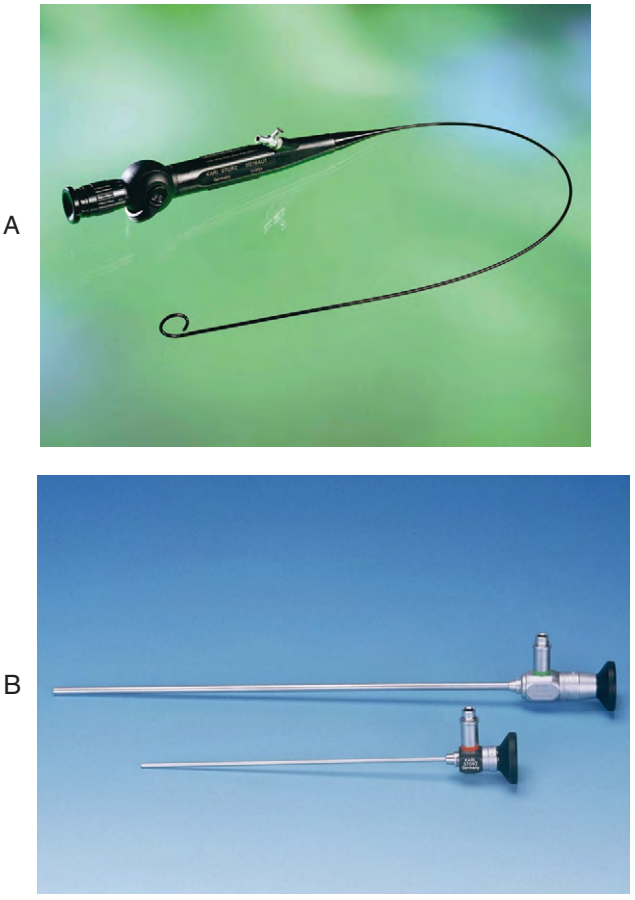



**Fig. 1-2**
Endoscope types. A, Flexible fiberscope, 5 mm in diameter, commonly used for endoscopy of the respiratory tract. B, Rigid endoscopes, a 5-mm-diameter telescope with a 0-degree viewing angle commonly used for laparoscopy and thoracoscopy in humans and animals and a 2.7-mm telescope with a 30-degree viewing angle commonly used for arthroscopy in humans and for multiple procedures in small animals. This telescope has been termed the *multipurpose rigid telescope* because of its applicability to a wide range of procedures in small animals.

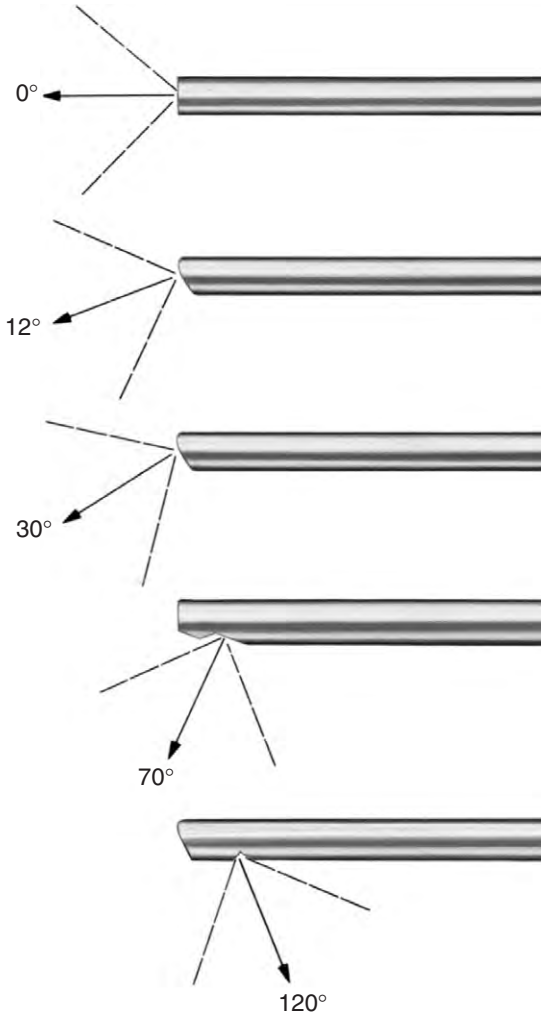



**Fig. 1-3**
Common viewing angles of rigid telescopes. The viewing angle refers to the *center* of the viewing field.

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**Fig. 1-4**
Video laparoscopy being performed in a dog.

Although diagnostic endoscopy can be performed by directly visualizing structures through the endoscope's eyepiece, an increasing number of clinicians use video cameras, which attach to the endoscope's eyepiece, to view the procedure on a TV monitor (Fig. 1-4). Video imaging not only is more comfortable for the endoscopist but also provides a way of sharing information with an assistant or other members of the medical team during the procedure. Video imaging provides a way to document the procedure with video prints, tapes, or digital images for medical records and later viewing by clinicians or clients.

## RIGID ENDOSCOPES

In small animal medicine, rigid endoscopes are most commonly used for otoscopy, cystoscopy, laparoscopy, thoracoscopy, arthroscopy, and rhinoscopy. They are also used for bronchoscopy, esophagoscopy, gastroscopy, colonoscopy, vaginoscopy, transcervical insemination, and other less common procedures.

The simplest rigid endoscope is composed of a hollow tube with no fiberoptic or lens system for the transmission of the image. A fiberoptic cable transmits light to the distal tip. One example of this type of instrument is the proctoscope or, in human medicine, the sigmoidoscope. Even though these instruments have been useful in veterinary medicine for proctoscopy and esophagoscopy, they have, for the most part, been replaced by more technologically advanced equipment.

The highest quality rigid endoscopes (also called *telescopes*) are composed of a metal tube, which houses a series of high-resolution optical glass rod lenses. Compared to conventional lens systems, the Hopkins rod lens system uses significantly more glass, which is a better medium than air for transmitting images (Fig. 1-5). In a rod lens system, air acts as a negative lens, within a glass medium, as opposed to the glass lenses within an air medium found in conventional telescopes. Rod lens telescopes transmit considerably more light and have a wider field of view. These telescopes have optical glass fibers surrounding the lens system for transmission of light to the distal tip of the telescope, which illuminates the cavity being examined. Light enters the telescope at the light guidepost by means of a flexible fiberoptic light guide cable, which is attached to the post at one end and

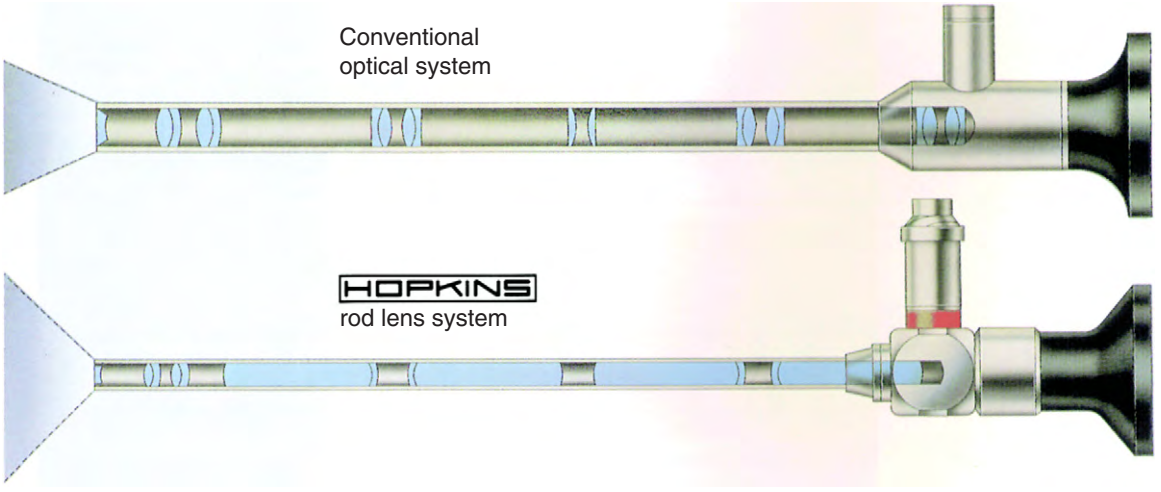



**Fig. 1-5**
Traditional optical system vs. Hopkins rod lens system. *(From Tams TR:* Small animal endoscopy, *ed 2, St Louis, 1999, Mosby.)*

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to a remote light source at the other end (Fig. 1-6). Because telescopes and fiberoptic light cables contain optical quality glass, they need to be handled with care and never be dropped, banged, or crushed.

The proximal lens of the telescope is contained within the eyepiece, where the image can be viewed directly, or an endoscopic video camera can be attached. Direct viewing is feasible for many types of diagnostic endoscopy; attachment of an endoscopic video camera is highly desirable for other procedures and is mandatory for minimally invasive surgery and other technically demanding procedures such as arthroscopy and avian endoscopy.

Rigid telescopes are available in a large range of external diameters, from 1 to 10 mm. They may be forward viewing (0 degrees) or angled (10, 25, 30, 45, 70, 90, 120 degrees) to allow visualization out of the axis of the telescope and to increase the field of view by rotation of the instrument (Figs. 1-3 and 1-7). Although the forward-viewing rigid telescope is the easiest to use, there are many cases in which angled view telescopes are preferred or necessary to perform a thorough endoscopic examination. The most commonly used telescope in small animals, often referred to as a "universal" or "multipurpose" rigid endoscope, is 2.7 mm in diameter with an 18-cm working length and a 30-degree viewing angle (Fig. 1-8).

The optics of rod lens telescopes produce magnification that enables the endoscopist to visualize the surface of organs, their vessels, or pathologic changes much more clearly than with the naked eye. The highest quality telescopes offer an appropriate balance of the following criteria: viewing angle, depth of field, magnification, image brightness, image quality and contrast, distortion, and image size. When comparing the quality of one telescope with another, it is important to realize that each of these criteria are interdependent, such that maximizing one could cause undesirable deficits in another.



**Fig. 1-6**
A rigid telescope and a flexible fiberoptic light cable. The light cable attaches to the light guidepost of the telescope on one end and plugs into a remote light source at the other end.



**Fig. 1-7**
Close-up of the tips of two 10-mm laparoscopes with 0-degree and 30-degree viewing angles. *(From Tams TR:* Small animal endoscopy, *ed 2, St Louis, 1999, Mosby.)*



**Fig. 1-8**
The multipurpose rigid telescope is 2.7 mm in diameter and 18 cm long and has a 30-degree viewing angle. Accessories for this telescope include (top to bottom) an operating or cystoscopy sheath, an arthroscopy sheath, an examination or guard sheath, and a laparoscopy trocar or cannula.

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## ACCESSORY INSTRUMENTATION FOR RIGID TELESCOPES

Rigid telescopes are generally inserted into a patient with a protective sheath or cannula designed specifically for the procedure being performed and the telescope being used. In addition to providing protection to the telescope, sheaths and cannulae provide access to the body cavities where there is no previously existing orifice, minimize trauma to surrounding structures, provide a means for the passage of fluids or gas, and provide a channel for passing ancillary instrumentation into the body cavity. For example, distention of the bladder with fluid or gas is necessary to perform cystoscopy and is achieved through the side port of a urology sheath. This sheath also has an operating channel for passage of flexible instruments for procurement of biopsy specimens or for removal of calculi or foreign bodies (Fig. 1-9). This sheath can be used for rhinoscopy to accommodate instrumentation and the instillation of fluids to minimize interference of hemorrhage and exudate with visualization.

An alternative to sheath systems that accommodate different flexible instruments is the *optical forceps*. Available in a variety of styles and sizes, optical forceps integrate a protective sheath and biopsy or retrieval forceps into one instrument that locks onto the telescope, minimizing total outer diameter, while maximizing instrument strength and maneuverability in a simple design that is easily operated with one hand (Fig. 1-10). Optical forceps are most commonly used for bronchoscopy, esophagoscopy, gastroscopy, colonoscopy, cystoscopy, and vaginoscopy.

Ancillary instrumentation for laparoscopy and thoracoscopy includes trocars and cannulae for access to the body cavity. A variety of rigid instruments, as well as the telescope, are inserted into the body cavity through the cannulae after the sharp trocars are removed (Fig. 1-11). Detailed information is given in subsequent chapters on each telescope and its recommended accessories.

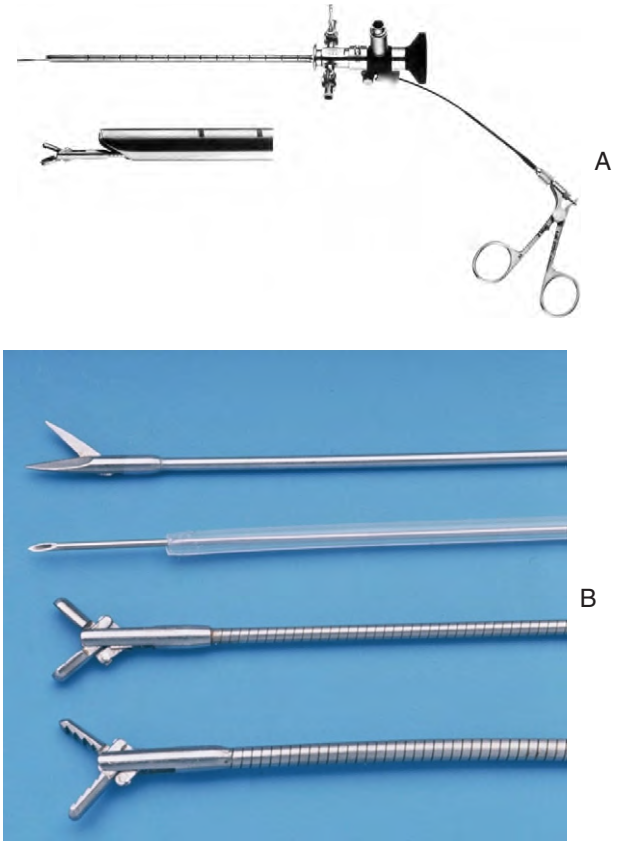



**Fig. 1-9**
The 2.7-mm multipurpose rigid endoscope with operating sheath and flexible instruments. A, Biopsy forceps inserted through the channel of the operating sheath. B, Flexible instruments for use with the operation sheath: scissors, injection or aspiration needle, biopsy forceps, alligator graspers. *(*A *From Tams TR:* Small animal endoscopy, *ed 2, St Louis, 1999, Mosby.)*

## FLEXIBLE ENDOSCOPES

There are two types of flexible endoscopes: *fiberoptic* and *video*. Fiberoptic endoscopes, or fiberscopes, use glass fiber bundles to transmit images, whereas video endoscopes use computer technology for image transmission. Both types of endoscopes can provide a video image on a monitor, but fiberscopes require attachment of an endoscopic video camera. Most veterinarians use fiberscopes because they are affordable and because they have the option of the detachable endoscopic video camera, which can be used for multiple scopes, both rigid and flexible. However, as in the human endoscopy field, more veterinary practitioners are using video endoscopes because they offer numerous advantages over fiberoptic endoscopes.

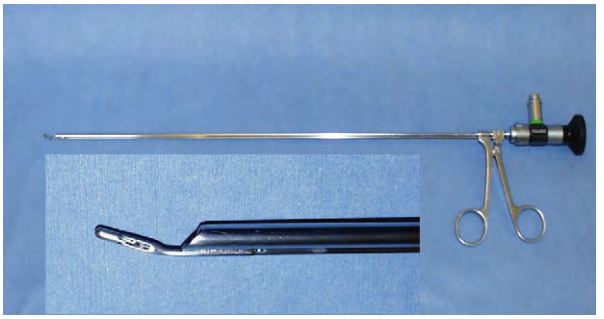


**Fig. 1-10**
A 2.9-mm × 36-cm telescope with universal optical forceps attached.

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**Fig. 1-11**
Basic 5-mm diagnostic laparoscopy set including two trocar/cannulae, telescope, palpation probe, and biopsy forceps.

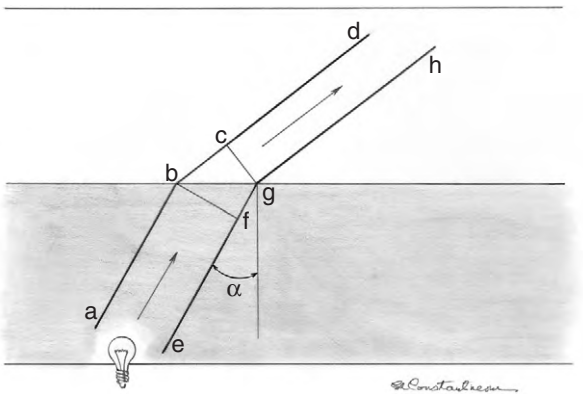



**Fig. 1-12**
Light beam being bent as it passes from one medium to another of lower refractive index.

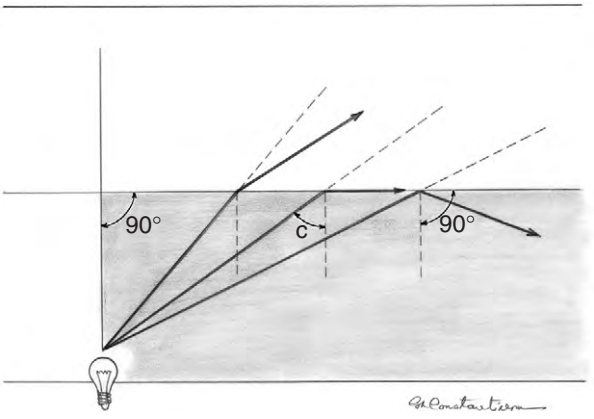



**Fig. 1-13**
The light beam is bent to varying degrees, depending on the angle at which it hits the medium of lower refractive index.

## Fiberoptic Endoscopes

Fiberoptics is the transmission of images and light by way of long thin fibers of optical glass. As light enters one end of a glass fiber, it is reflected internally and refracted (because light travels at different speeds in different media) until it is emitted at the opposite end.

As light passes from a medium of one density to that of another density with a different refractive index (ri = velocity of light in vacuum/velocity of light in substance), the wave bends or undergoes refraction. In Fig. 1-12, the darker medium has a higher refractive index (where light travels slower) than the surrounding lighter medium, which has a lower refractive index (where the light travels faster). If the light wave goes through the interface of the two media at an angle, one edge of the light wave "ab" goes through the interface first and the other edge "eg" goes through the interface later. In the time that it takes the edge "fg" to reach the interface between the two materials, the other side of the wave has traveled the distance "bc." The segment "bc" is longer than "fg" because it travels faster in the second, less dense medium. This causes a bending or refraction of the light wave. As the angle of incidence of the light wave "α" increases, so does the angle of the refracted light. When "α" (see Fig. 1-12) equals "c" (Fig. 1-13), the refracted light travels along the interface of the two media. This angle is known as the *critical angle of incidence*. When the angle of incidence of the light beam hitting the interface is greater than the critical angle of incidence, the light reflects back into the original medium (see Fig. 1-13).

Light entering the end of a glass fiber is transmitted through the fiber if its surface is clean and it is surrounded by a substance of a lower refractive index (Fig. 1-14, *A*). This is known as *total internal reflection* of light. Each fiber is clad with a substance (usually glass) with a lower refractive index than the core of the fiber. In fiberoptic endoscopes, the fibers are very small so that they can be flexible, and many fibers are assembled to create a flexible fiber bundle. If a fiber is not clad properly, if there is any foreign matter on the fiber, or if the fiber touches adjacent fibers, light leaks at those points, total internal reflection does not occur, and light is lost through the sides of the fiber (see Fig. 1-14, *B*).

In practice, not all light that enters the fiber is transmitted to exit at the other end. Many variables determine the amount of light that exits. Light can be absorbed by the fibers and the loss is proportional to the length of the optic path of the light. The length of the fiber and the

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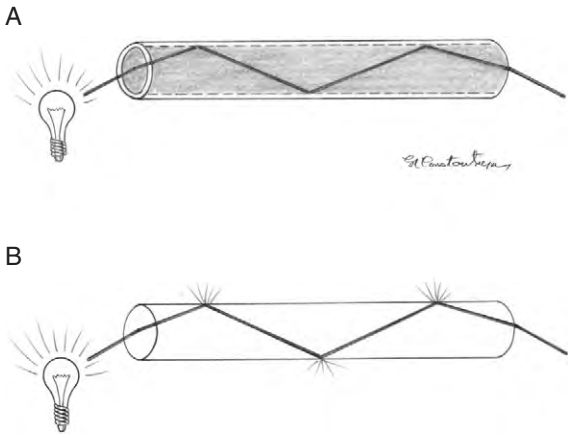



**Fig. 1-14**
Total internal reflection of light in a fiberoptic glass fiber. A, Proper cladding of a glass fiber minimizes light loss as it travels along the fiber. B, Light is lost as it hits the surface of an improperly clad fiber.

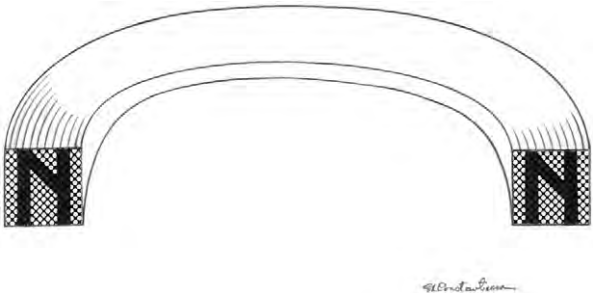


**Fig. 1-15**
A coherent fiber bundle maintains the exact arrangement of individual fibers at both ends, providing transmission of an image.

number of internal reflections determine the optical path length. The amount of light lost at each internal reflection is small in a properly clad fiber. However, because there are thousands of internal reflections per meter, the amount of light lost may be significant by the time the light has traveled from one end of the fiber to the other end. Fibers of small diameter and long length are most susceptible to this type of light loss. Light may also be lost at the surface of both ends of the fiber. Light may be reflected back at either end. In a fiber bundle, light that falls between fibers or on the cladding is not transmitted to the distal end of the fiber bundle.

Fiber bundles are of two types: *coherent* and *incoherent*. Coherent bundles are spatially oriented so that the fibers at one end of the bundle are at the same location as at the other end of the fiber bundle. Because each individual glass fiber transmits a small piece of the total image, coherent fiber bundles are used for the transmission of images from the distal tip to the eyepiece. Images transmitted through a coherent fiber bundle look like a completed jigsaw puzzle with each fiber transmitting one piece of the puzzle (Fig. 1-15). Fiber bundles of this type are called *image guide bundles*. In general, image guide bundles are composed of fibers of small diameter with little cladding, which improves the image resolution.

Incoherent bundles consist of clad fibers arranged at random. They are used to transmit light from the light source to the distal end of the insertion tube. Fiber bundles of this type are called *light guide bundles*. Because image resolution is not important, individual fibers are thicker than in the image guide bundles; therefore light guide bundles are more efficient at transmitting light. Flexible endoscopes have one or two incoherent fiber bundles for the transmission of light from the light source to the distal tip.

## Video Endoscopes

Video endoscopes were first introduced to the medical community in the mid-1980s. Instead of using a fiberoptic bundle for transmission of the image to the eyepiece on the endoscope, a microelectronic charge coupled device (CCD) chip is located at the distal end of the endoscope and senses the image. The image is electronically transferred to a processor that assimilates it into a meaningful format that is sent to a video monitor for viewing. The result is image resolution superior to that generated by fiberscopes. The only significant limitation to current videoendoscope technology is the miniaturization of the CCD. Smaller diameter flexible scopes (less than 6 mm) are not currently available as video endoscopes.

The rest of the components of the videoendoscope are similar to those of a fiberoptic endoscope except there is no eyepiece or image guide bundle. Just like fiberoptic endoscopes, video endoscopes use one or two incoherent fiber bundles for the transmission of light to the distal tip of the insertion tube.

## Anatomy of Flexible Endoscopes

Several criteria are important for selecting endoscopes for application in small animal veterinary medicine. For gastrointestinal endoscopy, the outer diameter of the insertion tube should not exceed 10 mm. Gastrointestinal endoscopes made for the veterinary market and pediatric gastroscopes range in diameter from 7.8 to 10 mm (Fig. 1-16). Smaller diameter gastrointestinal endoscopes are easier to insert through the pylorus but usually have smaller operating channels. The smaller diameter endoscopes can be used for bronchoscopy and are especially useful for feline duodenoscopy. Working length of gastrointestinal endoscopes varies from 80 to 150 cm with most being

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**Fig. 1-16**
A gastrointestinal or multipurpose veterinary endoscope: 9-mm diameter, 140-cm working length.

100 to 110 cm in length. The 100- to 110-cm length is adequate for gastrointestinal endoscopy in most patients; however, greater length is required for duodenoscopy in larger breeds of dogs.

Flexible fiberscopes that are smaller in diameter than 7.8 mm are useful for specialty applications in small animals, such as bronchoscopy, rhinoscopy, and urethrocystoscopy in males. These scopes typically range from 2.5 to 6.0 mm in diameter and from 55 to 100 cm in length (Fig. 1-17). Because of the size limitations, these smaller flexible fiberscopes generally have only one- or two-way tip deflection and a small working channel, if any. The combination of small diameter and long length increases the versatility of any fiberscope for general veterinary use.

The endoscope featured and described in this section is a multipurpose endoscope in that it is the most practical endoscope for the small animal practitioner. Its features include four-way tip deflection, irrigation, insufflation, and an accessory channel used for suction and passage of flexible instruments. Gastrointestinal endoscopy (both upper and lower) as well as bronchoscopy in larger dogs can be performed with this instrument.

The anatomic parts of a gastrointestinal flexible endoscope starting at the light source are the light guide connector, the umbilical cord, the handpiece, the insertion tube, and the distal tip (Fig. 1-18).

## Light Guide Connector

The tip of the umbilical cord contains the light guide connector, which plugs into the light source and houses connections for the lens-washing water container, suction tube, air pump, and pressure compensation port with its cap. The pressure compensation port is used for leakage testing. Attaching the cap equalizes pressure between the inner cavity of the endoscope and the external

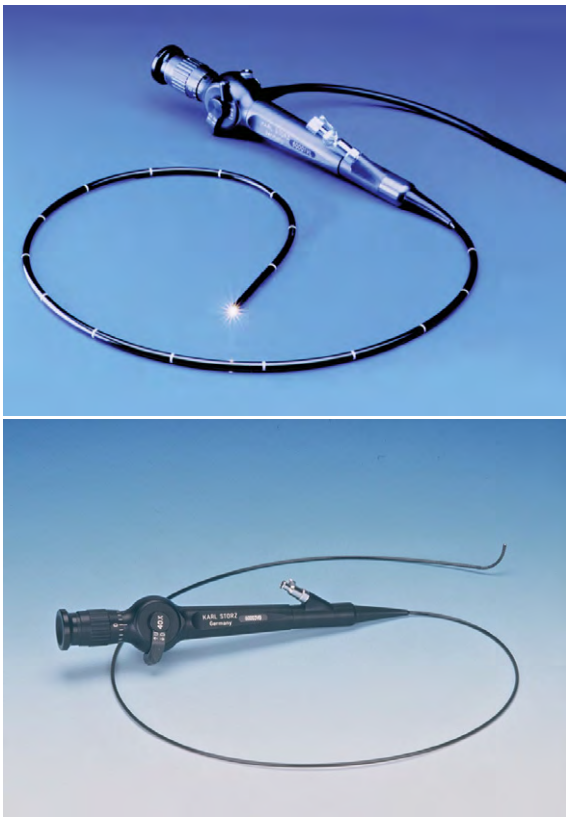



**Fig. 1-17**
Small-diameter fiberscopes. A, Small animal bronchoscope: 5 mm × 85 cm. B, Specialty fiberscope: 2.5 mm × 100 cm.

environment and thus prevents damage to the endoscope. This is necessary only under extremes of pressure, such as during gas sterilization and shipment by air. The pressure compensation cap should never be attached while the endoscope is immersed in fluids, because this could cause leakage of fluids inside the scope.

## Umbilical Cord

The umbilical cord contains the incoherent fiber bundles for the transmission of light to the distal tip of the endoscope. Channels for air, lens-washing water, and suction are also contained in this segment of the endoscope.

## Handpiece

The handpiece of the endoscope is designed to be held in the left hand (Fig. 1-19). This leaves the right hand free to hold and manipulate the insertion tube. The deflection knobs control the distal bending section. Some endoscopes have only one- or two-way tip deflection. For gastrointestinal endoscopy, it is highly recommended to have an endoscope with four-way tip deflection and the ability to deflect at least 180 degrees in one direction.

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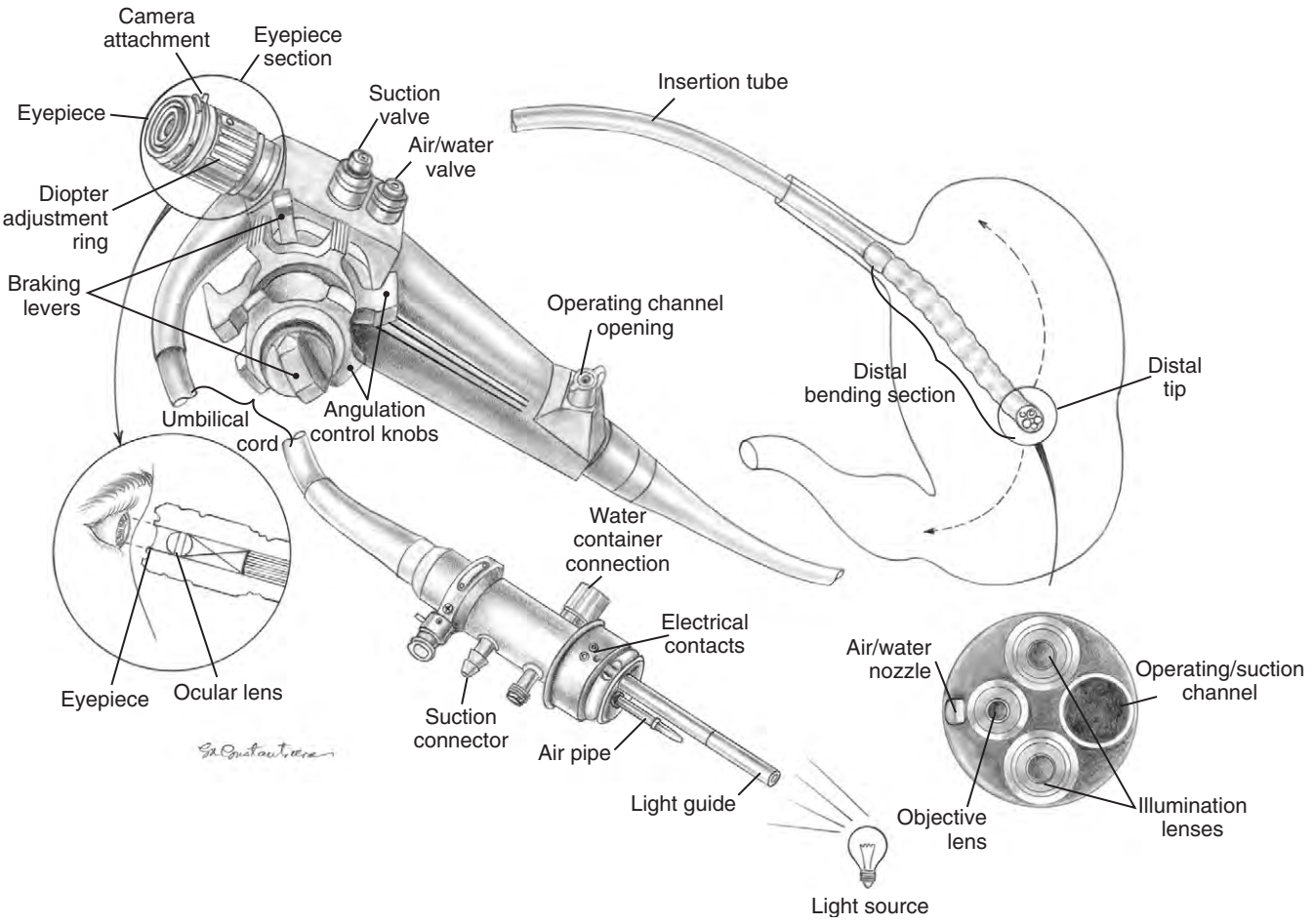



**Fig. 1-18**
Diagram of a multipurpose or gastrointestinal flexible endoscope.

Four-way tip deflection and a small bending radius enhance maneuverability of the endoscope. Many endoscopes have a locking system to fix the deflection of the distal tip. This allows the endoscopist to free his or her hand from the control knobs and still maintain deflection of the tip. This is a valuable feature when it is critical to have the tip location stable while obtaining a target biopsy specimen or grabbing a foreign body at a specific point with graspers. To avoid damage to the endoscope, the endoscopist must be careful not to inadvertently force the deflection control knobs while they are locked.

Suction and air/water control valves are located in the handpiece of the endoscope. Their specific function may vary by manufacturer. An external suction pump is attached to the light guide connector region of the umbilical cord to supply negative pressure for aspiration of air or fluid. When the suction valve is activated, material is aspirated through the operating channel and into the collection bottle of the suction pump. Air insufflation is



**Fig. 1-19**
Typical positioning of endoscope handpiece in the left hand.

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required for gastrointestinal endoscopy and is supplied by an air pump located in or near the light source. When the air valve is activated (in most endoscopes by just putting a finger over a hole in the air/water valve), air is emitted from a nozzle at the distal tip of the endoscope. Air insufflation is needed to properly distend the organ being examined so that endoscopic visualization is possible. By fully depressing the air/water valve (in most models), water is emitted from the nozzle and directed across the distal lens. Water is needed to wash off the lens, because mucus and debris frequently get on the lens and obscure the view or make the view appear out of focus.

The eyepiece has a diopter adjustment ring, and the user should always focus the endoscope before passage. If this is done, an out-of-focus view is usually indicative of mucus or debris on the lens, which needs to be washed off by activating the water irrigation system.

The handpiece also houses the accessory channel opening through which various flexible instruments may be passed. Replaceable rubber caps make the port on the handpiece airtight so that water and air cannot escape from or enter into the operating channel. This is important to maintain distention of the viscus when insufflated and for proper functioning of the suction function. A small perforation in the cap allows passage of operating instruments while maintaining an airtight seal.

## Insertion Tube

The insertion tube of the endoscope contains an image guide bundle or CCD chip connecting wires, incoherent fiber bundles for the transmission of light to the distal tip, the accessory/suction channel, the air and water channels, and deflection cables. Because glass fibers are contained within the insertion tube, this is the most commonly and easily damaged portion of the fiberscope. Care is taken to avoid trauma to the insertion tube, which can occur by overbending or kinking, banging, or crushing the tube. A mouth speculum is always used before the endoscope is passed through the oral cavity of a patient. During manipulation the endoscope is never forced. Forced passage of flexible instruments through the accessory channel, particularly against resistance when the bending tip is deflected, can cause punctures internally.

The most expensive damage to flexible endoscopes occurs when the insertion tube is severed or punctured and liquid is allowed to leak into the inner workings of the fiberscope. Without immediate attention, this moisture can lead to corrosion of internal parts, which may necessitate the replacement of the entire insertion tube. This expense can often be minimized, however, if the leak is detected early by performing a pressure test. This test, which should be done before and after every procedure, takes less than a minute. The manometer supplied with the scope is attached to the pressure compensation cap and simple instructions are followed (Fig. 1-20). When a leak is detected, the manufacturer or supplier of the endoscope should be contacted for service immediately.



**Fig. 1-20**
Fiberscope leakage tester (manometer). This attaches to a pressure compensation valve to test the integrity of the endoscope seals.

Most flexible endoscopes are equipped with an operating channel for the passage of biopsy forceps, grasping forceps, brushes, and other instruments for specimen collection or surgical manipulations. In most flexible endoscopes, the operating channel also serves as the suction channel. The size of the operating channel in most gastroscopes and multipurpose fiberscopes varies from 2 to 3 mm in diameter and in general is dependent on how much room is present in the insertion tube. Its size is directly proportional to the size of the endoscope. A large channel allows passage of larger instruments through the endoscope. For example, larger biopsy forceps can be passed through larger operating channels, allowing larger specimens to be obtained and thus enhancing the probability of an accurate interpretation by the pathologist. One of the major advantages of endoscopy is the ability to obtain a histologic diagnosis by using a relatively noninvasive procedure. Furthermore, with a larger channel size, larger retrieval forceps can be passed, which enhances the ability to retrieve foreign bodies with endoscopy.

## Distal Tip

The end view of the distal tip of the insertion tube of a typical flexible endoscope is shown in Fig. 1-18. On the face of the tip are several lenses and channel openings or nozzles. The image guide bundle objective lens focuses the image onto the distal face of the image guide bundle

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for transmission to the eyepiece and provides for a wide field of view. Lenses on the light guide bundles diffuse the light so that there is even illumination of the field of view. The largest opening is the operating/suction channel. Smaller openings for insufflation of air and lens-washing water channels are capped with nozzles facing the objective lens so substances such as mucus, blood, or lumen contents can be blown or washed off the lens. On some models, one nozzle is used for both air and water.

## ACCESSORY INSTRUMENTATION FOR FLEXIBLE ENDOSCOPES

A wide variety of flexible endoscopic accessories is available, the most common being biopsy forceps, cytology brushes, foreign body grasping forceps, stone baskets, polypectomy snares, dilation balloons, coagulating electrodes, injection or aspiration needles, scissors, lithotriptor probes, and laser fibers (Fig. 1-21).

### Biopsy Forceps

Biopsy forceps are basically similar but have some differences. The size of the biopsy forceps is probably the most critical factor, because the size of the biopsy sample obtained is directly proportional to the size of the biopsy forceps. Other features are bayonet pins, serrated edges, and fenestrated cups (Fig. 1-22). Bayonet pins help prevent slippage of the forceps along the mucosal wall but can cause trauma to the central aspect of the biopsy specimen. Serrated cups help in tearing off tougher tissues. Fenestrations relieve the pressure within the cups of the forceps as they are being closed, minimizing artifactual damage to the specimen. Most types procure adequate specimens, and selection of one style over another depends on the preference of the individual.

To obtain specimens, the endoscope is placed approximately 1 to 2 cm from the area to be biopsied, and the forceps are advanced through the operating channel until they emerge from the operating channel. The forceps are opened and advanced until they touch the mucosa, gentle pressure is applied to the forceps until they start to bow (Fig. 1-23), and the forceps are closed and pulled back into the operating channel to cut and tear off a biopsy specimen.

To increase diagnostic yield, forceps are placed at the specific site to be biopsied. As a rule, it is best to place the forceps at the junction of normal tissue and abnormal tissue. The small size of specimens obtained is a disadvantage of endoscopically obtained biopsies; pathologists prefer larger samples. To compensate, multiple samples are obtained for each site. A second biopsy specimen obtained at the same location can increase diagnostic yield because diseased tissue is frequently seen in the submucosa. Risk of perforation is minimal.

Obtaining biopsy specimens of tubular organs such as the esophagus or duodenum is complicated by the tendency of the forceps to slide along the mucosa. In these cases, forceps with a central spike help anchor the forceps to the mucosa. Aspiration of some of the air from the organ, allowing it to collapse slightly, may provide more mucosal folds and allow the biopsy forceps to take a deeper bite.

### Cytology Brushes

Obtaining tissue for cytologic evaluation is an important adjunct procedure. Sheathed brushes are best because they prevent loss of cells from brush bristles upon withdrawal through the operating channel (Fig. 1-24). A sheathed cytology brush is passed through the operating channel of the endoscope. After emerging from the operating channel, the brush is extended out of the sheath, placed on the lesion, and rubbed back and forth. Cells from the lesion adhere to the brush bristles. The brush is retracted back into the sheath and the entire unit is withdrawn from the endoscope. The brush is extended out of the sheath and the cells are transferred to a microscope slide by gently rolling the brush on the microscope slide.

### Retrieval Equipment

A variety of flexible instruments are passed through the operating channel to retrieve foreign bodies (FBs) from the esophagus, trachea, and stomach. The most commonly used instruments include rat-tooth or alligator-type forceps, recommended for flat bodies with an edge, such as coins or bottle caps; two- or three-prong graspers, ideal for cloth or irregularly shaped FBs; and snares or wire baskets, ideal for spherical FBs.

## THE VIDEO TOWER

Video imaging offers many advantages over direct viewing through the eyepiece of an endoscope. Viewing the procedure on a monitor creates an atmosphere of team participation in that more than one person can visualize the image. Procedure time is reduced because there is greater coordination between the endoscopist and technician assisting during the procedure. In addition, the larger image enhances visualization and fewer lesions are missed. There is less eye and neck strain for the endoscopist with video endoscopy, which is important for individuals performing a considerable number of procedures in a day. With the procedure viewed on a monitor, there is no need for the endoscopist to have his or her face near the channels of the endoscope and the risk of having liquid from the endoscope or body secretions from the patient splash onto the examiner's face is minimized. Video endoscopy also facilitates documentation

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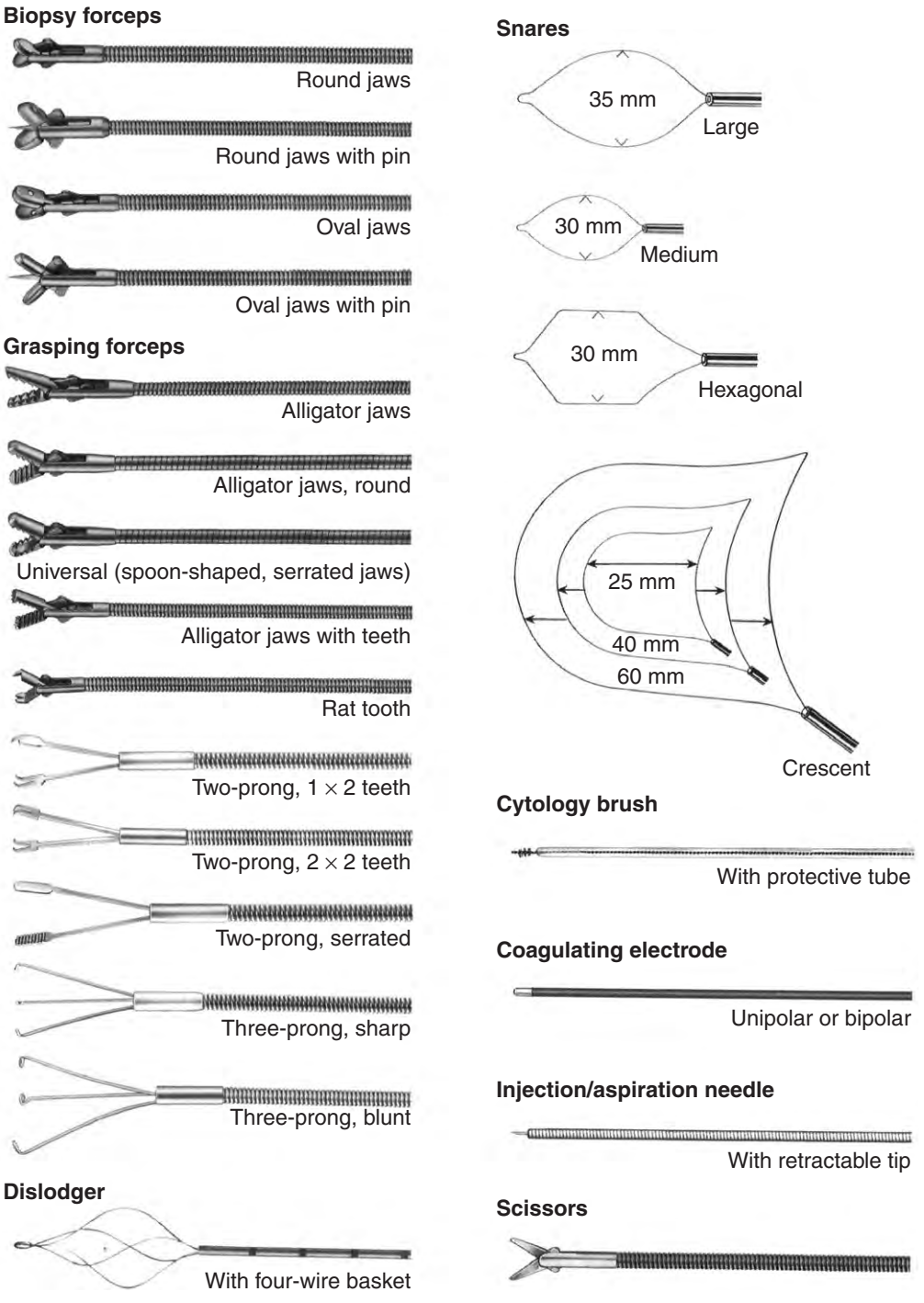



**Fig. 1–21**
A variety of flexible instruments available for use through the working channel of flexible fiberscopes. *(From Tams TR:* Small animal endoscopy, *ed 2, St Louis, 1999, Mosby.)*

and sharing of endoscopic findings for later review by colleagues or clients.

The *video tower* refers to the endoscopy cart, which holds a video camera, video monitor, and light source, plus other optional devices such as a video printer, video recorder, digital capture device, insufflator, suction pump, power shaver, and electrosurgical unit. These items should be permanently stored on a mobile cart, so that set up time is minimal. The tower is stored in a convenient place for easy access. Smaller towers (Fig. 1-25) can sometimes

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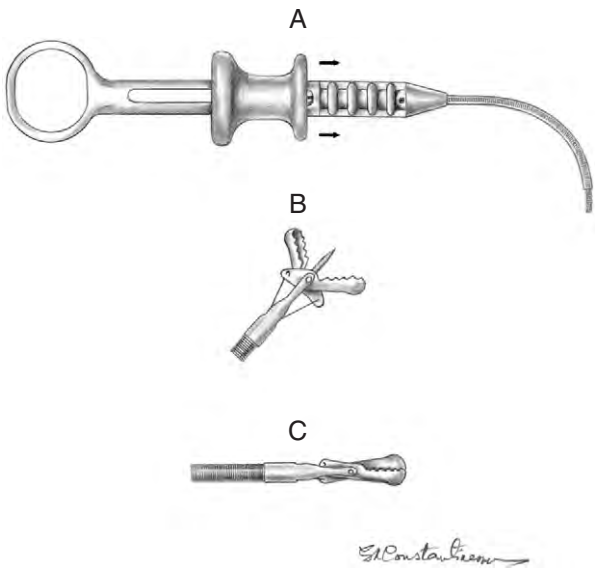



**Fig. 1-22**
Detail of a flexible biopsy forceps with serrated cups and central bayonet spike. A, Handle. B, Cups, open. C, Cups, closed.

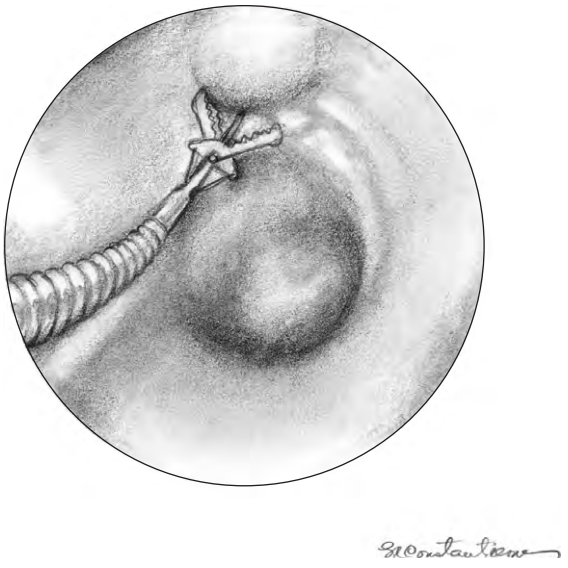


**Fig. 1-23**
Forceps shaft begins to bow as slight pressure is applied against the mucosa. This is the desired amount of pressure when biopsy specimens are taken.

be stored in a larger examination room, for video otoscopic examinations in front of clients. A more elaborate tower (Fig. 1-26) is typically stored in the surgery or treatment area.

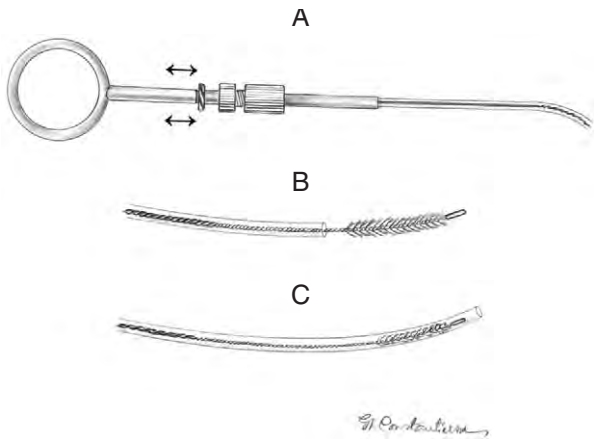



**Fig. 1-24**
Detail of sheathed cytology brush. A, Handle. B, Brush extended from sheath. C, Brush withdrawn into sheath.



**Fig. 1-25**
Basic endoscopy tower, including 13-inch video monitor, halogen light source, camera, and printer.

## Light Sources

An essential component of the endoscope system is a light source to illuminate the anatomic site being examined. Many types of light sources are available, ranging from relatively low-powered halogen to high-intensity xenon units. Fiberoptic light-transmitting cables can be

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**Fig. 1-26**
Surgical video endoscopy tower, including 19-inch monitor, keyboard, video printer, xenon light source, electronic insufflator, two camera control units, and a medical grade VCR.




**Fig. 1-27**
Light sources. A, A 150-watt halogen light source with an air pump for gastrointestinal endoscopy. B, A 175-watt xenon light source.

equipped with various adapters to allow a variety of light sources from different manufacturers to be used. Thus veterinarians can buy one light source for all endoscopes whether they are rigid or flexible.

A 150- to 175-watt halogen or xenon light source is recommended for most procedures in small animal endoscopy (Fig. 1-27). A 150-watt xenon light source emits considerably more light than a 150-watt halogen light source, because xenon bulbs produce more lumens per watt. Not only do they produce a brighter light but also the color of xenon light is close to that of natural sunlight, providing a whiter light that more accurately reproduces the colors of living tissues. A halogen light source is adequate for direct visualization, but a xenon light source is more suitable for video imaging and documentation. Xenon light sources also provide significantly better illumination of larger, light-absorptive cavities, such as the abdomen or inflated stomach of a large dog. Most higher end light sources are equipped with a rheostatic control knob to adjust light intensity. The dial is turned down to a point just above where illumination of the anatomic site begins to decrease. This extends the life of expensive xenon bulbs and reduces the amount of heat generated and transmitted along the cable to the tip of the scope.

A 300-watt xenon light source is commonly used in human and equine laparoscopy. The greater the intensity of the light, the better, but the additional power of a 300-watt light source is rarely required in small animals. The more powerful the light source, the more expensive they and their bulbs are. An air pump for insufflation during gastrointestinal endoscopy may also be housed in the light source, or it may come as a separate unit.

The quality and condition of the light guide cable or the incoherent fiber bundles are important. Broken fibers, damaged cladding, or dirty faces of a light cable markedly reduce light transmission. Similarly, the face of the light guidepost on the telescope must be kept meticulously clean. The best way to clean these and other optical surfaces is with a gauze or soft cloth soaked in a neutral pH enzymatic cleaner. This dissolves adherent organic debris and removes particulate matter. The surfaces are

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then wiped with alcohol and dried with a lint-free soft cloth. Light guide cables must be handled carefully and coiled loosely to minimize breakage of fibers.

## Insufflators

Insufflators are electronic devices used for insufflation of the abdomen during laparoscopy (Fig. 1-28). Similar devices are occasionally used for distention of joints or the urinary bladder during arthroscopy and cystoscopy, but more often this is achieved with fluid distention. Insufflators should not be confused with air pumps used in gastrointestinal endoscopy for insufflation with room air. Using room air to insufflate the abdomen, urinary bladder, or joint cavity could cause air embolism, resulting in death of the patient or contamination of a sterile cavity. Insufflators generally use carbon dioxide, although nitrous oxide ($N_2O$) models do exist. $N_2O$ works well for abdominal insufflation as long as electrocautery is not used because $N_2O$ is a combustible gas. Insufflators automatically flow at the selected flow rate until the desired abdominal pressure set by the user is reached (recommended pressure range is 10 to 15 mm Hg). An insufflator is never relied upon as a replacement for good monitoring by the technical staff. Overinflation of the abdomen during laparoscopy, as well as overinflation of the stomach during gastrointestinal endoscopy, may compromise cardiopulmonary function. These types of problems are extremely rare; this type of monitoring is always part of the overall anesthetic monitoring performed during these procedures.

## Video Imaging Systems

The basis of any endoscopic video imaging system is the endoscopic video camera (Fig. 1-29). The camera consists of a camera head with endoscopic adapter, which attaches to the eyepiece of an endoscope; a processor or camera control unit (CCU), which processes the image; and a video monitor (Fig. 1-30). The camera head contains either one or three semiconductors (CCDs), which sense the image and convert it to an electronic signal. An exception to this basic design is the true *videoendoscope*, mentioned previously in this chapter, which contains a chip in the tip of the scope. Modern video cameras are lightweight, soakable, gas sterilizable, and, in some cases, autoclavable. They may contain automatic exposure control, a zoom lens, contrast enhancement capability, and buttons on the camera heads to control various settings or activate peripheral devices.

The CCD is the "chip" referred to in *single-chip* vs. *three-chip* cameras. The optical quality of modern single-chip cameras is high, but that of three-chip cameras is even better. Horizontal resolution and accuracy of color reproduction is superior with three-chip cameras. In single-chip cameras, an electronic process is required to reconstruct the colors and detail of the original image, which is not fully recovered. In three-chip cameras, this process is bypassed, in that the three sensors each transmit one of three colors (red, green, and blue), resulting in more




**Fig. 1-28**
Mechanical insufflator for laparoscopy with insufflation tubing and Veress needle attached.




**Fig. 1-29**
Endoscopic video camera. A, Control unit with camera head. B, Camera head coupled to an arthroscope. *(From Tams TR:* Small animal endoscopy, *ed 2, St Louis, 1999, Mosby.)*

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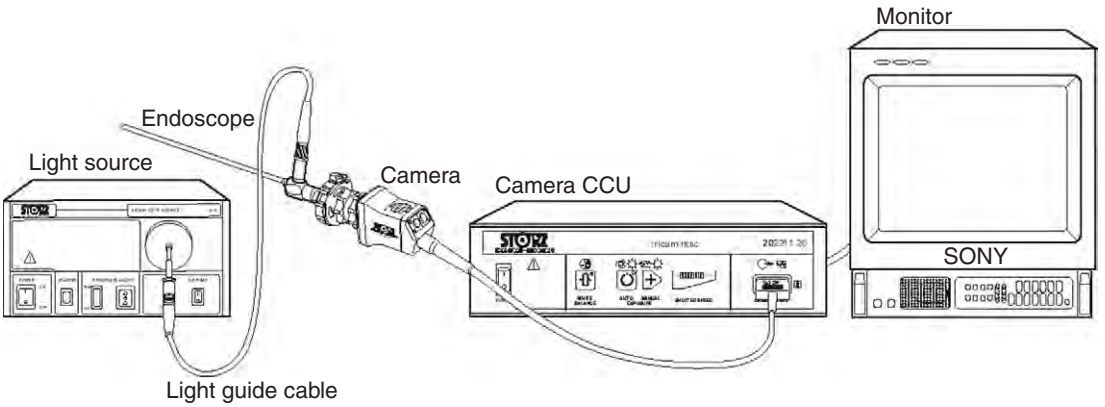



**Fig. 1–30**
The video chain.

accurate color reproduction, and all of the signal available for resolution is used solely for that purpose. Three-chip cameras have horizontal resolution that exceeds 750 lines vs. the 450 average lines of horizontal resolution commonly achieved by single-chip cameras. Because they are relatively affordable, single-chip cameras are more popular than three-chip cameras in the veterinary field.

Single-chip cameras are more than adequate for clinical application, providing excellent image quality. The difference between single-chip cameras and three-chip cameras becomes apparent with video capture of still images for use in publications and presentations. The three-chip camera technology provides digital images that are photographic quality.

## "Digital" Endoscopic Video Cameras

The most recent advances in endoscopic video cameras center around the concept of "digital" imaging. The most obvious advantage of digital video is the ability to send images directly to a digital recording device or computer. (See the discussion on digital image capture in the Documentation Devices section.) In addition, a digital video signal does not degrade as it travels through cables or digital components, and it has the *potential* for increased image accuracy and reduced susceptibility to outside interference.

The terminology and value of a digital endoscopic video camera, however, can be confusing, because the reality of the current technology is such that no endoscopic video camera on the market is entirely digital. In *all* endoscopic video cameras available currently, the initial image sensed at the CCD is analog, and, for digital cameras, the signal is converted to digital somewhere along its path. In many cases, the signal is converted back to analog again in the CCU, so that it can be sent to an analog monitor. With each conversion of a video signal, from analog to digital and back again, there is some degradation of image quality. Although digital imaging certainly will be established in the future, one should be wary of claims that may not result in any real advantage to the endoscopist.

Some of the valuable features of digital endoscopic video cameras include digital contrast enhancement, digital outputs (i.e., firewire, digital-video interface [DVI], serial-digital interface [SDI]), computerized camera head control, upgradability, and user-friendliness.

## Video Monitors

A video monitor and various other video peripheral devices (e.g., printer, VCR, digital recorder) may be attached in series or in parallel to the CCU via cables that exit the back of the unit. Analog signals are typically sent to a monitor via one of three cable types: composite (BNC), separated (S)-video (Y/C), or RGB (Fig. 1-31). S-video is the highest quality signal for single-chip video cameras. This is the same signal used to produce super (S)-VHS tapes. Three-chip cameras use four distinctive cables containing BNC-type connectors. A 15-pin VGA connector (HD 15) is also sometimes used for transmitting RGB signals.

Cameras with digital output capability may have connectors and cables such as DV (digital video or "firewire"), DVI, or SDI. These cables do not plug into most analog cathode ray tube (CRT) monitors without adaptors but instead are designed to connect to digital recording devices or flat panel monitors. These flat panels are attractive mainly because of their streamlined size and weight, but they come at a high cost and the image quality still does not match that of a standard, medical grade analog CRT monitor. CRT monitors currently are the most common, most inexpensive, and highest performing display device available.

The video chain is always terminated with the video monitor. The quality of the final image in a video chain can be only as good as the weakest link. For example, a high-quality video camera hooked up to a consumer-grade television as a monitor does not provide the best possible image. There is some loss of image quality with

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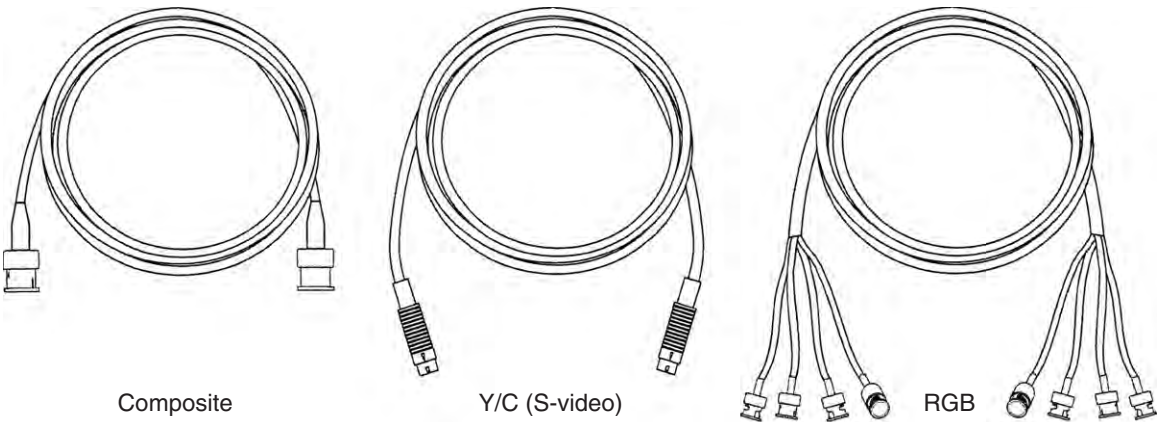



**Fig. 1-31**
Common video cable types.

each peripheral device that is attached in series. To provide the best possible image, higher quality endoscopic cameras are equipped with multiple output ports, so that one may be used for peripheral devices, while the other is used for direct attachment to a monitor.

## Documentation Devices

The most common device for documenting endoscopic findings is the video printer (Fig. 1-32). The video printer enables the clinician, with the click of a button, to create a print that can be used for medical records, for demonstrating visual findings to the client, or for sending an image to a referring veterinarian. Video printers are generally equipped with a remote control or a foot pedal for ease of operation during a procedure. Several programmable options are also available, such as *caption, number of images per print,* and *number of prints.*

Another commonly used video documentation device is the video recorder. Almost any video recorder can be used to record a procedure. S-VHS is recommended because it reproduces the full quality of high-resolution endoscopic video camera images. S-VHS provides more accurate and complete chrominance or color information, as well as approximately 100 lines of horizontal resolution *more* than standard VHS. The only disadvantage of S-VHS is that the videotapes can *only* be played on an S-VHS player.

The newest method of capturing and storing endoscopic images is via computer. With a video capture card and associated software installed into a computer, images can be downloaded directly from the output cable of the camera. Compact and convenient digital image capture devices are also available, specifically designed for endoscopy (Fig. 1-33). Such a device can store hundreds of images and several minutes of video onto a CD or DVD. The devices can also be networked to a centralized computer system. Images can then be archived for later retrieval, manipulation, and reproduction. Digital images can be sent by electronic mail (e-mail) or turned into prints, slides, or reports including text that can be used for medical records, client education, or referral to other veterinarians. Large numbers of digital images can be archived at minimal cost (no film or videotape is required), and there is no degradation over time.

Another simple option for endoscopic documentation is to photograph findings with a digital still camera or a single-lens reflex film camera attached to the eyepiece of an endoscope. Adapters that fasten into the lens mount of the camera and attach directly to the scope are commercially available from endoscope manufacturers.

Numerous documentation devices are available, and new ones appear frequently. Perhaps the most important features for the prospective buyer to consider are (1) ease of use or programmability, (2) resolution or dots per inch (dpi), and (3) cost of media (prints, videotapes, disks).




**Fig. 1-32**
Video printer.

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**Fig. 1–33**
Digital capture device with pull-out touch screen panel capable of recording still images and video onto CDs and DVDs.

Other considerations may include expandability, remote control, and computer compatibility.

## SHOULD ENDOSCOPY BE PART OF YOUR PRACTICE?

There are two main reasons to include endoscopy as a diagnostic and therapeutic tool in a practice. The first is to improve the quality of medical care for the patients, and the second is to improve the financial status of the practice. It is not practical to provide the ultimate in patient care if it does not pay for itself.

To move forward, however, the practice must be willing to dedicate time and resources to learn new techniques and new technology. As with learning any new technique, to be a good endoscopist takes patience and dedication to learning. To achieve competence as an endoscopist, it is necessary to take courses and spend time practicing. Technicians in the practice also need to be willing to learn new procedures so that they can assist the veterinarian, and they must also learn the new technology to be able to maintain the equipment.

Once the commitment to perform endoscopy has been made, it is helpful to develop a multiyear endoscopy plan. Most practices do not have the financial resources or personnel to initiate every type of endoscopy service at the same time. The type of endoscopy a practice begins performing can be based on the number of cases involving each organ system the practice sees in a given period, on the interest of the practitioners (i.e., an orthopedic surgeon may start out with arthroscopy), or on the ease of learning the various endoscopic procedures.

To develop a plan, data can be collected to determine the number of cases that would benefit from endoscopy in the practice. Obtaining these data could be as simple as having the doctors, front office personnel, or technicians manually keep track of the types of cases in which endoscopy could be used that are seen over a certain period. If the medical records of the practice are computerized, this task becomes easy and potentially detailed. This case study can also be done in a retrospective manner. With these data, the practice can then determine which endoscopy services to offer first and then develop a multiyear endoscopy plan. Traditionally, small animal veterinarians have started with gastrointestinal endoscopy, probably because gastrointestinal endoscopy techniques are well defined, it was the first area of endoscopy to be widely used in small animal practice, and gastroenterology represents a high percentage of the cases in small animal practice. Advances in video technologies and the growing awareness of the simplicity and cost-effectiveness of rigid endoscopy have led many practices to begin with other areas. After the practice has decided which endoscopic procedures to offer, then the decision is made concerning what equipment to purchase. Specific information about equipment requirements is covered in subsequent chapters on the various techniques. In considering the financial situation of the practice relative to instrument expense vs. potential income generated by endoscopic procedures, the charge per procedure and number of procedures that will be performed per year are estimated. The use of instrumentation for multiple procedures is also determined. For example, with a laparoscope, one can perform laparoscopy, thoracoscopy, and bronchoscopy. With a 2.7-mm multipurpose rigid telescope, one can perform rhinoscopy, cystoscopy, otoscopy, arthroscopy, avian endoscopy, sometimes laparoscopy and thoracoscopy, and some of the "otheroscopies." The current indications for each procedure are considered and the practice determines the number of cases seen in which use of a given endoscope is indicated. An estimate is made of the net income that the clinic needs to make to cover equipment costs and to make a profit. Revenues and expenses generated by endoscopy are not limited to the endoscopy procedure fees but also include services involving blood work, histopathology, culture and sensitivity, cytology, anesthesia, radiographs, surgical monitoring, and hospitalization.

## INCORPORATING ENDOSCOPY INTO THE PRACTICE

Once endoscopy equipment has been purchased, it is important to use this equipment. It is easy to continue practicing without endoscopy because it takes work to do

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new and different techniques. In a busy practice, it is sometimes difficult to find the time to initiate new procedures even when they are better.

When the equipment is delivered, the veterinarian and technicians should read the instruction manuals. The guidelines for instrument care are important and need to be strictly followed. With purchase of a new endoscope, most salespeople are eager to schedule an in-house training session to review its care and maintenance. In addition to training the veterinarians, it is imperative that the technician in charge of endoscope care (usually a senior technician) be included in the in-house training session. It is recommended that one technician be in charge of care and maintenance of the endoscopy equipment. This gives consistency to equipment care, extends equipment life expectancy, and reduces repair costs.

It is important to set up the endoscopy equipment so that it can be used quickly and easily. If this is not done, the equipment will not get used. An area in the hospital designated as the endoscopy room is where the equipment is set up and most of the endoscopy procedures are performed. This room can be the treatment room, the radiology room, the surgery room (especially for laparoscopy, thoracoscopy, and arthroscopy that need to be performed in an aseptic environment), or a special room for endoscopy. The equipment is permanently set up in this area so that an endoscopy procedure can be initiated with minimum effort. If the endoscopy tower is not assembled and associated equipment is not organized, it is frequently perceived as inconvenient to set up for an endoscopy procedure even when the procedure is indicated. The endoscopy room and equipment are set up and organized for maximum efficiency during the procedure with storage of the endoscopy accessories such as biopsy forceps, cytology brushes, and graspers close by for easy access by the endoscopy assistant.

Once the endoscopy equipment is acquired, set up, and organized, it is advantageous to have one clinician designated as the primary endoscopist. The learning curve for certain endoscopic procedures is steep, and the individuals who will be performing the endoscopy need time to learn the endoscopic techniques. The primary endoscopist, with training and experience, will have the skills needed to efficiently perform a variety of procedures and the knowledge to interpret lesions seen during the procedures. This approach improves patient care, greatly extends equipment life expectancy, and greatly increases the number of procedures that are performed.

## CLEANING AND CARE OF EQUIPMENT

Endoscopes and endoscopic instruments need to be treated with the same or greater care as other valued surgical instruments to ensure long instrument life and minimize maintenance costs. If one veterinarian and one technician are responsible for endoscopy in the practice, they will have a solid understanding of the equipment and will be less likely to cause damage to the endoscope and instruments than inexperienced staff. Based on this same logic, it is not recommended that two or more practices share endoscopy equipment.

No general discussion of endoscope cleaning, disinfection, and care can replace recommendations of the specific manufacturer of the equipment. The following guidelines apply to most endoscopes and accessories.

For cleaning and disinfection, certain items need to be partially disassembled so that all bodily fluids, debris, and infectious agents can be removed or inactivated. A thorough mechanical cleaning and disinfection after each procedure are essential, using brushes and sponges soaked in dilute solutions of neutral pH enzymatic cleaners designed for endoscopes (e.g., Enzol by Johnson & Johnson, Irvine, Calif; EZ-Zyme by Miltex, Bethpage, NY; Endozime by Ruhof, Valley Stream, NY; Metrizyme by Metrex, Orange, Calif). If enzymatic cleaners are not available, any mild, nonabrasive liquid detergent can be used. Periodic lubrication and sharpening, following the recommendations of the manufacturer, are also advised.

For sterilization, most high-quality, reusable instruments, endoscopes, cannulae, light cables, and camera heads are soakable and tolerate ethylene oxide gas. Instruments and accessories that do not contain optics are generally autoclavable. Certain camera heads, endoscopes, and light cables are autoclavable, but specific criteria from the manufacturer regarding autoclavability, time, temperature, pressure ranges, and cooling must be followed. Cameras, endoscopes, and light guide cables are the most fragile items and are subject to shock insults. They need to be handled and washed carefully, separately from other instruments. The most commonly recommended cold sterilant/high-level disinfectant is glutaraldehyde. (A 2%, 14-day, low-surfactant solution is recommended, such as Cidex 14 day by Johnson & Johnson, MetriCide 14 day by Metrex, or ProCide NS by Cottrell, Englewood, Calif.) Most telescopes are soakable, but extended soaking times are not recommended by most manufacturers and maximum soaking times of 30 to 45 minutes derive full benefit of the sterilizing process.

All endoscopes and instruments should be stored dry in sturdy cases that prevent contents from coming in contact with each other or with any object that may cause damage. Commercially available trays designed for endoscopic equipment sterilization and storage are ideal (Fig. 1-34). With all endoscopes, flexible or rigid, optical clarity is of the utmost concern. It is important, therefore, for optical surfaces to be kept meticulously clean and protected from damage.

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**Fig. 1-34**
Tray for storage and disinfection of telescopes and instruments.

## THE FUTURE

Endoscopy in small animal practice is not a new concept, and it is clearly gaining widespread popularity among general practitioners as well as specialists. Partially driven by the explosion in consumer electronics, the ability to visualize and record magnified pictures of lesions with a minimally invasive approach is almost irresistible. As an ever-increasing number of minimally invasive diagnostic and surgical techniques become standard in human medicine, the pet-owning public begins to expect similar services for their pets. Furthermore, progressive veterinarians are beginning to realize that endoscopy can be good business, as well as good medicine. Working together with endoscope manufacturing companies, veterinarians in academia and private practice have begun to drive development of products customized to the needs of small animal practice. Successful development of new endoscopic procedures and instrumentation will depend on continued effective communication between members of the veterinary profession and innovative industry partners.

## REFERENCES

1. Haubrich WS: History of endoscopy. In Sivak MV, editor: *Gastroenterologic endoscopy*, Philadelphia, 1987, WB Saunders.
2. Bozzini PH: Lichtleiter, Eine Erfindung zur Anschauung Innere Teile und Krankheiten, *J Prakt Heilk* 24:207, 1806.
3. Killian G: Zur Ceschichte der Oesophago- Und Gastroskopie, *Dtsch Z Chir* 58:499-512, 1901.
4. Nitze M: Beobachtungs und Untersuchungsmethode für Harnrohre Harnblase und Rectum, *Wien Med Wochenschr* 24:1651, 1879.
5. Kelling G: Ueber Oesophagoskopie, Gastroskopie, und Kolioskopie, *Munch Med Wochenschr* 49:21, 1902.
6. Jacobaeus HC: Ueber Laparo- und Thorakoskopie, *Beitr Kim Erforsch Tuberk* 25:183, 1912.
7. Jacobaeus HC: Ueber Die Moglichkeit Die Zystoskopie Bei Untersuchung Seroser Hohiungen Anzuwenden, *Munchen Med Wochenschr* 57:2090-2092, 1910.
8. Bernheim BM: Organoscopy; cystoscopy of the abdominal cavity, *Ann Surg* 53:764-767, 1911.
9. O'Brien JA: Bronchoscopy in the dog and cat, *J Am Vet Med Assoc* 156(2):213-217, 1970.
10. Dalton JFR, Hill FWG: A procedure for the examination of the liver and pancreas in dogs, *J Small Anim Pract* 13: 527-530, 1972.
11. Lettow E: Laparoscopic examination in liver diseases in dogs, *Vet Med Rev* 2:159-167, 1972.
12. Johnson GF, Jones BD, Twedt DC: Esophagogastric endoscopy in small animal medicine, *Gastrointest Endosc* 22:226, 1976.

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# 2 Anesthetic Considerations for Endoscopy

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Endoscopy is a rapidly advancing technique with applicability to many areas of veterinary medicine. Gastrointestinal endoscopy, arthroscopy, and bronchoscopy have become routine in many veterinary practices. Endoscopy has also been used less commonly in such procedures as otoscopy, fistuloscopy, laceroscopy, and oculoscopy. Integration of anesthesia and endoscopy is necessary for a successful procedure and may necessitate special anesthetic consideration for some endoscopic procedures.

## GENERAL CASE MANAGEMENT

As with any procedure requiring anesthesia, a thorough physical examination with appropriate blood work and diagnostics determines choice of anesthetic protocol. The general condition of the patient is considered, including ongoing disease processes that may or may not be related to the disorder necessitating endoscopic examination. Liver disease is often associated with gastrointestinal disease and can result in detoxification deficiencies, as well as deficiencies in synthesis of such substances as clotting factors and albumin. The nutritional status of the patient is optimized, and dehydration and acid-base disturbances are corrected before anesthesia is given. Renal function and excretion of drug metabolites may be affected by disease or by changes in systemic and renal hemodynamics.

Withholding food for 12 hours and water for 2 hours is recommended[1] and may help reduce the incidence of vomiting or regurgitation during the anesthetic period. However, prolonged preoperative fasting has been associated with an increased incidence of gastroesophageal reflux and increased gastric acidity.[2] Complete gastric emptying has been observed in dogs within 10 hours when they were fed canned meat-based food or dry cereal-based food,[3] with complete water emptying occurring in a mean time of 54 minutes.[4] To prevent hypoglycemia during or after anesthesia, the veterinarian should order a shorter fasting interval for animals younger than 3 months old[1] or for animals with impaired glucose metabolism.

Weight loss associated with chronic gastrointestinal or liver disease may result in a decrease in volume of distribution and protein binding and may affect the dosage requirement and duration of action of some drugs. The requirement for all anesthetic drugs is often decreased in these patients. Most notably, recovery from thiobarbiturates and, to a lesser extent, propofol is dependent on redistribution, so these drugs are used in reduced amounts.[4] Propofol undergoes both hepatic and extrahepatic metabolism and may be used in individuals with liver disease. Similarly, isoflurane undergoes minimal hepatic metabolism and may be the inhalation agent of choice for general anesthesia in patients with liver disease. In contrast, 50% to 70% of methoxyflurane and at least 10% to 25% of halothane may be metabolized by the liver.[5-7]

Anticholinergics may be administered to prevent secretions that may occur with instrumentation or as a drug side effect, although some clinicians may prefer to leave secretions unchecked and to use suction. Anticholinergics may also provide protection from bradycardia that may occur with endoscopic stimulation of the airways or visceral manipulation. In humans, however, protection from bradycardia during endoscopic examination is effected with atropine only when administered intravenously 5 minutes before the beginning of the procedure.[8]

## GASTROINTESTINAL ENDOSCOPY AND LAPAROSCOPY

Vomition or regurgitation and aspiration pneumonitis are potential complications with any general anesthesia, but particularly so for the patient that suffers from a gastrointestinal ailment that may be accompanied by vomiting.

Anticholinergics may decrease the acidity of gastric secretions[9] and reduce the severity of pneumonitis if aspiration of gastric contents occurs. However, no effect on gastric pH was observed in anesthetized dogs administered



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atropine or glycopyrrolate.[10] Anticholinergic drugs also interfere with the protective mechanism that prevents regurgitation by relaxing the gastroesophageal sphincter.[11,12] Although this may facilitate passage of the endoscope into the stomach, the potential for regurgitation and aspiration of gastric contents increases. Gastroesophageal sphincter pressure may also be lowered by morphine, meperidine, diazepam,[13] xylazine, and acepromazine.[12] Gastric barrier and gastroesophageal sphincter pressures are significantly lower in dogs anesthetized with propofol compared with pressures in dogs given thiopental.[14] Laryngeal and pharyngeal reflexes may be fairly well maintained after ketamine administration, but the swallowing reflexes may not be adequate to protect the airway in case regurgitation occurs.[15]

Regardless of anesthetic protocol, the goal of anesthesia induction with such patients is rapid intubation and cuff inflation to protect the airway and avoid aspiration of gastric contents. These patients should be held in sternal recumbency with head up until intubation and cuff inflation are accomplished. Because endoscopic examination of the upper gastrointestinal tract may stimulate regurgitation, maintenance of cuff inflation is imperative for airway protection and is checked periodically during the procedure.

Drugs that induce vomiting are avoided as premedications in animals with esophageal obstruction or gastric foreign bodies that could cause esophageal trauma during emesis. Xylazine premedication is commonly associated with emesis in cats and is occasionally associated with emesis in dogs. Xylazine administration is also associated with acute abdominal distention in large dogs as a result of aerophagia or parasympatholytic activity.[16] Morphine administration in dogs may result in nausea, vomiting, and defecation, followed by a slowing of gastrointestinal motility.[17] In addition, passage of the endoscope to the level of the proximal duodenum has been significantly hindered by preanesthetic medication with morphine and atropine in dogs anesthetized with halothane.[18] Vomiting and defecation have also been observed occasionally with oxymorphone and fentanyl administration. Acepromazine and other phenothiazine tranquilizers possess antiemetic properties[19] and may help prevent vomiting during the anesthetic period.

Nitrous oxide ($N_2O$) causes distention as it enters air spaces from the blood; it is avoided in individuals with gastrointestinal distention or pneumothorax and should not be used as part of the anesthetic regimen during procedures in which pneumothorax may occur. Pneumothorax may suddenly develop during esophagoscopy of the intrathoracic esophagus for removal of foreign bodies or dilation of esophageal strictures, and preparations are made for the sudden development of pneumothorax during these procedures.[4] It has been recommended that $N_2O$ not be included in the anesthetic regimen if it is used for insufflation during endoscopic examination of the stomach or abdomen.[20]

Gastrointestinal endoscopy and laparoscopy require insufflation with gas to facilitate visualization. $N_2O$ is preferred to avoid the possibility of fatal embolus associated with the use of air,[21,22] as well as alterations in the patient's acid-base balance associated with carbon dioxide ($CO_2$).[23] During surgical endoscopy procedures in which cautery is used, however, $CO_2$ is the insufflating gas of choice to prevent combustion. Pressure of the gas in the abdomen during laparoscopy should not exceed 20 mm Hg.[24] Decreases in cardiac output by more than 40% in the dog have occurred with intraabdominal pressures of 20 to 40 mm Hg produced with either $N_2O$ or $CO_2$.[25] Cranial displacement of the diaphragm occurs with distention of the stomach or abdomen and interferes with ventilation, often necessitating intermittent positive pressure ventilation. It has been suggested that minute ventilation is reduced by 30% with peritoneal insufflation during laparoscopy.[24] A reduction in tidal volume of 19% to 20% has been measured with 10– and 20–mm Hg insufflation pressure, whereas intraabdominal pressure of 30 mm Hg decreased tidal volume by 38%.[26]

Although regional anesthesia has been used successfully for laparoscopic examination in humans,[27] the restraint afforded with general anesthesia is more practical and recommended for veterinary patients. General anesthesia is also recommended for transurethral and percutaneous cystoscopy[28] and for vaginoscopy.

Intestinal distention of the colon or rectum during endoscopy can cause severe bradycardia and may interfere with ventilation.[4] With prolonged distention, retrograde movement of intestinal fluid followed by regurgitation may occur.[4]

Evaluation of intestinal function during endoscopy is performed with the awareness that anesthetic drugs may alter motility. Decreases in intestinal motility may occur with atropine,[29] xylazine,[29] meperidine,[17] butorphanol, and pentazocine.[30] Acepromazine may decrease electrical activity of the intestinal wall but increase volume transport.[31] Thiobarbiturates may increase both tonus and motility of the intestinal musculature after an initial depression of activity.[32] Halothane decreased motility of the stomach, jejunum, and colon in dogs, with contractions returning rapidly when administration was discontinued.[33] Ketamine does not alter intestinal activity.[34]

## RESPIRATORY ENDOSCOPY

General anesthesia is required for endoscopic examination of the respiratory tract.[35] A light plane of anesthesia may be best for assessing laryngeal function to avoid obscuring subtle abnormalities that may be hidden

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with deep anesthesia.[36] Thiopental,[37-39] propofol,[38] and diazepam-ketamine have been used to evaluate laryngeal function. In a study we conducted comparing thiopental, propofol, and diazepam-ketamine for assessing laryngeal function, thiopental seemed to provide the best exposure for examination while preserving laryngeal function.[40]

Preoxygenation with a mask is desirable in patients with respiratory disease or distress, if the mask is tolerated. Excitement should be minimized in these individuals during the induction period, and ventilatory support should be available in case of worsening respiratory distress. Chamber or mask inductions are avoided in patients with respiratory distress because there may be a delay in establishing a patent airway. $N_2O$ can significantly reduce the percentage of inspired oxygen and is also avoided in these individuals.[41]

For individuals in whom rapid access to the airway is of primary concern, no premedication and rapid ("crash") induction with a thiobarbiturate or propofol may be desirable. Rapid thiobarbiturate or propofol induction may result in hypotension, and cardiac dysrhythmias have been associated with rapid induction with thiobarbiturates. This type of induction is avoided in the individual whose condition indicates inability to tolerate such an induction. Dose-related apnea may also occur after rapid induction with a thiobarbiturate or propofol, and respiratory support is provided as needed.

General anesthesia may further depress respiration in an individual with an already compromised respiratory system,[41] and it may be best to delay administration of opioids in these individuals until appropriate respiratory support is provided.[8] There is a ceiling, however, to the amount of respiratory depression induced by some opioid agonist-antagonists, such as butorphanol.[42]

Isoflurane or sevoflurane are preferred for rapid recovery and return of pharyngeal and laryngeal reflexes. With halothane or isoflurane anesthesia, an increase in $Paco_2$ may be observed, bronchial smooth muscle tone may be reduced, a dose-related reduction in the ventilatory response to $CO_2$ may occur, and pulmonary oxygen transfer may be impaired.[43] Copious salivation associated with ketamine administration in the cat may complicate intubation and can be avoided by premedication with an anticholinergic. Apneustic breathing, decreased tidal volume, and increased respiration rate are characteristic responses to ketamine. End-tidal $CO_2$ may also increase, but ventilatory response to $CO_2$ remains high.[44] Airway resistance may be decreased, and bronchospasm may be abolished with ketamine administration.[45]

Intubation is not possible during examination of the upper airway or in small patients who require an endotracheal tube that is too small to allow passage of the endoscope. In these patients, anesthesia is maintained with injectable agents.[37-39] If examination of the lower airway is desired and if the patient is large enough for placement of an endotracheal tube that will allow passage of the endoscope, anesthesia may be maintained with gas anesthesia using a special swivel adaptor (Fig. 2-1) with a diaphragm that prevents leakage of anesthetic waste gases. In either situation, passage of the endoscope obstructs the airway and increases airway resistance, resulting in hypoventilation.[41] Endoscopic examination of the airway is performed rapidly to minimize the time of obstruction and hypoventilation, with supplemental oxygen available to relieve respiratory distress. When intubation is not possible, oxygen may be provided through the endoscope[41] or a separate catheter passed alongside the endoscope.[46] Oxygen administration is attempted only if there is room around the endoscope to allow escape of gas during exhalation to avoid lung barotrauma and the development of pneumomediastinum or pneumothorax. Passage of the endoscope may be facilitated in the cat by anesthetizing the larynx with lidocaine topically to prevent laryngospasm.[41] Xylazine also relaxes the larynx and facilitates passage of the endoscope.[47] Adverse effects observed in humans during bronchoscopy include decreased $Pao_2$, increased $Paco_2$, cardiac dysrhythmias, and transient positive end-expiratory pressure that may cause barotrauma.[48,49]

Endoscopic examination of the upper airway or upper gastrointestinal tract, such as rhinoscopy, tracheoscopy, pharyngoscopy, or esophagoscopy, may result in bleeding into the pharynx and trachea, which poses an aspiration hazard for the patient. Similarly, flushing with fluid during the endoscopic examination may result in fluid accumulation in the pharynx and trachea and possible aspiration. The importance of an adequately inflated endotracheal tube cuff during these procedures cannot be overemphasized. General anesthesia may be difficult to




**Fig. 2-1**
A swivel adaptor that allows simultaneous ventilation and bronchoscopy.

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maintain during rhinoscopy because of the sensitivity of the area to any type of stimulus; additional anesthesia or analgesia and positive pressure ventilation may be needed. Epistaxis can be a major complication of rhinoscopy.[36] Pneumothorax or hemoptysis can occur as a result of biopsies or physical damage caused by the endoscope[41] and should be anticipated. Appropriate support for ventilation and suction should be available. Blood and other fluids or debris are removed by suction before extubation to prevent aspiration. Extubation is delayed until the swallowing reflex is present. The head is lowered and the cuff should remain inflated while extubating to "sweep out" any remaining material. Bleeding from the airway should be controlled and removed with suction before extubation. Postrhinoscopy sedation may be desirable to help reduce sneezing and bleeding but is administered cautiously to avoid interfering with the patient's ability to protect the airway. The patient is monitored frequently during recovery for complications such as respiratory distress, hemoptysis, or excessive bleeding.

Administration of corticosteroids and tracheostomy are considered to relieve obstruction if swelling is anticipated after endoscopic examination of the airway.[1]

## THORACOSCOPY

Thoracoscopy is less invasive than thoracotomy. In fact, some thoracoscopic procedures are performed in human patients without general anesthesia. However, for the procedures that are performed in veterinary medicine and with the equipment that is available, thoracoscopy requires general anesthesia in veterinary patients. Because animals that require diagnostic or therapeutic thoracoscopy may be predisposed to cardiopulmonary instability as a result of their disease process, and because the anesthetic drugs and techniques themselves are likely to cause some cardiopulmonary dysfunction, it is important for the practitioner to evaluate patients carefully before giving anesthesia. In addition, it is important to monitor patients carefully during the procedure to avoid morbidity or mortality.

Thoracoscopic procedures can be performed using a variety of sedative, analgesic, induction, and maintenance anesthetic drugs. For the most part, the choice of anesthetic drugs is dictated by the condition of the animal, not by the procedure being performed. However, management of both thoracotomy and thoracoscopy may include the need to abolish spontaneous ventilatory movement. Thus, neuromuscular blocking drugs (NMBs) are often used in the anesthetic management of patients undergoing thoracoscopy. In veterinary medicine, NMBs are typically administered after induction of anesthesia, intubation of the patient, and initiation of mechanical ventilation. It is important that veterinarians assess the efficacy of NMBs during a procedure and especially at the conclusion of a procedure and before withdrawal of anesthesia or ventilatory support. If ventilatory support is discontinued before termination of NMB effects, life-threatening hypoxemia and hypercapnia may occur. The presence of spontaneous respiratory movements is an indication that NMB activity is diminished. However, a more objective evaluation is obtained using a peripheral nerve stimulator positioned to stimulate the peroneal or ulnar nerve.[50] Many different stimulation patterns can be used to assess neuromuscular blockade, but train-of-four and double-burst stimulation are used most commonly in our practice.

NMBs are classified as depolarizing or nondepolarizing.[51] Depolarizing NMBs work by activating the nicotinic acetylcholine receptor of the muscular endplate.[51] As a result of activation, muscle depolarization and fasciculation may be observed after administration of this class of NMBs. Prolonged receptor activation by the NMB results in desensitization of the nicotinic acetylcholine receptor and muscle paralysis. Succinylcholine is an example of a depolarizing NMB. Although the drug has a rapid onset of action, its administration is associated with significant cardiovascular effects and cannot be reversed.[50,51]

Nondepolarizing NMBs are used more frequently than succinylcholine in small animal veterinary medicine. They act primarily by preventing interaction of acetylcholine with nicotinic acetylcholine receptors at muscle endplates.[51] The action of nondepolarizing NMBs may be reversed by administration of cholinesterase inhibitors (i.e., neostigmine and edrophonium).[50] Anticholinergic drugs may be administered before the anticholinesterase inhibitors to prevent bradycardia, bronchoconstriction, and increased production of oral and respiratory secretions associated with the muscarinic effects of cholinesterase inhibition.[51]

Atracurium is a nondepolarizing NMB with a short (i.e., 15 to 30 min) duration of action in dogs and cats. A significant percentage of the administered dose of this compound undergoes nonenzymatic breakdown (Hoffmann elimination). Some of the administered dose may be eliminated unchanged in the urine, and enzymatic metabolism occurs in and outside the liver. As a result of multiple elimination pathways, the duration of action of atracurium is minimally affected by diminished liver and kidney function.[51] Although atracurium may induce histamine release and cause hypotension, these effects are infrequently seen at clinical doses.[51] The combination of short duration of action, reversibility, relative independence of hepatic and renal metabolism, and hemodynamic stability make atracurium a popular choice with veterinary anesthesiologists. Cisatracurium is a stereoisomer of atracurium that is approved for use in humans. Cisatracurium has the same positive attributes as atracurium and does not

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induce histamine release in animals. Pancuronium and vecuronium are two chemically related nondepolarizing muscle relaxants.[51] Pancuronium bromide has a longer duration of action than atracurium, and administration may be associated with increased heart rate, blood pressure, and cardiac output as a result of vagolytic action and increased norepinephrine release.[51,52] Vecuronium is devoid of these cardiovascular effects and has a shorter duration of action than pancuronium. Doxacurium chloride, mivacurium, and rocuronium are other newer nondepolarizing NMBs that may be used to evoke muscle relaxation in dogs or cats.[51]

Thoracoscopy may be performed with or without collapsing the lung in the operative thorax. When the lungs are conventionally intubated, and in the presence of an open thorax, prolonged and complete deflation of the lungs does not occur. This management technique is identical to that used for most thoracotomies and is the simplest from the viewpoint of anesthetic management. However, conventional ventilation with an open thorax may make the surgical procedure more technically difficult to perform because the lung on the operative side of the thorax inflates with each ventilatory cycle. The movement of the lung may interfere with surgical manipulations, and the inflated lung may limit intrathoracic visualization.

In procedures in which deflation of lung in the operative thorax is necessary, selective intubation of the dependent lung or sustained pneumothorax may be used. One-lung ventilation is frequently used during thoracoscopy in humans.[53] The technique allows collapse of the lung in the operative hemithorax, increased field of view, and easier tissue manipulation compared with conventional two-lung ventilation.[54] One-lung ventilation is also indicated in patients with lung abscesses to prevent blood or exudates from spilling into the noninvolved lung from the operative lung.[53] In addition, one-lung ventilation is used to prevent ventilation of a specific region of lung with a localized problem (bulla, cyst, or bronchopleural fistula).[53]

One-lung ventilation is accomplished in humans using a double-lumen endotracheal tube, endobronchial tubes, or bronchial blockers.[53] Double-lumen tubes and endobronchial tubes are not easily adapted to veterinary use, but bronchial blockers have been used to isolate a single lung during anesthesia in the dog.[55] A single-lumen tube with an integrated bronchial blocker may be used in veterinary patients (Univent tube, Fuji Systems Inc., Tokyo). The system consists of a cuffed endotracheal tube that has a channel in the tube wall for insertion of an inflatable bronchial blocker. The Univent tube is inserted into the trachea using a conventional laryngoscope and an orotracheal approach. The cuff is inflated, oxygen is administered, and the patient is ventilated. A fiberoptic bronchoscope is then used to direct placement of the bronchial blocker. The bronchial blocker of the Univent tube is advanced through the accessory lumen of the Univent tube and manipulated to occlude the desired (operative) lung. The concavity of the main tube can be used to direct the advancing blocker.[53] The blocker is inflated to just occlude the operative lung and the bronchoscope withdrawn. A conventional endotracheal tube and a Fogarty embolectomy catheter may also be used in a manner similar to the Univent tube, but with the bronchial blocker (Fogarty catheter) inserted down the main lumen of the endotracheal tube or alongside the endotracheal tube.[53,54]

Once isolated, the operative lung can be collapsed by one of two methods: (1) positive pressure may be applied to the pleural space (forced pneumothorax) before inflation of the bronchial blocker or (2) the lumen of the bronchial blocker can be connected to a suction device to deflate the operative lung.[53,54]

The cardiopulmonary response to one-lung ventilation differs from that seen during conventional mechanical ventilation. Cantwell and co-workers investigated the hemodynamic effects of one-lung ventilation in halothane-anesthetized dogs.[55] Dogs were ventilated to a tidal volume of 10 ml/kg and at a frequency that maintained end-tidal $CO_2$ tension at 40 mm Hg before isolation of the left lung by bronchial blocker placement. Heart rate, mean arterial pressure, and arterial $CO_2$ tension increased moderately during one-lung ventilation. Arterial oxygen tension was decreased during one-lung ventilation, but clinically significant hypoxemia was not observed. Finally, Cantwell and colleagues observed that end-tidal $CO_2$ measurements did not reflect arterial $CO_2$ tension during one-lung ventilation.[55]

As discussed previously, one-lung ventilation increases the surgeon's field of view compared with conventional ventilation, and it may have less of an effect on blood flow compared with conventional ventilation with sustained pneumothorax.[53,56] Even so, one-lung ventilation carries certain risks. Bronchial rupture can result from overinflation of a cuff or malpositioning of the tube. Malpositioning of the tube may also result in hypoventilation and hypoxemia. Careful tube or bronchial blocker placement using bronchoscopic visualization decreases risk of malpositioning or bronchial trauma. However, even with bronchoscopic visualization, one-lung ventilation in dogs may be problematic because of early lobar branching. Additionally, specialized tubes designed specifically for dogs are not commercially available. Finally, proper placement of the bronchial blocker requires time and the use of a fiberoptic bronchoscope.

As an alternative to one-lung ventilation, two-lung ventilation with sustained pneumothorax can be used to provide working space for thoracoscopic procedures without the time required for bronchoscopic placement of

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an endobronchial tube or bronchial blocker. Sustained pneumothorax is attained by insufflation of the pleural space with gas (usually $N_2O$ or $CO_2$) to a pressure greater than atmospheric pressure. Airtight instrument and camera ports must be used to sustain positive intrapleural pressure. Conventional ventilation with sustained pneumothorax has been used during thoracoscopy when one-lung ventilation failed or was considered too dangerous.[54] The major concern associated with two-lung ventilation and sustained pneumothorax is cardiopulmonary compromise associated with sustained positive intrapleural pressure used to provide adequate field of view and working space. Indeed, application of conventional ventilation and sustained pneumothorax ($CO_2$ insufflation gas) was associated with decreased cardiac index and mean arterial pressure in pigs anesthetized with pentobarbital/isoflurane.[56] In contrast, conscious dogs tolerated up to 150% of lung volume in the pleural space without significant change in mean arterial pressure, heart rate, or cardiac index.[57] More importantly, we have observed that healthy anesthetized dogs had increased cardiac output and mean arterial blood pressure during conventional ventilation, sustained pneumothorax with $N_2O$, and thoracoscopic lung biopsy.[58] Conventional mechanical ventilation was used to ventilate these animals at a rate of 14 breaths/min and a tidal volume of 10 ml/kg. Although oxygen tension decreased in these animals, desaturation of hemoglobin did not occur. Mixed venous oxygen tension was also maintained during thoracoscopy with conventional intubation, ventilation, and sustained pneumothorax with $N_2O$. Moreover, visualization of thoracic structures was adequate for lung biopsy, and this approach has also been used for thoracoscopic pericardial window surgeries.[59] However, because these investigations were done in healthy dogs without preexisting respiratory or cardiovascular problems, it is prudent to use conventional mechanical ventilation and sustained pneumothorax only for those patients undergoing short procedures, and with normal cardiopulmonary stability and function before thoracoscopy.

One of the most important aspects of anesthetic management for thoracoscopy is patient assessment. Indeed, many anesthetic changes may be made intraoperatively that will influence the outcome of the procedure, and information provided by respiratory and cardiovascular monitoring is extremely important in that decision-making process. Because oxygenation and ventilation are likely to be compromised in patients with thoracic disease during thoracoscopy, this chapter discusses assessment of oxygenation and ventilation during anesthesia.

## Oxygenation

$Pa_{O_2}$ is used to assess lung function and delivery of oxygen to tissues. Normal $Pa_{O_2}$ when breathing room air (21% $O_2$) is approximately 100 mm Hg. Because of the shape and position of the oxygen-hemoglobin dissociation curve, hemoglobin saturation at this $Pa_{O_2}$ is approximately 100%. As $Pa_{O_2}$ decreases below the normal (hypoxemia), desaturation of hemoglobin occurs, and decreased arterial blood oxygen content is observed.[60]

During anesthesia, when patients are given 100% oxygen, $Pa_{O_2}$ is expected to be approximately 500 mm Hg. During thoracoscopy, and especially during thoracoscopy in animals with pulmonary or cardiovascular disease, $Pa_{O_2}$ is likely to decrease well below the ideal, even with administration of 100% oxygen. The primary reason for decreased $Pa_{O_2}$ is decreased gas exchange efficiency as a result of physiologic shunt. Indeed, Cantwell and colleagues and Faunt and co-workers showed that $Pa_{O_2}$ is decreased below expected levels during one-lung ventilation or during two-lung ventilation with thoracoscopy, respectively.[55,58]

## Pulse Oximetry

Pulse oximeters combine spectrophotometry with plethysmography and work on the principle that the absorbance characteristics of hemoglobin change when oxygen is bound by the hemoglobin molecule.[61] The instrument detects pulsatile flow using an optical probe and calculates the percent functional saturation of hemoglobin in arterial blood ($Sp_{O_2}$):

$$\frac{\text{oxyhemoglobin}}{(\text{oxyhemoglobin} + \text{deoxyhemoglobin})} \times 100$$

Pulse oximeters monitor $Sp_{O_2}$ continuously, do not require calibration before use, and are noninvasive. For these reasons, this instrument is a valuable monitoring tool during thoracoscopy. The accuracy and reliability of a pulse oximeter is adversely affected by methemoglobinemia, carboxyhemoglobinemia, skin pigmentation, peripheral vasoconstriction, motion, optical interference, and electrical interference.[61,62] Measurements are usually made during anesthesia using a transmittance probe placed across the tongue, although reflectance probes have been developed for esophageal or rectal use.[62]

## Carbon Dioxide

$CO_2$ is produced in the mitochondria during aerobic metabolism, diffuses into the capillary venous blood, and is eliminated by ventilation in the lungs. $CO_2$ is transported in solution, as bicarbonate ion or carbonic acid, or bound to plasma proteins or hemoglobin.[60] Although dissolved $CO_2$ accounts for only 10% of the total $CO_2$ content in blood, it is the only form routinely and directly measured and it is the only form permeable to membranes.[60] Moreover, it is this fraction that participates in determining the pressure gradient between blood and alveolar air or between blood and tissue.

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$Paco_2$ is influenced by two factors: ventilation and $CO_2$ production (metabolic rate).[60] $CO_2$ production may be influenced by body temperature, physical activity, shivering, endocrine alterations (i.e., hyperthyroidism, catecholamine release), malignant hyperthermia, and parenteral nutrition with solutions containing high glucose concentrations. In most circumstances, $CO_2$ production (metabolism) is relatively constant and inspired gas is devoid of significant $CO_2$ content.

Alveolar ventilation is effective ventilation and removes $CO_2$ from the body. Dead space ventilation, on the other hand, is wasted ventilation. It is composed of gases that remain in airways during the respiratory cycle (anatomic dead space), gases from ventilated nonfunctional alveoli (alveolar dead space), and gases from portions of the anesthetic circuit where two-way flow of gas or rebreathing may occur (apparatus dead space). If alveolar ventilation is in excess of metabolic production, hypocapnia ($Paco_2$ < 35 mm Hg) results. Voluntary hyperventilation (e.g., resulting from pain or anxiety), iatrogenic hyperventilation (a consequence of overzealous mechanical or manual ventilation), hypoxemia, hypotension, and metabolic acidosis can all cause hypocapnia. Hypercapnia ($Paco_2$ > 45 mm Hg) defines alveolar hypoventilation and may be caused by central nervous system depression (e.g., anesthetic drugs, central nervous system trauma), paralysis or damage of the muscles of ventilation (e.g., from NMBs), disruption of thoracic wall integrity (e.g., flail chest), respiratory failure, or malignant hyperthermia.

Capnography is a noninvasive method of estimating $Paco_2$.[61] Normally, peak expired $CO_2$ tension (end-tidal $CO_2$) correlates closely with $Paco_2$, but it is about 5 mm Hg less.[61] Changes in ventilatory status, anesthetic circuit function, and cardiovascular performance may all be detected by monitoring exhaled $CO_2$. However, capnography is not a reliable method of estimating arterial $CO_2$ tension during thoracoscopy. Cantwell and colleagues found that expired $CO_2$ tension did not correlate with $Paco_2$ during one-lung ventilation.[55] Similarly, Faunt and co-workers observed that alveolar dead space increased significantly during conventional ventilation and thoracoscopy.[58] Thus assessment of $Paco_2$ using blood-gas analysis is the preferred method of assessing adequacy of ventilation during thoracoscopy.

## Postoperative Pain Control

The control of pain after thoracotomy is a challenging and often unsuccessful endeavor. In contrast, recovery period after minimally invasive thoracoscopic procedures can be relatively pain-free and uncomplicated with proper management. The use of preoperative, intraoperative, and postoperative opioids is the cornerstone of many pain management programs. Full μ-receptor agonists such as morphine, oxymorphone, and fentanyl provide significant analgesia after administration, but they may be associated with significant respiratory depression.[63] Their use necessitates careful postoperative observation. Because of the noninvasive nature of thoracoscopy, opioid partial agonists or agonist-antagonists are often sufficient to control postoperative pain. Buprenorphine is a partial μ-receptor agonist that provides moderate pain relief and is associated with minimal respiratory depression.[63] Butorphanol is likewise effective for treating mild to moderate pain and has minimal respiratory depressant effects, but its short duration of action in the dog necessitates frequent administration for effective analgesic therapy.[63]

The administration of local anesthetic drugs is also an effective way to treat postthoracoscopy pain.[64] We routinely perform intercostal nerve blocks dorsal to the entrance sites of all instrument and camera ports. In fact, the camera can be used to facilitate placement of local anesthetic drugs in close proximity to the intercostal nerves. We use bupivacaine in our patients as it has a relatively long (6-hour) duration of action. Total dose should not exceed 1 mg/kg in dogs or cats.

Nonsteroidal antiinflammatory drugs (NSAIDs) may also be used to treat postoperative pain. Most currently available NSAIDs are associated with significant gastrointestinal, renal, and hemostatic side effects. The newer, less toxic NSAIDs may prove to be extremely valuable in the perioperative period because they can obtund pain without causing significant cardiopulmonary depression.

## REFERENCES

1. Trim CM: Anesthetic considerations of the gastrointestinal tract. In Short CE, editor: *Principles of veterinary anesthesia*, Baltimore, 1987, Williams & Wilkins.
2. Galatos AD, Raptopoulos D: Gastro-oesophageal reflux during anaesthesia in the dog: the effect of preoperative fasting and premedication, *Vet Rec* 13:479-483, 1995.
3. Burrows EF, Bright RM, Spencer CP: Influence of dietary composition on gastric emptying and motility in dogs: potential involvement in acute gastric dilatation, *Am J Vet Res* 46:2609-2612, 1985.
4. Leib MC and others: Gastric emptying of liquids in the dog: serial test meal and modified emptying-time techniques, *Am J Vet Res* 46:1876-1880, 1985.
5. Holaday DA, Rudofsky S, Treuhaft PS: The metabolic degradation of methoxyflurane in man, *Anesthesiology* 33: 589-593, 1970.
6. Rehder K and others: Halothane biotransformation in man: a quantitative study, *Anesthesiology* 28:711-715, 1967.
7. Holaday DA and others: Resistance of isoflurane to biotransformation in man, *Anesthesiology* 43:325-332, 1975.
8. Donlon JV: Anesthesia for eye, ear, nose, and throat. In Miller RD, editor: *Anesthesia*, ed 2, New York, 1986, Churchill Livingstone.

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9. Short CE: Anticholinergics. In Short CE, editor: *Principles and practice of veterinary anesthesia*, Baltimore, 1987, Williams & Wilkins.
10. Roush JK and others: Effects of atropine and glycopyrrolate on esophageal, gastric, and tracheal pH in anesthetized dogs, *Vet Surg* 19:88-92, 1990.
11. Brock-Utne JF and others: The effect of glycopyrrolate (Robinul) on the lower oesophageal sphincter, *Can Anaesth Soc J* 25:144, 1978.
12. Strombeck DR, Harrold D: Effects of atropine, acepromazine, meperidine, and xylazine on gastroesophageal sphincter pressure in the dog, *Am J Vet Res* 46:963-965, 1985.
13. Hall AW and others: The effects of premedication drugs on the lower oesophageal high pressure zone and reflux status of Rhesus monkeys and man, *Gut* 16:347, 1975.
14. Waterman AE, Hashim MA: Effects of thiopentone and propofol on lower oesophageal sphincter and barrier pressure in the dog, *J Small Anim Pract* 33:530-533, 1992.
15. Wright M: Pharmacologic effects of ketamine and its use in veterinary medicine, *J Am Vet Med Assoc* 180:1462-1470, 1982.
16. Booth NH: Non-narcotic analgesics. In Booth NH, McDonald LE, editors: *Veterinary pharmacology and therapeutics*, ed 5. Ames, 1982, Iowa State University Press.
17. Sawyer DC: Use of narcotics and analgesics for pain control. Proceedings from the AAHA 52nd Annual Meeting, Orlando, March 1985.
18. Donaldson LL and others: Effect of preanesthetic medication on ease of endoscopic intubation of the duodenum in anesthetized dogs, *Am J Vet Res* 54:1489-1495, 1993.
19. Smith TC, Wollman H: History and principles of anesthesiology. In Filman AG, Goodman LS, Hall TW, Murad F, editors: *The pharmacological basis of therapeutics*, ed 7, New York, 1985, Macmillan.
20. Steffey EP, Gauger GE, Eger EI: Cardiovascular effects of venous air embolism during air and oxygen breathing, *Anesth Analg* 53:599-604, 1974.
21. Gilroy BA, Anson LW: Fatal air embolism during anesthesia for laparoscopy in a dog, *J Am Vet Med Assoc* 190:552-554, 1987.
22. Thayer GW, Carrig CB, Evans TE: Fatal venous air embolism associated with pneumocystography in a cat, *J Am Vet Med Assoc* 176:643-645, 1980.
23. Baratz RA, Karis JG: Blood gas studies during laparoscopy under general anesthesia, *Anesthesiology* 30:463-464, 1969.
24. Jones BD, Hitt M, Hurst T: Hepatic biopsy. In Jones BD, editor: *Veterinary clinics of North America small animal practice: veterinary endoscopy*, Philadelphia, 1985, WB Saunders.
25. Ivankovich AD and others: Cardiovascular effects of intraperitoneal insufflation with carbon dioxide and nitrous oxide in the dog, *Anesthesiology* 42:281-287, 1975.
26. Gross ME and others: The effects of abdominal insufflation with nitrous oxide on cardiorespiratory parameters in spontaneously breathing isoflurane-anesthetized dogs, *Am J Vet Res* 54:1352-1358, 1993.
27. Ciofolo MJ and others: Ventilatory effects of laparoscopy under epidural anesthesia, *Anesth Analg* 70:357-361, 1990.
28. McCarthy TC, McDermaid SL: Cystoscopy. In Jones BD, editor: *Veterinary clinics of North America small animal practice: veterinary Endoscopy,* Philadelphia, 1990, WB Saunders.
29. Hsu WH, McNeel SV: Effect of yohimbine on xylazine-induced prolongation of gastrointestinal transit in dogs, *J Am Vet Med Assoc* 183:297-300, 1983.
30. Sojka JE, Adams SB, Lamar CH: The effect of two opiate agonist-antagonists on intestinal motility in the pony (abstract). Second Equine Colic Research Symposium, Athens, GA, 1985.
31. Davies JV, Gerring EL: Effect of spasmolytic analgesic drugs on the motility patterns of the equine small intestine, *Res Vet Sci* 34:334-339, 1983.
32. Booth NH: Intravenous and other parenteral anesthetics. In Booth NH, McDonald LE, editors: *Veterinary pharmacology and therapeutics*, ed 5. Ames, 1982, Iowa State University Press.
33. Marshall FTV, Pittinger CB, Long JP: Effects of halothane on gastrointestinal motility, *Anesthesiology* 22:363-366, 1961.
34. Healy TEJ and others: Effect of some IV anaesthetic agents on canine gastrointestinal motility, *Br J Anaesth* 53: 229-233, 1981.
35. McKiernan BC: Lower respiratory tract diseases. In Ettinger SJ, editor: *Textbook of veterinary internal medicine: diseases of the dog and cat*, ed 2, Philadelphia, 1983, WB Saunders.
36. Roudebush P: Diagnostics for respiratory diseases. In Kirk RW, editor: *Current veterinary therapy*, ed 8, Philadelphia, 1983, WB Saunders.
37. Greenfield CL: Canine laryngeal paralysis, *Comp Contin Educ Pract Vet* 9:1011-1020, 1987.
38. LaHue TR: Laryngeal paralysis, *Semin Vet Med Surg (Small Anim)* 10:94-100, 1995.
39. Gaber CE, Amis TC, LeCouteur RA: Laryngeal paralysis in dogs: a review of 23 cases, *J Am Vet Med Assoc* 186: 377-380, 1985.
40. Gross ME and others: A comparison of thiopental, propofol, and diazepam-ketamine anesthesia for evaluation of laryngeal function in dogs premedicated with butorphanol-glycopyrrolate, *J Amer Anim Hosp Assoc* 38:503-506, 2002.
41. Riedesel DH: Diagnostic or experimental surgical procedures. In Short CE, editor: *Principles and practice of veterinary anesthesia*, Baltimore, 1987, Williams & Wilkins, 1987.
42. Nagashima H and others: Respiratory and circulatory effects of intravenous butorphanol and morphine, *Clin Pharmacol Ther* 19:738-745, 1976.
43. Marshall BE, Wollman H: General anesthetics. In Gilman AG, Goodman LS, Hall TW, Murad F, editors: *The pharmacologic basis of therapeutics*, ed 7, New York, 1985, Macmillan.


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44. Jaspar N and others: Effect of ketamine on control of breathing in cats, *J Appl Physiol* 55:851-859, 1983.
45. Bovill JF and others: Some cardiovascular effects of ketamine in man, *Br J Pharmacol* 41:411-412, 1971.
46. Landa JF: Bronchoscopy: general considerations. In Sackner MA, editor: *Diagnostic techniques in pulmonary disease*, vol 16, New York, 1980, Marcel Dekker.
47. Gleed RD: Tranquilizers and sedatives. In Short CE, editor: *Principles and practice of veterinary anesthesia*, Baltimore, 1987, Williams & Wilkins.
48. Lindholm CE and others: Cardiorespiratory effects of flexible fiberoptic bronchoscopy in critically ill patients, *Chest* 74:362-368, 1978.
49. Shrader DL, Lakshminarayan S: The effect of fiberoptic bronchoscopy on cardiac rhythm, *Chest* 73:821-824, 1978.
50. Cullen LK: Muscle relaxants and neuromuscular blockade. In Thurmon JC, Tranquilli WJ, Benson GH, editors: *Lumb & Jones veterinary anesthesiology*, ed 3, Baltimore, 1996, Williams & Wilkins.
51. Adams HR: Neuromuscular blocking agents. In Adams HR, editor: *Veterinary pharmacology and therapeutics*, ed 7, Ames, 1995, Iowa State University Press.
52. Reitan JA, Warpinske MA: Cardiovascular effects of pancuronium bromide in mongrel dogs, *Am J Vet Res* 36: 1309-1311, 1975.
53. Benumof JL, Alfery DD: Anesthesia for thoracic surgery. In Miller RD, editor: *Anesthesia*, ed 4, New York, 1994, Churchill Livingstone.
54. Hasnain JU, Keasna MJ: Anesthetic, equipment, and pathophysiologic considerations of thoracoscopic surgery. In Bailey R, editor: *Complications of thoracoscopic surgery*, St Louis, 1994, QMP.
55. Cantwell SL and others: One-lung versus two-lung ventilation in dogs: comparison of cardiopulmonary parameters, *Vet Surg* 29:365-373, 2001.
56. Jones D and others: Effects of insufflation on hemodynamics during thoracoscopy, *Ann Thoracic Surg* 55:1379-1382, 1993.
57. Bennett RA and others: Cardiopulmonary changes in conscious dogs with induced progressive pneumothorax, *Am J Vet Res* 50:280-284, 1989.
58. Faunt KK and others: Cardiopulmonary effects of bilateral hemithorax ventilation and diagnostic thoracoscopy in dogs, *Am J Vet Res* 59:1494-1498, 1998.
59. Faunt KK and others: Evaluation of biopsy specimens obtained during thoracoscopy from lungs of clinically normal dogs, *Am J Vet Res* 59:1499-1502, 1998.
60. West JB: *Respiratory physiology—the essentials*, ed 5, Baltimore, 1995, Williams & Wilkins.
61. Moon RE, Campmoresi EM: Respiratory monitoring. In Miller RD, editor: *Anesthesia*, ed 4, New York, 1994, Churchill Livingstone.
62. Haskins SC: Monitoring the anesthetized patient. In Thurmon JC, Tranquilli WJ, Benson GJ, editors: *Lumb & Jones' veterinary anesthesia*, ed 3, Baltimore, 1996, Williams & Wilkins.
63. Thurmon JC, Tranquilli WJ, Benson GJ: Preanesthetics and anesthetic adjuncts. In Thurmon JC, Tranquilli WJ, Benson GJ, editors: *Lumb & Jones' veterinary anesthesia*, ed 3, Baltimore, 1996, Williams & Wilkins.
64. Skarda RT: Local and regional anesthetic and analgesic techniques. In Thurmon JC, Tranquilli WJ, Benson GJ, editors: *Lumb & Jones' veterinary anesthesia,* ed 3, Baltimore, 1996, Williams & Wilkins.

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# 3 Endoscopic Biopsy Handling and Histopathology

*Beth A. Valentine*

This section describes the ideal sample handling techniques (and pitfalls) for pathologic evaluation of endoscopic biopsies and briefly describes the characteristic pathologic findings in various disorders in which endoscopic biopsy may be used.

## SOURCES OF ERROR

There are sources of error inherent in the evaluation of any biopsy sample. *Sampling error* can occur when samples are not representative of the lesion, such as when areas of superficial necrosis and inflammation are sampled rather than an underlying neoplasm or when too little tissue is available for pathologic evaluation. *Handling error* can occur at the time of biopsy (most often distortion of tissue after crush) or after surgery when samples are not fixed immediately, are not fixed properly, or are inadvertently lost. *Processing error* occurs in the histology laboratory when samples are improperly oriented during embedding or when procedures are not followed to ensure that small samples are not lost. Even though other sources of error may account for an inability to make a diagnosis or for giving an incorrect interpretation of the tissue changes, it has been my humbling experience that the most common source of error in histopathology is an error in interpretation. If the histopathologic interpretation does not seem to fit well with the clinical findings, one should not hesitate to call the pathologist to discuss the problem. A bit more clinical or clinicopathologic information may be just enough to help the pathologist make a more accurate diagnosis or differential diagnosis list. Do not hesitate to ask for second opinions. Simply looking at the slide again the next morning can be an eye-opening experience, and I often marvel at the apparent ability of fixed and processed tissue sections to "alter themselves" overnight (Box 3-1).

A study by Willard and colleagues[1] found a disturbingly high degree of interobserver variation when different pathologists viewed the same intestinal biopsy slides. The study concluded that better standards for interpretation of changes in intestinal samples from dogs and cats are needed. For interpretation of endoscopic biopsies, as well as for other samples, it is important for the clinician to establish a working relationship with a single or a small group of pathologists whose findings generally contribute positively to patient management and outcome, and who are available for consultation when needed.

## BIOPSY HANDLING

Endoscopic biopsies include mucosal, solid organ, mass lesion, and intraarticular samples. Techniques for optimum processing and interpretation vary depending on the type of sample. In all cases, samples should be carefully teased out from the biopsy instrument, using a fine-pointed instrument such as a needle and a gentle handling technique (Fig. 3-1 and Box 3-2).

### Mucosa

Samples of mucosa from the respiratory, gastrointestinal, or urogenital system are commonly obtained in veterinary practice. For adequate histopathologic interpretation, proper orientation of the samples is vital. For example, sectioning of samples to include only the superficial mucosal layer does not allow for adequate evaluation of villous structure or crypt lesions in small intestinal mucosa. Inappropriate sectioning may miss deeper areas of inflammation or neoplasia.

It may be difficult for the pathologist or histotechnologist to determine the orientation of mucosal samples

**Box 3-1 Sources of Error**

Sampling
Handling
Processing
Interpretation



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**Fig. 3-1**
Gently tease the sample out of the biopsy instrument using a needle or other fine-pointed object. *(Courtesy Dr. Timothy McCarthy.)*

floating freely in a container of formalin. Although simply placing samples into a formalin-filled container may be faster at the time of surgery, taking the time to ensure proper orientation of samples greatly improves diagnostic accuracy. Nasal mucosal biopsies are less of a problem in this respect, in that turbinates are highly folded and biopsy samples typically contain mucosa on more than one surface.

Mucosal samples from the gastrointestinal and urogenital systems are much more problematic. Special procedures to ensure that samples are oriented such that the full thickness of the sample is evaluated histopathologically are vital. The ideal technique (1) keeps mucosal samples from curling up, (2) provides a flat surface and identifies the deep edge of the sample such that each sample can be embedded on edge at the laboratory to ensure a full-thickness section, and (3) preserves mucosal integrity. Several such procedures have been described.

Some authors advocate placement of mucosal samples on a specially prepared slice of cucumber, which can then be fixed and processed, cucumber and all.[2] Although this technique works, there are other, less cumbersome techniques.

**Box 3-2 General Comments**

By their nature, endoscopic biopsies are small.
More is always better.
Obtain samples from multiple areas of a lesion.
If it is important, separate samples obtained from different sites and label them.
Handle samples gently.
Do not place small samples into a blood tube or other narrow, deep container.
For mucosal biopsies, optimize the ability to orient them properly (see text).

Some pathologists prefer samples be placed muscularis side down on a piece of wooden tongue depressor, which is then placed in the container of formalin.[3] The disadvantage is that samples need to be lifted from the tongue depressor before paraffin infiltration, which risks handling artifact.

Another technique is to obtain the plastic tissue cassettes used for preparation of paraffin tissue blocks, along with the plastic foam sponges that are often used by laboratories to ensure that small samples are not lost through the holes of the cassette. Mucosal samples are placed, muscularis side down, between the two sponges in the cassette, ready to process.[2] Although this procedure seems to provide a convenience to laboratory personnel, it has been the experience of a colleague, Dr. Peter Rowland, that this procedure often results in undesirable tissue crush injury.[3]

Placement of mucosal biopsies, muscularis side down, on a single plastic sponge and gently floating the sponge in formalin, sample side down, rather than placing it in a cassette, is an acceptable method of mucosal biopsy submission.[4] This method was used at a veterinary teaching hospital where samples were delivered by hand to the laboratory; however, it is not clear whether samples would remain on the sponge during shipment to a laboratory.

The handling technique that has worked best in my hands is to place mucosal samples, mucosal surface up and muscularis side down, on a piece of filter paper (Fig. 3-2), then placing the paper on a rigid object such as a portion of tongue depressor. Samples tend to stick to the filter paper. Then the tongue depressor with the samples on filter paper can be loosely wrapped in lens paper. Multiple samples from the same area can be placed on one piece of paper (Fig. 3-3). When samples are obtained

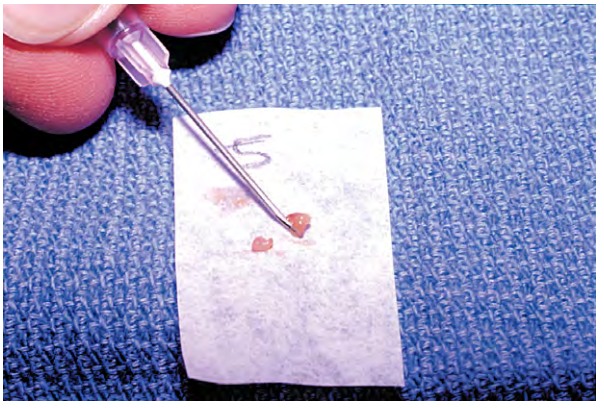


**Fig. 3-2**
When performing gastrointestinal or urinary bladder mucosal biopsies, place the sample, mucosal surface up, on a piece of filter paper. The paper can be labeled in pencil to indicate where the samples were obtained. *(Courtesy Dr. Timothy McCarthy.)*

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**Fig. 3-3**
Obtaining multiple samples is vitally important. All samples from the same area can be placed on the same piece of paper. *(Courtesy Dr. Timothy McCarthy.)*

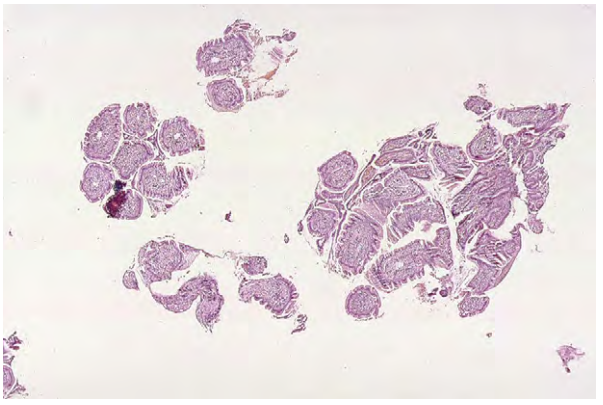


**Fig. 3-4**
The inability to properly orient intestinal mucosal biopsy samples results in fragmented and folded histopathologic sections that are difficult to interpret. H&E stain. *(Courtesy Dr. Michael Willard.)*

from different areas, such as from stomach and duodenum, the site of origin can be written on the tongue depressor or filter paper. On arrival at the laboratory, the filter paper containing samples is trimmed to fit into the cassette, maintaining orientation through the paraffin infiltrating process. Samples are then carefully removed and embedded on edge for sectioning. Multiple sections are embedded within each block.

The importance of proper handling of endoscopic biopsies is underscored by the findings of Willard and colleagues[4] who studied duodenal mucosal biopsy samples from dogs and cats. In comparing samples submitted on a plastic sponge and embedded on edge with samples floating in formalin in which no orientation during embedding was possible, 6% to 26% of slides from free-floating samples were clearly inadequate for diagnostic purposes, whereas only 0% to 4% of slides from sponge-mounted sections were inadequate (Figs. 3-4 and 3-5).

Some samples, no matter how carefully handled, cannot be used as diagnostic samples. When conducting endoscopic biopsies, it is important to obtain as many samples as possible. Although I try to avoid "pathology by numbers," the recommendation to obtain six or more endoscopic biopsy specimens[2] is reasonable. The study by Willard and colleagues[4] of endoscopically obtained duodenal biopsy specimens concluded that at least eight tissue samples should be submitted.

## Solid Organ

Solid organ biopsies include samples of lung, kidney, liver, pancreas, spleen, adrenal, lymph node, or other solid organ. Adequate sampling depends on the nature of the organ and of the lesion. Careful handling to reduce crush artifact is essential. Because orientation of solid organ samples is not such a critical issue, submission of samples

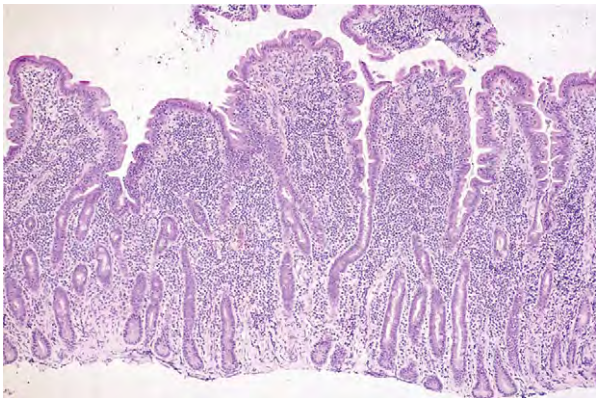


**Fig. 3-5**
A properly handled intestinal mucosal sample results in histopathologic sections oriented in such a way that the entire mucosal thickness can be evaluated, as can villous length and width. In this case, infiltrating lymphocytes and plasma cells cause increased cellularity of the lamina propria as well as an increased number of intraepithelial lymphocytes, which is indicative of lymphocytic-plasmacytic enteritis. H&E stain. *(Courtesy Dr. Michael Willard.)*

free in formalin is possible. The laboratory submits samples of sections with as large an area of tissue as possible.

## Mass Lesions

If mass lesions are encountered on endoscopic evaluation of the abdomen, thorax, or within the lumen of respiratory, gastrointestinal, or urogenital organs, it may be possible to obtain reasonably large diagnostic samples for histopathology with a loop-ligature technique. From a pathologist's point of view, though, if mass lesions are

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encountered on endoscopy, exploratory surgery and excision biopsy are much preferred to endoscopic biopsy.

### Intraarticular Lesions

There is increasing interest in endoscopic evaluation of diseased joints in small animals. Synovial biopsy samples are similar to respiratory mucosal samples in that precise orientation of sections for histopathology is less critical than for gastrointestinal mucosal samples. A combination of cytologic evaluation of joint fluid, bacterial culture if indicated, and synovial biopsy often results in a definitive diagnosis.

## CYTOLOGY AND CULTURE

Cytologic preparations using endoscopic techniques include (1) fluid aspiration for cytology or bacterial culture, (2) brush cytologic preparation, and (3) impression smears made by rolling biopsy samples on a glass slide before fixation in formalin. Fluid aspiration is most useful when evaluating gastric or duodenal samples for the presence of organisms such as *Helicobacter*, *Giardia*, and *Ollulanus tricuspis*, or when submitting samples for bacterial culture to identify bacterial overgrowth disorders of the small intestine. Brush cytologic preparations appear to be promising for identification of various inflammatory and neoplastic conditions of the gastrointestinal, respiratory, and urogenital tract. Impression smears of biopsy samples may be rewarding in some cases, but even with the gentlest of techniques, this procedure risks inducing artifacts in the sample that make histopathologic evaluation after formalin fixation even more difficult than usual.

The value of fine needle aspiration (FNA) cytology in veterinary diagnostic pathology depends greatly on the tissue or organ sampled and on the quality of the preparations. For example, hepatic FNA preparations are often difficult to interpret, and a definitive diagnosis is only possible in a small percentage of cases. In some cases, though, FNA is valuable. Differentiation of lymphoblastic leukemia from monocytic, myelogenous, or myelomonocytic leukemia is often possible only with cytologic preparations. Identification of large granular lymphocyte (LGL) tumors of the feline intestinal tract can also require cytologic evaluation of tumor cells. Although some references state that the characteristic intracytoplasmic granules of the tumor cells can be visualized in histologic sections with special stains, in particular Giemsa, periodic acid–Schiff (PAS), and phosphotungstic acid–hematoxylin preparations,[5,6] it has been my experience that there are LGL tumors of the intestine of cats in which the granules are only visible on cytologic preparations, and they are not apparent regardless of the special stain used on formalin-fixed histologic preparations (Fig. 3-6).

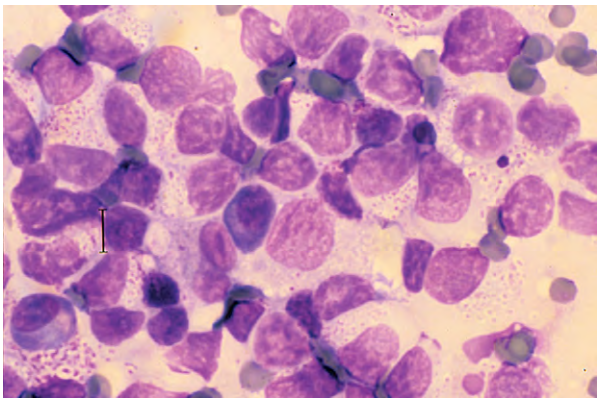


**Fig. 3-6**
The small eosinophilic intracytoplasmic granules that characterize cells of large granular lymphocyte (LGL) tumors may only be visible on cytologic preparations, as was the case in this nodular LGL tumor of the small intestine from a cat. Diff-Quik stain. *(Courtesy Dr. Barry Cooper.)*

The cell of origin of poorly differentiated tumors of any sort may be more readily identified in cytologic preparations than in histopathologic sections. In some cases, it takes a savvy and experienced clinical pathologist to determine the cell type in cytologic preparations. Even though one might examine the cytologic preparations with Diff-Quik or other readily available stains, these stained slides as well as unstained slides should be submitted to an experienced veterinary clinical pathologist for interpretation. Although rapid staining techniques such as Diff-Quik stains are useful, the Wright-Giemsa stain used by clinical pathology laboratories offers many advantages when interpreting cytologic preparations.

## SUBMISSION OF SAMPLES

Formalin fixation is routinely used to prepare endoscopic and other biopsy specimens. Ten percent formalin should be adequately buffered. Using unbuffered formalin results in artifacts that can make interpretation difficult. Some laboratories supply premixed formalin, which is easier and better to use than individually prepared formalin.

The minimum adequate volume of formalin is 9 parts formalin to 1 part tissue, a ratio that is readily achieved when dealing with small endoscopically obtained samples (Fig. 3-7). Small samples should not be submitted in blood collection tubes, because they are difficult to retrieve.

Samples are carefully packaged in formalin to ensure that leakage does not occur during shipment. Double bagging the sample is ideal. Proper packaging of samples for diagnostic analysis of any sort is becoming increasingly important, particularly since the U.S. Postal Service and other courier services have become sensitive to

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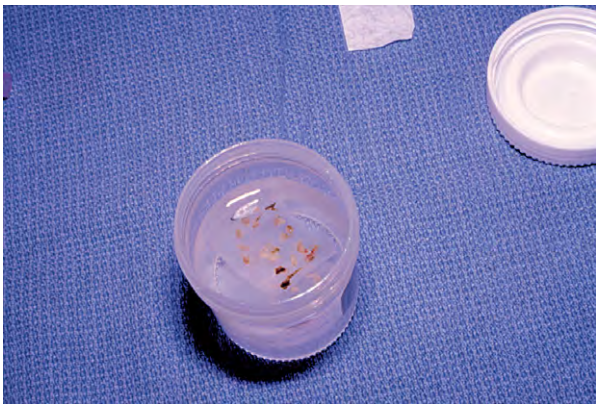


**Fig. 3-7**
Place samples in an adequate volume of neutral buffered 10% formalin. *(Courtesy Dr. Timothy McCarthy.)*

possible environmental contamination and biohazardous material risks.

Formalin can freeze in subzero temperatures, and the resultant freeze artifact in the tissue can render samples almost useless. Samples should be adequately protected during shipment in cold weather; heat does not seem to be a problem.

The information included on the submission sheet is a vital part of ensuring the best and most accurate pathologic interpretation. Inclusion of a clinical diagnosis or differential diagnosis can sometimes help reduce turnaround time. For example, if the clinician suspects fungal rhinitis, then a special stain for fungus at the time of processing can be ordered, rather than waiting until after hematoxylin and eosin (H&E) stained sections have been prepared and examined (Box 3-3).

**Box 3-3 Submission Form**

Provide for all samples:
- A complete signalment; if a specific age is not known, even "young adult," "mature," or "aged" is useful information
- A description of endoscopic findings, including presence or absence of a mass lesion, erosions, or ulcers
- A complete history of clinical signs
- A record of previous treatments and response or lack of response
- Relevant clinicopathologic findings with actual values, and cytologic findings if performed
- A description of the sites where specimens were obtained
- Clinical diagnosis or differential diagnoses

With nasal and sinus mucosal and intraarticular biopsies, also include:
- Radiographic findings
- Bacterial or fungal cultures completed or pending

With gastrointestinal mucosal biopsies, also include:
- Radiographic or ultrasonographic findings
- Results of fecal evaluation for parasites
- Results of barium or other imaging studies

With urogenital system biopsies, also include:
- Urinalysis results
- Radiographic or ultrasonographic findings
- Results of other imaging studies
- Bacterial cultures completed or pending

## HISTOPATHOLOGIC TECHNIQUES

All histology laboratories are equipped to process formalin fixed tissue for routine paraffin embedding, sectioning, and staining. The quality of the preparations may be variable, especially in smaller private laboratories. The quality of the sectioning and staining affects the ability of the pathologist to interpret the changes. The American Association of Veterinary Laboratory Diagnosticians (AAVLD) conducts an in-depth evaluation of all aspects of a veterinary diagnostic laboratory, including histology, before offering accreditation. However, many nonaccredited laboratories also produce an excellent product.

All laboratories should offer routine H&E stains and a battery of histochemical reactions known as *special stains*. Immunohistochemistry assays that use specific antibodies to identify cell types or viral, bacterial, fungal, or other infectious agents are not available in all laboratories. Even in laboratories that regularly use immunohistochemistry for diagnostic purposes, not all antibodies are available. If needed, the pathologist can research which laboratories provide particular immunohistochemical procedures. The advent of the World Wide Web has made use of the Internet for rapid gathering of electronic information, and answers regarding immunohistochemical questions are often found on the AAVLD Website. When a case is interesting or unusual, it may be possible to get immunostaining at no additional charge.

Animal tissue can be adequately processed in laboratories that routinely handle human tissue. Evaluation of animal tissue by a physician pathologist, though, is not advised. As a veterinary pathologist interested in comparative medicine, I am interested in examining human tissue, but I would never consider offering a diagnosis.

### Routine Histopathology

All formalin fixed samples are embedded in paraffin and processed for routine staining. Most laboratories use a

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variant of the H&E stain. In many cases, examination of H&E stained sections is sufficient for the diagnosis. Use of special stains depends on findings on H&E staining. Special staining of human tissue for diagnostic purposes invariably involves additional charges, which are covered by medical insurance. Some veterinary diagnostic laboratories also charge extra for special stains. Many veterinary laboratories, however, especially those associated with academic institutes, still offer "routine special stains" at no additional charge (Table 3-1).

### Immunohistochemistry

Immunohistochemistry has long been used to identify cell types in a research setting, and it is being increasingly used in veterinary diagnostic pathology. Immunohistochemical evaluation of lymphocyte markers, for example, can help differentiate lymphocytic inflammation from lymphocytic neoplasia and can differentiate B-cell and T-cell lymphomas. Immunohistochemical identification of epithelial cell markers, usually cytokeratins, can identify invasive carcinoma cells in cases such as sclerosing carcinoma, in which the number of neoplastic cells can be very small and difficult to detect on routine preparations.

In most cases there is not a specific antibody to distinguish a normal cell from a neoplastic cell, and therefore immunohistochemistry is not an answer in itself. It takes careful evaluation of immunohistochemical preparations by an experienced pathologist before an accurate interpretation can be made. An increasing number of antibodies are being used for identification of etiologic agents of infectious diseases. Whereas many laboratories offer routine special stains at no additional charge, immunohistochemical preparations are reagent and labor intensive, and their use generally incurs additional charges.

## HISTOPATHOLOGIC FINDINGS

This section provides general guidelines of what distinguishes various pathologic processes in different organs, as well as the pitfalls that the pathologist may encounter.

### Gastrointestinal Tract

Endoscopic biopsy can be a valuable tool in the diagnosis of disorders of the gastrointestinal tract. Only disorders involving the mucosal lining are detected by this technique.

### Atrophy

Although mucosal atrophy, particularly of the stomach, can occur in various chronic inflammatory conditions, in most cases it is not possible to make this diagnosis based on mucosal biopsy samples. A variable degree of villous atrophy or fusion accompanies various chronic inflammatory intestinal disorders, but requires precise orientation of villi in histopathologic sections to be detectable.

### Hyperplasia

Hyperplastic conditions of gastrointestinal mucosa include hyperplastic gastritis secondary to gastrin-secreting

*Table* **3-1 Commonly Used Special Stains**

| Stain | Use |
|---|---|
| Giemsa | Stains many bacterial, protozoal, and fungal organisms; identifies mast cells and eosinophils; aids in identification of plasma cells |
| Toluidine blue | Detects mast cell granules and chondroid matrix |
| Gram | Differentiates gram-positive and gram-negative bacteria |
| PAS,* GMS | Stain yeast and fungi, some protozoa (amebae), and some algae (prototheca) |
| Acid fast | Identifies acid fast organisms such as mycobacteria |
| Silver stains | Detects spirochetes |
| Trichrome | Stains collagen to detect fibrosis |
| Reticulin | Highlights architectural alterations in damaged liver |
| PAS, JMS | Highlight basement membrane alterations in glomeruli and renal tubules |
| Congo red | Identifies amyloid |
| Rhodanine, rubeanic acid | Detect copper |
| Prussian blue | Detects iron |
| PAS for glycogen | Identifies glycogen |
| Oil red O, Sudan black | Stain lipid |
| PTAH | Stains some large granular lymphocyte granules and fibrin; highlights cross-striations of skeletal muscle cells |

*PAS, *periodic acid–Schiff;* GMS, *Gomori's methenamine silver;* JMS, *Jones methenamine silver;* PTAH, *phosphotungstic acid–hematoxylin.*

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pancreatic islet cell tumors in dogs (Zollinger-Ellison syndrome),[7] hypertrophic pyloric gastropathy in dogs,[8] and adenomatous polyps in dogs and cats.[9] Cats of Asian origin (e.g., Siamese and Himalayan) appear to have a higher incidence of adenomatous polyps in the duodenum.[9] To detect hyperplasia on biopsy samples, it is imperative that as many large samples as possible are obtained and that a description of mucosal thickening or of a polypoid mass is provided to the pathologist.

Gastric mucosal thickening can result from edema in any dog that has been vomiting. True mucosal hyperplasia, which may involve only a portion of the gastric mucosa, is a common finding in the gastroenteritis of Basenji dogs.[10,11]

## Neoplasia

Gastrointestinal lymphoma can cause either a mass lesion or a diffuse infiltration of the stomach or intestinal wall. Therefore lymphoma is the most likely neoplasm to be diagnosed on endoscopic mucosal biopsies. Problems in interpretation can arise because lymphocytes are normally found within intestinal mucosa, and their number within the epithelium and within the lamina propria increase in lymphocytic and plasmacytic and in eosinophilic enterocolitis. Dense lymphoid nodules, most often associated with *Helicobacter* infection, can also occur in gastric mucosa. It can be difficult for the pathologist to clearly distinguish a lymphocytic neoplastic process from a lymphocytic inflammatory condition, especially if sample size, number, and condition are less than optimal. Gastrointestinal lymphoma is also often accompanied by lymphocytic and plasmacytic inflammatory infiltrates, which can obscure underlying neoplasia.[12] Lymphoma within the wall of the stomach is often accompanied by mucosal ulceration and secondary inflammation, along with a deep submucosal neoplastic infiltrate, and can be difficult to detect on endoscopically obtained biopsy samples.

Lymphoma cells, most often B cells, can be seen as a dense infiltrate of relatively homogeneous and often slightly atypical lymphocytes, in the absence of plasma cells, that obscure or efface normal architecture (Fig. 3-8). In full-thickness samples, the pathologist looks for evidence of submucosal invasion to support the diagnosis of most lymphomas. This is not an option with mucosal samples; it is not surprising if the pathologist is unwilling to definitively diagnose lymphoma on the basis of endoscopically obtained biopsies. Lymphoma can also be epitheliotropic, characterized by a large number of a relatively homogeneous population of intraepithelial lymphocytes that often obscure the basement membrane zone. Epitheliotropic lymphoma may be more common in Shar Pei dogs.[13]

Mitotic activity within the infiltrating cell population helps distinguish neoplasia from inflammation, but it may not be evident in well-differentiated lymphoma. Particularly difficult cases benefit from the use of immunohistochemistry for lymphocyte markers. The identification of a uniform population of B cells or T cells confirms the neoplastic nature of the lesion and identifies the cell of origin. Because B-cell lymphomas are more readily controlled by chemotherapy than are T-cell lymphomas, determining the cell type of gastrointestinal lymphoma can be important.

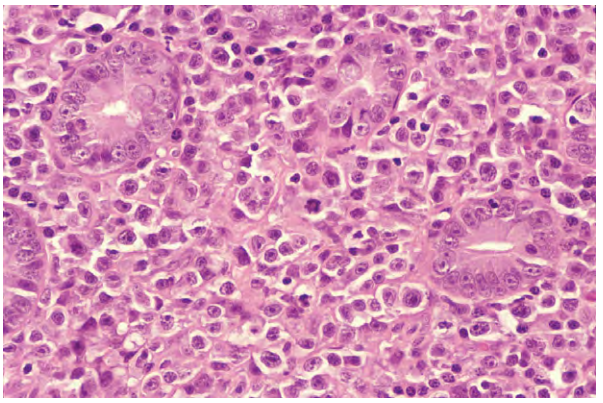


**Fig. 3-8**
Lymphoma is characterized by sheets of relatively homogeneous and often atypical lymphocytes causing architectural distortion or effacement, as in this intestinal lymphoma sample from a dog. Lymphoma must be distinguished from inflammatory bowel disease (see Figs. 3-5 and 3-10). H&E stain. *(Courtesy Dr. Barry Cooper.)*

Carcinoma and adenocarcinoma are more common in the gastrointestinal tract of dogs and cats than is lymphoma.[14-16] Adenocarcinoma appears to be more common in Siamese cats than in other breeds.[17] Adenocarcinoma typically forms a mass lesion, and excisional biopsy via exploratory surgery is preferred over endoscopic biopsy. Adenocarcinoma is often associated with marked fibrosis, resulting in sclerosing (sometimes called *scirrhous*) adenocarcinoma, in which a small number of infiltrating neoplastic cells are associated with a large amount of collagen. Mucosal ulceration, secondary inflammation, and formation of granulation tissue are also common (Fig. 3-9). These features can make diagnosis of adenocarcinoma on small mucosal samples difficult. Proliferating fibroblasts and endothelial cells within active granulation tissue can be misinterpreted as mesenchymal neoplasia. Use of immunohistochemistry to identify invasive epithelial cells can help make the diagnosis of epithelial neoplasia in difficult cases.

Tumors of the tunica muscularis, leiomyoma and leiomyosarcoma, extend into the mucosa only in advanced stages of tumor growth[18] and are not typically apparent on mucosal biopsy samples. Less common

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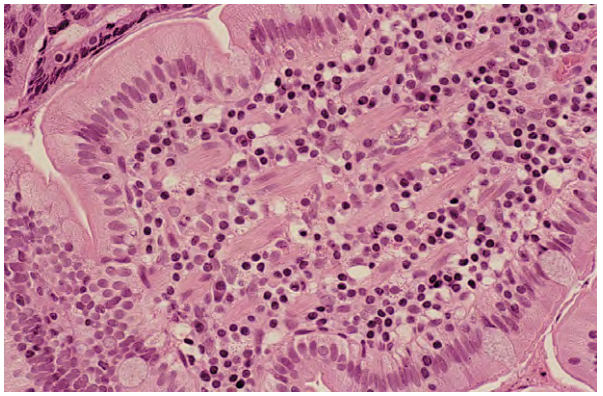


**Fig. 3–9**
The nests of neoplastic epithelial cells in this intestinal adenocarcinoma from a cat are embedded in, and obscured by, dense granulation tissue. H&E stain. *(Courtesy Dr. Barry Cooper.)*

tumors of the gastrointestinal tract include tumors of endocrine cells (carcinoid tumors), mast cell tumors, plasma cell tumors, and tumors of globule leukocytes or large granular lymphocytes. All of these tumors form mass lesions that may involve mucosa and that are best approached and diagnosed via exploratory surgery.

Esophageal neoplasms in dogs include squamous cell carcinoma, adenocarcinoma, and leiomyoma. In areas where the parasite *Spirocerca lupi* is prevalent, esophageal osteosarcoma and fibrosarcoma are seen.[19]

## Inflammation

Inflammation is the most common finding in gastrointestinal samples from dogs and cats.[20-24] Leukocytes of any type are abnormal if present in the stomach, and neutrophils are abnormal at any level. In my opinion, in dogs and cats, ready identification of eosinophils within the mucosa at any level of the gastrointestinal tract is also abnormal. Recognition of lymphocytic and plasmacytic inflammation within the small and large intestine is more problematic, because these cells are normal residents of the lamina propria of the intestines.

Inflammatory bowel disease (IBD) resulting from hypersensitivity and protein-losing enteropathy are familial disorders in certain breeds, such as the Irish Setter, Basenji, Soft Coated Wheaten Terrier, Yorkshire Terrier, and Norwegian Lundehund.[25-27] In cats, some studies indicate that the domestic shorthair is most likely to have generalized IBD.[20] Lymphocytic/plasmacytic colitis may be more common in purebred cats.[21] Knowing the breed can be an important pathologic clue when interpreting the sections.

In most cases of IBD, the number of inflammatory cells within the gastric mucosa is small, perhaps even undetectable. In my experience, inflammation within the small intestinal mucosa is typically more severe than in the colon, unless the disorder is primarily a colitis. This was also the finding of Jergens and co-workers[24] in cats with IBD, but in this study colonic inflammation was more severe than duodenal inflammation in dogs with IBD. It is often easier to obtain larger samples of colonic mucosa than it is to obtain large samples of small intestinal mucosa, and the detection of even a mild inflammation in these samples can be enough to confirm a diagnosis of IBD.

The presence of neutrophils most often indicates a bacterial infection, which may be primary or secondary. Neutrophils often accompany zones of mucosal erosion or ulceration, so their presence does not always indicate primary bacterial disease. When obtaining biopsy samples from patients with areas of loss of mucosal integrity, samples are obtained from the edges of lesions, deep in the center of lesions, and from apparently unaffected mucosa.

Eosinophils are normal residents of the intestinal mucosa and are readily identified in the intestinal mucosa of normal horses and livestock. In cats and dogs, however, readily identified eosinophils are indicative of inflammatory disease,[20,24] either as a result of endoparasites or hypersensitivity. Eosinophilic infiltrates are most dense in the deep mucosa and at the base of the glands, and less dense within the villous lamina propria. It can take careful searching to identify these cells, but this is an important part of pathologic evaluation. Eosinophilic IBD is often accompanied by an increased number of lymphocytes and plasma cells, by an increased number of intraepithelial lymphocytes, and by eosinophilic granulated mononuclear cells interspersed with glandular mucosal epithelial cells. These intraglandular cells may be identified as globule leukocytes or large granular lymphocytes, depending on the size of the granules. Large granular lymphocytes have small granules, whereas globule leukocytes have large granules. Large granular lymphocytes and globule leukocytes are thought to be variants of the same cell type. Some pathologists may refer to these cells as intraepithelial eosinophils. In all cases in which cells with eosinophilic granules are found within any area of mucosal samples, ongoing or recent endoparasitism must be ruled out before making a diagnosis of eosinophilic IBD due to hypersensitivity. Provision of information regarding testing or prior treatment for endoparasites helps the pathologist determine whether IBD is likely. Eosinophilic IBD generally requires corticosteroid therapy in addition to other medical and dietary therapy; therefore, it is important for the pathologist to differentiate eosinophilic IBD from lymphocytic and plasmacytic IBD. Rottweilers and German Shepherd dogs seem to be predisposed to a severe form of eosinophilic IBD. I have seen cases of intestinal perforation in dogs, particularly

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of these breeds, in which underlying eosinophilic IBD was thought to play a role. Although some texts indicate that protein-losing enteropathy in the dog is most often associated with intestinal lymphangiectasia, in my experience loss of protein from the intestinal tract is most common in dogs with eosinophilic IBD. Although I have not specifically analyzed the data, I suggest that at least 20% to 30% of mucosal biopsies from dogs and cats with clinical signs of chronic gastrointestinal disease show underlying eosinophilic IBD.

Lymphocytes and plasma cells are normal residents of the intestinal lamina propria, and determining that these cells are increased in number as a result of lymphocytic or plasmacytic IBD can be a judgment call. An increase in the number of intraepithelial lymphocytes accompanies the increase in lamina propria cells (Fig. 3-10 and see Fig. 3-5). In severe cases, the villi are shorter and thicker than normal and may exhibit villous fusion, but these findings are only detected in optimally oriented sections. In many cases, the pathologist relies to some extent on the clinical history of chronic gastrointestinal disease to make a diagnosis of lymphocytic and plasmacytic IBD. I have seen more evidence for this disorder in a few necropsy samples from dogs with no history of gastrointestinal disease than I have seen in some biopsy samples, perhaps because signs of gastrointestinal disease were not detected before death or perhaps because they were not considered a significant part of the history in a dog euthanized with a more severe disorder, such as metastatic osteosarcoma. The pathologists recruited for participation in the study by Willard and colleagues[28] also detected abnormalities in intestinal samples from clinically normal research dogs. There is undoubtedly a spectrum of normal when it comes to lymphocyte and plasma cell populations within the intestinal tract of dogs and cats. One study concluded that lymphocytic and plasmacytic IBD in dogs and cats can only be accurately diagnosed after a count of the number of inflammatory cells in the lamina propria.[29] It is unlikely that this type of analysis will be applied to samples examined by a veterinary pathologist in a diagnostic laboratory setting. Interpretation depends on the pathologist's experience and on the signalment and clinical history. Clinicians should provide all the information necessary to aid the pathologist who interprets the samples.

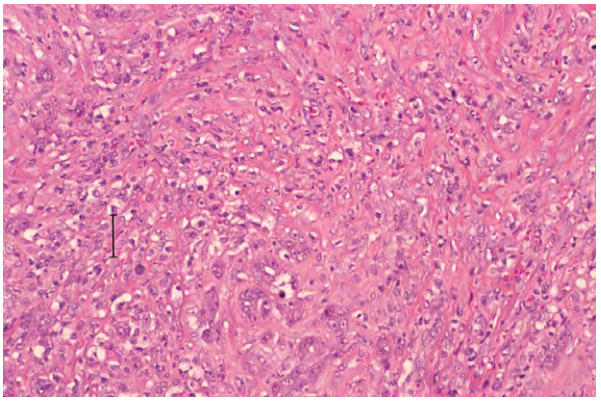


**Fig. 3-10**
Infiltrates of admixed lymphocytes and plasma cells that do not efface architecture, accompanied by an increased number of intraepithelial lymphocytes, are characteristic of lymphocytic-plasmacytic inflammatory bowel disease and must be distinguished from intestinal lymphoma (see Fig. 3-8). H&E stain. *(Courtesy Dr. Barry Cooper.)*

Histiocytic (granulomatous) inflammation due to macrophage infiltration is uncommon in dogs and cats. It is the characteristic feature of histiocytic colitis of the Boxer dog, and it is found in rare cases of intestinal infection by mycobacterial organisms or fungi. Macrophages in Boxer dog colitis contain PAS-positive granular intracytoplasmic material. Various acid fast stains identify mycobacterial species, and PAS or Gomori's methenamine silver (GMS) stains identify fungi.

Small intestinal cryptitis that may be unaccompanied by inflammation elsewhere in the mucosa is recognized as a cause of protein-losing enteropathy in the dog.[1] Dilated crypts filled with mucus and degenerate cells are characteristic. Crypt necrosis in the absence of inflammation is a characteristic feature of canine and feline enteric parvoviral infection, although endoscopic biopsy of animals with this type of acute gastroenteritis is unlikely to be performed. A similar histopathologic pattern of crypt loss has been associated with feline leukemia virus causing subacute to chronic diarrhea in cats.[30] Immunohistochemistry for feline leukemia virus antigen within affected mucosa is required for confirmation of this viral enteropathy. These diagnoses cannot be made on mucosal specimens that are not deep enough to include crypts.

## Ulceration

Ulcerative lesions are most common in the gastric and duodenal mucosa. Although severe inflammation of various causes can result in mucosal ulceration, most ulcers are associated with either underlying neoplasia or administration of medications such as nonsteroidal antiinflammatory drugs. In cats, ulcerative gastritis has also been reported in association with infection by the nematode parasite *Aonchotheca putorii*.[31] Biopsy samples obtained from the superficial portion of ulcerative lesions are likely to be unrewarding, because such samples are undoubtedly composed of necrotic debris and inflammation, regardless of the underlying cause. Biopsy samples from deep within the ulcer and at the edge are best for identification of underlying neoplasia. Biopsy samples

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from more normal appearing mucosa are useful for identification of underlying IBD.

## Infectious Agents

Lymphocytic inflammation within the stomach often accompanies infection with *Helicobacter* spp. Dense lymphoid nodules deep in the mucosa are common and can be mistaken for lymphoma if these areas are sampled. The spirochetes can be seen in the surface mucus and in superficial glands on routine H&E preparations, but their number can really only be appreciated following staining with one of the several silver stains that identify spirochetes. Whether or not *Helicobacter* infection is associated with gastritis and clinical signs of vomiting, or whether the number of organisms can increase due to altered gastric environment in dogs with IBD, is not clear. Some studies suggest that gastric *Helicobacter* infection in dogs is not associated with clinical disease[32,33]; others link helicobacteriosis to chronic gastritis.[34] I agree with the conclusions of Simpson and colleagues,[35] who believe that the role of *Helicobacter* infection in clinically apparent gastritis in dogs and cats is still unclear. But, I still consider the presence of *Helicobacter* organisms to be worthy of note. In cases with a large number of spiral organisms, even when there is evidence of underlying IBD, antibiotic treatment seems a prudent approach.

Protozoal organisms such as *Giardia* and trichomonads are occasionally found on the luminal surface of mucosal biopsy specimens, but this is rare. Evaluation of feces for these organisms is the diagnostic test of choice.[36] Intracellular and intramucosal organisms such as cryptosporidia,[37] coccidia, and amebae are more likely to be found within mucosal biopsy samples, but sampling error may result in false-negative samples. Staining of sections with Giemsa, PAS, or GMS stains can aid in identification of some of these organisms. These protozoal organisms are accompanied by a variable degree and type of inflammation. In some cases, inflammation is not apparent.

*Enterococcus* infection causes diarrhea in cats and dogs that is associated with adherent gram-positive cocci on the villous surface.[38-40] Gram stain of sections confirms the nature of these bacteria. *Campylobacter* infection is another bacterial infection associated with enteritis in dogs,[41] but this organism is typically found only in the ileum, causing proliferative enteritis, and it is not likely to be evident on endoscopic biopsies of duodenum or colon. One of the various silver stains for spirochetes readily identifies *Campylobacter* organisms. Colitis due to *Clostridium* (formerly *Bacillus*) *piliformis* infection occurs in kittens and cats, and results in glandular hyperplasia with a mixture of lymphocytes, plasma cells, and sometimes neutrophils within colonic mucosa. These organisms may be faintly visible on H&E stained sections, but their presence can only be confirmed with a silver stain for spirochetes.[42]

## Fibrosis

Fibrosis is most often detected within gastric mucosal samples but can also be found within intestinal mucosa. Fibrosis of varying severity can accompany chronic inflammatory disorders of any type. Fibrosis is also a feature of sclerosing carcinoma and adenocarcinoma, and of ulcerative mucosal disorders of any type. Fibrosis is an irreversible change that may alter the prognosis for full recovery with medical therapy.

A profound dissecting interstitial fibrosis within gastric mucosa, accompanied by a large increase in globule leukocytes and scattered lymphoid nodules, is characteristic of *O. tricuspis* infection in cats.[43] This tiny nematode parasite may be seen partially embedded in the surface mucosa on endoscopic examination, and rarely sections of the parasite are present on mucosal biopsy samples. Typically, though, this diagnosis is suspected on the basis of characteristic histopathologic findings in cats with a history of chronic vomiting. Although this parasite was initially described in cats in the Pacific Northwest, it is likely to be a ubiquitous organism; I have encountered *O. tricuspis* infection in cats living only in upstate New York. I have occasionally seen similar findings of unknown cause in canine gastric mucosa.

## Vascular and Lymphatic Disorders

Lymphangiectasia in the dog is a congenital or acquired abnormality of small intestinal lymphatics resulting in protein-losing enteropathy. This disorder can present in dogs of all ages.[44] Mucosal biopsies exhibit marked and diffuse dilation of villous lacteals that often contain protein. There may be associated inflammation. Because some lacteal dilation can accompany any inflammatory disorder, in most cases the changes must be profound before a diagnosis of primary lymphangiectasia is made. Some cases of lymphangiectasia are accompanied by granulomatous inflammation resulting from leakage of lymph from dilated lymphatics, but this change is typically seen only in submucosal and serosal lymphatics[44] and is not apparent on mucosal biopsies.

Vascular anomalies of the intestinal wall occur occasionally in dogs.[45] These cases present with intestinal bleeding that can occur at a relatively young age. Bleeding can be severe and life threatening in some cases. These vascular lesions can be difficult to detect on mucosal biopsies, because affected vessels are often submucosal. In affected mucosal samples, the characteristic dilated thin-walled blood vessels may not be identified as abnormal by the examining pathologist.

## Conditions with No Significant Mucosal Changes

Several conditions affect gastrointestinal function but do not result in mucosal alterations detectable on light microscopy of endoscopically obtained biopsies.[46,47]

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Rather than being considered a disappointing result, the diagnosis of "no significant lesions" in specimens of adequate quality rules out certain conditions and helps define the possible differential diagnoses and determine the most appropriate follow-up procedures (Box 3-4).

## Respiratory Tract

Respiratory tissue specimens are obtained from nasal and sinus tissues, tracheal and bronchial lesions, and lung. Samples from the nasal passages often contain bacteria of no significance, and secondary bacterial infection of eroded or ulcerated lesions is common. Samples from deep below the surface may be necessary to diagnose a neoplasm with surface ulceration.

### Neoplasia

Various neoplastic processes occur in the respiratory tract. In the upper respiratory tract, *nasal* adenocarcinoma is the most common, followed by squamous cell carcinoma, lymphoma, mast cell tumor, osteosarcoma, chondrosarcoma, and paranasal meningioma.[48-50] Most tumors are also accompanied by some degree of inflammation and necrosis. Differentiation of reactive and neoplastic surface and mucosal glandular epithelium can be difficult. The pathologist often relies heavily on clinical and radiographic findings when interpreting upper respiratory tract samples. An adequate history must include results of radiographic studies as well as endoscopic findings.

Within the larynx, rhabdomyoma (oncocytoma) is an uncommon neoplasm in dogs that typically forms a smooth nodular mass that bulges into the lumen. Histopathology reveals characteristic round cells filled with PAS-positive granules. Leiomyoma can arise within tracheal smooth muscle, forming a smooth-surfaced bulging mass composed of smooth muscle cells.[18]

Lung biopsy techniques are relatively recent additions to veterinary medicine. Interpretation of these samples can be difficult, particularly when differentiating reactive and neoplastic processes. The appearance of type 2 alveolar lining cells and bronchiolar epithelial cells is sometimes markedly altered during reactive processes involving mitoses and regeneration and can mimic neoplasia. True neoplasia can be primary carcinoma or adenocarcinoma, or it can reflect metastatic disease.

**Box 3-4 Conditions with Few or No Gastric, Duodenal, or Colonic Mucosal Changes**

- Mesenteric plexus disorders
- Mural tumors
- Mural parasitic granulomas
- Mural enteritis
- Brush border defects
- Bacterial overgrowth
- Ileal disease

### Inflammation

As with gastrointestinal mucosa, the presence of neutrophils is most often indicative of a bacterial component. An increased number of eosinophils suggests underlying allergy or parasitism. Macrophage infiltration suggests fungal infection, especially when associated with necrotic debris and degenerate neutrophils, but it can also be seen in a foreign body reaction. In the lung, granulomatous to pyogranulomatous inflammation occurs in mycobacterial as well as fungal infections.

Inflammatory polyps within the nasal passage, sinuses, and larynx are common and can mimic neoplasia clinically. Examination of multiple samples from different regions of the lesion helps rule out underlying neoplasia. Parasitic nodules caused by *Filaroides osleri* can occur in the trachea of dogs.

## Solid Organ

Samples from solid tissue organs are most often examined for evidence of inflammation or neoplasia. As with gastrointestinal samples, it can be difficult to distinguish lymphocytic inflammation from lymphoma. In some cases, a definitive diagnosis is not possible. The histopathologic diagnosis of lymphoma relies on the tissue pattern, looking for infiltration and marked distortion or effacement of architecture by infiltrating lymphocytes, as well as on cytologic features of the infiltrating cells. Architectural patterns may not be recognizable on small tissue samples.

### Kidney

Kidney biopsies should include sections of cortex and of medulla if possible. These biopsies are evaluated for tubular and glomerular disease as well as for inflammation, fibrosis, and neoplasia. The presence of neutrophils most often indicates bacterial pyelonephritis. Lymphocytic interstitial inflammation is a common finding in canine and feline kidneys whose significance depends on the severity of the inflammation. Granulomatous to pyogranulomatous inflammation is characteristic of feline infectious peritonitis. Biopsies are adequate for evaluation of kidney only when sufficient glomeruli are present to evaluate for glomerular (glomerulonephritis and glomerular amyloidosis) as well as for tubular and interstitial disease. Some disorders, such as renal amyloidosis in Shar Pei dogs[51] and Abyssinian cats,[52] primarily affect the medullary interstitium. Congenital disorders such as renal dysplasia, renal hypoplasia, and juvenile renal disease are associated with a variety of gross and histopathologic changes. Renal dysplasia is characterized by segmental

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renal lesions with retention of fetal glomeruli and presence of embryonal tubules and interstitial mesenchyme.[53] Renal hypoplasia results in a diffuse cortical thinning with retention of fetal glomeruli, and juvenile renal disease in various breeds such as the Golden Retriever, Beagle, Samoyed, Bull Terrier, Cocker Spaniel, Bernese Mountain Dog, Rottweiler, Soft Coated Wheaten Terrier, Newfoundland, Shar Pei, and Doberman Pinscher is characterized by primary glomerulopathy.[54] Special stains, including trichrome stain, PAS, Jones methenamine silver stain, and Congo red stain, are often important when evaluating samples for evidence of renal disease.

## Liver

Liver biopsy samples should be large enough and numerous enough to include multiple portal and central zones for evaluation of lobularly distributed lesions. A recent study found that the accuracy of diagnosis of hepatic disease was significantly reduced when needle biopsies vs. wedge biopsies were used.[55] The ability to evaluate lobular structure is often critical to accurate interpretation of hepatic changes.

Liver biopsies are evaluated for lipidosis, vacuolar change, necrosis, vascular anomalies, amyloidosis, and copper storage, as well as for evidence of architectural alteration, inflammation, and neoplasia. Special stains may be used to detect collagen, reticulin, amyloid, glycogen, iron, or copper. Pathologists with little experience with hepatic biopsies may interpret the mild diffuse vacuolar change resulting from the high glycogen content of normal hepatocytes as a pathologic finding, because this glycogen is generally degraded in liver samples obtained at necropsy.

Deposition of amyloid within the space of Disse can be difficult to detect on routine H&E stained sections. This pale pink amorphous material can be mistaken for serum or fibrin. Hepatic amyloidosis occurs rarely in dogs with chronic inflammation of various types. Hepatic amyloidosis is most common in Shar Pei dogs with recurrent fever,[56] Siamese cats,[57] Abyssinian cats, and Oriental cats. Special stains such as Congo red confirm the presence of amyloid within liver samples. Severe hepatic amyloidosis in dogs and cats can result in hepatic rupture and massive intraabdominal hemorrhage.

The value of evaluation for copper in various inflammatory and degenerative conditions of the liver of cats and dogs is a vitally important aspect of pathologic evaluation. Increased hepatic copper storage due to confirmed or suspected primary copper-handling defects occurs in certain breeds, such as Bedlington and Skye Terrier dogs, Dalmatian dogs,[58] and Siamese cats.[57] In other breeds, such as the Doberman Pinscher, Cocker Spaniel, and a host of other breeds including mixed breeds, copper storage can occur as a secondary event associated with chronic active hepatitis. Identification of copper requires use of a special staining procedure, because the presence of copper is difficult to detect on H&E stained sections (Figs. 3-11 and 3-12). Copper storage, regardless of whether it is a primary or secondary event, has important implications for therapy, in that the presence of histochemically apparent copper may warrant inclusion of metal chelating agents in the therapeutic regimen.[59]

Hepatic nodular hyperplasia and hepatic adenoma are difficult to diagnose based on small samples, because both lesions are composed of relatively normal hepatocytes. A description of a mass lesion should be included when submitting such samples. Hemangiosarcoma involving the liver can also be difficult to detect, because lesions can consist mostly of organizing hemorrhage, or neoplastic endothelial cells can diffusely infiltrate and line sinusoids without forming a discrete mass. Nodular lesions due to lymphoma or primary or metastatic carcinoma are generally readily diagnosed on small samples, as is diffuse infiltration due to leukemia or mastocytosis. Special stains such as Giemsa and toluidine blue are useful for confirming hepatic mast cell neoplasia.

## Spleen

Processes affecting the spleen include mass lesions and diffuse infiltrative processes. Mass lesions of the spleen are often hemorrhagic, and bleeding into the abdomen is common.

Hemangiosarcoma is often the first considered when hemorrhagic masses of the spleen are found, but benign lesions such as nodular hyperplasia of older dogs, hematoma, and hemangioma can look similar. In fact, a study by Spangler and Culbertson[60] found that these

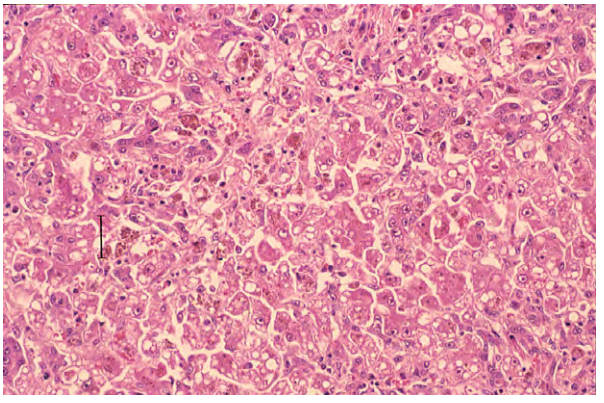


**Fig. 3-11**
Liver from a cat with chronic copper-associated hepatopathy, characterized by marked disruption of architecture and intrahepatocytic pigment granules and vacuoles. Copper granules are not readily distinguished on routinely stained sections (see Fig. 3-12). H&E stain. *(Courtesy Dr. Barry Cooper.)*

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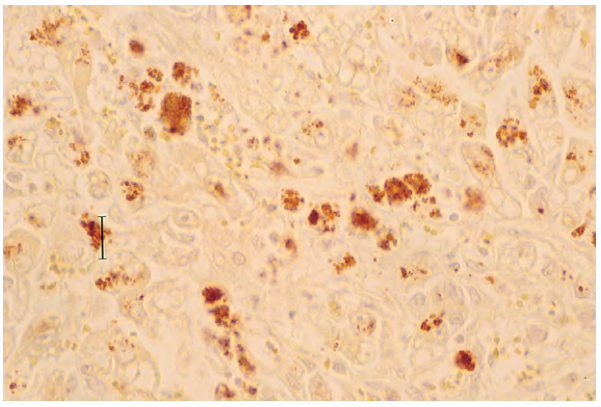


**Fig. 3-12**
Copper granules within hepatocytes often cannot be identified with H&E stain (see Fig. 3-11), but they are readily identified following special staining for copper. Rhodanine stain for copper. *(Courtesy Dr. Barry Cooper.)*

benign lesions were more common in the spleen of dogs than was hemangiosarcoma. Nodular lesions of all types within the spleen are susceptible to development of large areas of hemorrhage and necrosis, which makes histopathologic interpretation difficult even when the entire spleen is submitted for histopathologic study. In many cases, examination of several sections from different areas of the mass and from the interface of the mass and normal spleen are necessary to distinguish hemangiosarcoma from hematoma, hemangioma, or nodular hyperplasia. A definitive diagnosis based on endoscopically obtained splenic biopsy is even more difficult. Other primary tumors forming mass lesions within the spleen include leiomyoma, leiomyosarcoma, fibrosarcoma, and fibrohistiocytic tumors.

Leukemia, lymphoma, myeloproliferative disease, and systemic mastocytosis are the most common infiltrative processes involving the spleen. Infiltrative neoplasia is more common in the spleen of cats than are mass lesions.[61] Interpretation of small splenic samples for anything but mast cell neoplasia is difficult, in that the spleen contains lymphocytic and myeloid elements capable of mitosis, resulting in lymphoid hyperplasia and in marked extramedullary hematopoiesis (EMH). In particular, EMH is common in the spleen of older dogs. In cats with systemic mastocytosis, the presence of mast cells can be overlooked, because cytoplasmic granules are often faint or inapparent on H&E stained sections. Special stains such as Giemsa or toluidine blue readily detect their presence. Cytologic preparations may be useful to clearly identify the presence of atypical neoplastic cells.

Splenic infarcts occur as a result of various underlying systemic disorders and can result in localized swelling suggestive of a mass lesion.[62] Samples obtained from such areas are necrotic, although the cause (arterial thromboembolism) may not be apparent. The splenic capsule of older dogs is susceptible to development of nodules or plaques of firm pale tissue known as siderotic, siderofibrotic or siderocalcific plaques or nodules. These are benign lesions considered to be an incidental finding.

## Pancreas

Biopsy of the pancreas helps distinguish pancreatitis, islet disorders, and neoplastic processes of either the endocrine or the exocrine pancreas. Pancreatic biopsy can also help in diagnosis of exocrine pancreatic atrophy.

Pancreatitis can be accompanied by interstitial inflammation or may be manifest only as necrosis involving the pancreatic parenchyma and the peripancreatic fat. Chronic relapsing pancreatitis is associated with fibrosis and loss of parenchyma.

Degenerative disorders of islets resulting in diabetes mellitus include inflammatory conditions, loss of islets secondary to chronic relapsing pancreatitis, vacuolar degeneration, hypoplasia, and feline islet amyloidosis. When islet disorders are suspected, biopsy of the left (splenic) lobe of the pancreas is advised, because islets are more numerous in this area. In cats, changes of islet amyloidosis are present before onset of overt diabetes and are predictive of eventual development of diabetes mellitus.[63]

Islet cell tumors can be benign (adenoma) or malignant (carcinoma) and are associated with a variety of clinical syndromes depending on the type of hormone produced. Hypoglycemia from insulinoma is most common, but production of gastrin causing hyperplastic gastropathy in dogs (Zollinger-Ellison syndrome)[7] also occurs. Distinguishing a benign from a malignant islet cell tumor generally requires excisional biopsy and histopathologic evaluation for evidence of capsular or vascular invasion, because the cytologic features of the tumor cells of endocrine tumors are often not predictive of behavior.

Nodular masses of the exocrine pancreas include nodular hyperplasia, adenoma, and adenocarcinoma. Nodular hyperplasia often causes a diffuse nodular change within the pancreas of older dogs, characterized histologically by numerous hyperplastic nodules admixed with areas of parenchymal atrophy. This is a common lesion in older dogs and is considered to be a benign incidental finding. Adenomas can arise within areas of nodular hyperplasia. Pancreatic adenoma and adenocarcinoma are less common than nodular hyperplasia.

Exocrine pancreatic atrophy occurs in dogs, particularly German Shepherd dogs, and results in malabsorption. This disorder is thought to be heritable in German Shepherds and rough-coated Collies. It has recently been proposed that loss of exocrine cells is secondary to lymphocytic pancreatitis, suggestive of an immune-mediated

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process. Infiltration of T lymphocytes into acini in early stages of the disorder is not a diffuse process, however, and multiple biopsy samples may be needed to detect inflammatory changes.[64] In later stages, only atrophy and loss of acini are found.

## Adrenal

Adrenal disorders are common in dogs and rare in cats. Hyperplastic conditions can affect the cortex, and neoplasia can arise either in the cortex or the medulla.

Diffuse cortical hyperplasia and cortical adenoma and carcinoma results in hypercortisolemia and associated clinical signs. Nodular hyperplasia of the cortex is a common incidental finding in older dogs. Similar to islet cell tumors, it is often difficult to distinguish adenoma from carcinoma on the basis of cytologic features alone. Evidence of capsular or vascular invasion is the hallmark of cortical carcinoma, and detection of such changes generally necessitates excisional biopsy.

Pheochromocytoma is a tumor of the adrenal medulla that is most common in middle aged to older dogs. Approximately 50% of pheochromocytomas are apparently nonfunctional and are considered an incidental finding. Tumors that produce catecholamines can result in hypertension and nervous signs.[65,66] Because methods of evaluating blood pressure in dogs have only recently been developed, it is likely that many hypertensive dogs with pheochromocytoma have gone undiagnosed in the past. Sudden death in dogs with pheochromocytoma has been attributed to cardiovascular dysfunction such as arrhythmias. Malignant pheochromocytoma often invades into the caudal vena cava, with subsequent metastasis. Pheochromocytoma confined within the medulla results in overall adrenal enlargement. Malignant tumors invade the capsule and often the caudal vena cava. A metastatic rate of 13% to 24% has been reported.[65,66]

## Lymph Node

Endoscopic biopsy of mesenteric or intrathoracic lymph nodes may or may not result in diagnostic samples. To distinguish reactive hyperplasia from lymphoma, the pathologist relies heavily on presence or obliteration of nodal architecture rather than on cytologic features. Nodal architecture is unlikely to be apparent in small nodal samples. Inflammatory conditions may be apparent on small samples. Cytologic preparations can aid in distinguishing reactive hyperplasia from lymphoma. Metastatic neoplasia may or may not be detected in small endoscopic biopsies. In most cases, excisional biopsy is the preferred method of lymph node sampling.

## Urinary Bladder and Urethra

Inflammatory conditions are by far the most common lesion in the urinary bladder mucosa. Inflammatory polyps are common and can mimic neoplasia. The causes of cystitis involve mucosal irritation as well as bacterial infection. As in other tissues, the presence of neutrophils suggests a bacterial component. In cats, a syndrome of feline interstitial cystitis occurs in which submucosal edema, hemorrhage, and vascular reaction with minimal to no inflammation are found.[67] I have occasionally found scattered submucosal eosinophils in urinary bladder samples from dogs and cats. The significance of this finding is not clear, but I suspect that it may represent leakage of urine into the submucosa after epithelial damage.

Transitional epithelial cells within the urinary system are capable of markedly reactive and sometimes dysplastic changes that can mimic neoplasia. Transitional cell carcinoma is the most common tumor within the bladder and urethra of dogs.[68] Diagnosis of transitional cell carcinoma often relies on evidence of invasion, which may not be apparent in mucosal biopsies. Some pathologists may not be willing to give a definitive diagnosis of transitional cell carcinoma on small mucosal samples with epithelial alterations, especially when there is associated inflammation or necrosis.

Mural tumors such as leiomyoma and leiomyosarcoma occur most commonly in the urinary bladder, and rarely within the urethra or ureters.[18] Even if these tumors protrude into the lumen, it may be difficult to diagnose smooth muscle neoplasia with endoscopic biopsies, especially if it is a well-differentiated leiomyoma. A description of a mass lesion is of great benefit to the pathologist evaluating biopsies consisting of slightly disarrayed smooth muscle and trying to determine whether this finding represents sampling artifact, a reactive process, or a smooth muscle neoplasm.

## Joints

Lameness and joint swelling result from inflammatory, hyperplastic, and neoplastic conditions. Arthroscopic biopsy, combined with cytologic evaluation of joint fluid, and bacterial culture, when indicated, are valuable diagnostic procedures in the evaluation of joint disease in dogs and cats.

Inflammatory conditions include bacterial infections, immune-mediated disorders, and “idiopathic” disorders. Neutrophils predominate in the fluid of septic joints and are seen to a variable degree within synovial samples. Bacterial infection is less common in dogs and cats than in large animals. Joint disease due to Lyme disease,[69] systemic lupus erythematosus, idiopathic polyarthritis, and rheumatoid arthritis often results in a large number of neutrophils within joint fluid, but inflammation within synovial samples can be either predominantly neutrophilic or predominantly lymphocytic and plasmacytic with few or no neutrophils.[70] In some cases, it appears that

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neutrophils migrate rapidly from synovial vasculature into the joint space, without infiltrating synovial tissue. A hyperplastic condition with numerous intrasynovial hemosiderophages occurs in dogs that is similar to pigmentary synovitis in horses.[71,72] A lymphoplasmacytic synovitis associated with nodules of intrasynovial cartilage and bone, synovial chondrometaplasia, occurs in dogs.[73] Idiopathic juvenile-onset polyarthritis occurs sporadically in dogs and may have a heritable component in Akitas.[74] In cats, mycoplasma infection and viral-associated progressive polyarthritis can occur.[75,76]

Evaluation of endoscopically obtained synovium and joint capsule for evidence of inflammatory or hyperplastic conditions is generally rewarding. Evaluation of intra-articular tumors, however, is more problematic. The pathologist may be unable to make a definitive diagnosis of neoplasia on small tissue samples. Errors in interpretation are also possible, in that reactive synovium can mimic neoplasia, and well-differentiated synovial neoplasia can be misdiagnosed as a reactive change. The most common intraarticular tumors are synovial sarcoma and myxoma.

## REFERENCES


1. Willard MD and others: Intestinal crypt lesions associated with protein-losing enteropathy in the dog, *J Vet Intern Med* 14:298-307, 2000.
2. Jergens AE, Moore FM: Endoscopic biopsy specimen collection and histopathologic considerations. In Tams TR, editor: *Small animal endoscopy*, ed 2, St Louis, 1990, Mosby.
3. Rowland P: Personal communication, March 11, 2002.
4. Willard MD and others: Quality of tissue specimens obtained endoscopically from the duodenum of dogs and cats, *J Am Vet Med Assoc* 21:474-479, 2001.
5. McEntee MF and others: Granulated round cell tumor of cats, *Vet Pathol* 30:195-203, 1993.
6. Wellman ML and others: Lymphoma involving large granular lymphocytes in cats: 11 cases (1982-1991), *J Am Vet Med Assoc* 201:1265-1269, 1992.
7. Happé RP and others: Zollinger-Ellison syndrome in three dogs, *Vet Pathol* 17:177-186, 1980.
8. Leib MS and others: Endoscopic diagnosis of chronic hypertrophic pyloric gastropathy in dogs, *J Vet Intern Med* 7:335-341, 1993.
9. MacDonald JM, Mullen HS, Moroff SD: Adenomatous polyps of the duodenum in cats: 18 cases (1985-1990), *J Am Vet Med Assoc* 202:647-651, 1993.
10. MacLachlan NJ and others: Gastroenteritis of Basenji dogs, *Vet Pathol* 25:36-41, 1988.
11. Ochoa R, Breitschwerdt EB, Lincoln KL: Immunoproliferative small intestinal disease in Basenji dogs: morphologic observations, *Am J Vet Res* 45:482-490, 1984.
12. Couto CG and others: Gastrointestinal lymphoma in 20 dogs, a retrospective study, *J Vet Intern Med* 3:73-78, 1989.
13. Steinberg H and others: Primary gastrointestinal lymphosarcoma with epitheliotropism in three Shar-Pei and one boxer dog, *Vet Pathol* 32:423-426, 1995.
14. Patnaik AK, Hurvitz AI, Johnson GF: Canine gastrointestinal neoplasms, *Vet Pathol* 14:547-555, 1977.
15. Sautter JH, Hanlon GF: Gastric neoplasms in the dog: a report of 20 cases, *J Am Vet Med Assoc* 166:691-696, 1975.
16. Slawienski MJ and others: Malignant colonic neoplasia in cats: 46 cases (1990-1996), *J Am Vet Med Assoc* 211: 878-881, 1997.
17. Kosovsky JE, Matthiesen DT, Patnaik AK: Small intestinal adenocarcinoma in cats: 32 cases (1978-1985), *J Am Vet Med Assoc* 192:233-235, 1988.
18. Cooper BJ, Valentine BA: Tumors of muscle. In Meuten DJ, editor: *Moulton's tumors in domestic animals*, ed 4, Ames, 2002, Iowa State Press.
19. Ridgway RL, Suter PF: Clinical and radiographic signs in primary and metastatic esophageal neoplasms of the dog, *J Am Vet Med Assoc* 174:700-704, 1979.
20. Baez JL and others: Radiographic, ultrasonographic, and endoscopic findings in cats with inflammatory bowel disease of the stomach and small intestine: 33 cases (1990-1997), *J Am Vet Med Assoc* 215:349-354, 1999.
21. Dennis JS, Kruger JM, Mullaney TP: Lymphocytic/plasmacytic gastroenteritis in cats: 14 cases (1985-1990), *J Am Vet Med Assoc* 200:1712-1718, 1992.
22. Dennis JS, Kruger JM, Mullaney TP: Lymphocytic/plasmacytic colitis in cats: 14 cases (1985-1990), *J Am Vet Med Assoc* 202:313-318, 1993.
23. Jacobs G and others: Lymphocytic-plasmacytic enteritis in 24 dogs, *J Vet Intern Med* 4:45-53, 1990.
24. Jergens AE and others: Idiopathic inflammatory bowel disease in dogs and cats: 84 cases (1987-1990), *J Am Vet Med Assoc* 201:1603-1609, 1992.
25. Kimmel SE, Waddell LS, Michel KE: Hypomagnesemia and hypocalcemia associated with protein-losing enteropathy in Yorkshire terriers: five cases (1992-1998), *J Am Vet Med Assoc* 217:703-706, 2000.
26. Littman MP and others: Familial protein-losing enteropathy and protein-losing nephropathy in soft coated Wheaten terriers: 222 cases (1983-1997), *J Vet Intern Med* 14:68-80, 2000.
27. Manners HK and others: Characterization of intestinal morphologic, biochemical, and ultrastructural features in gluten-sensitive Irish setters during controlled oral gluten challenge exposure after weaning, *Am J Vet Res* 59: 1435-1440, 1998.
28. Willard MD and others: Interobserver variation among histopathologic evaluations of intestinal tissues from dogs and cats, *J Am Vet Med Assoc* 220:1177-1182, 2002.
29. Yamasaki K, Suematsu H, Takahashi T: Comparison of gastric and duodenal lesions in dogs and cats with and without lymphocytic-plasmacytic enteritis, *J Am Vet Med Assoc* 201:95-97, 1996.


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30. Reinacher M: Feline leukemia virus-associated enteritis: a condition with features of feline panleukopenia, *Vet Pathol* 24:1-4, 1987.
31. Curtsinger DK, Carpenter JL, Turner JL: Gastritis caused by *Aonchotheca putorii* in a domestic cat, *J Am Vet Med Assoc* 203:1153-1154, 1993.
32. Happonen I and others: Detection and effects of helicobacters in healthy dogs and dogs with signs of gastritis, *J Am Vet Med Assoc* 213:1767-1774, 1998.
33. Yamasaki K, Suematsu H, Takahashi T: Comparison of gastric lesions in dogs and cats with and without gastric spiral organisms, *J Am Vet Med Assoc* 212:529-533, 1998.
34. Lee A and others: Role of *Helicobacter felis* in chronic canine gastritis, *Vet Pathol* 29:487-494, 1992.
35. Simpson K and others: The relationship of *Helicobacter* spp. infection to gastric disease in dogs and cats, *J Vet Intern Med* 14:223-227, 2000.
36. Gookin JL and others: Diarrhea associated with trichomonosis in cats, *J Am Vet Med Assoc* 215:1450-1454, 1999.
37. Wilson RB, Holscher MA, Lyle SJ: Cryptosporidiosis in a pup, *J Am Vet Med Assoc* 183:1005-1006, 1983.
38. Collins JE and others: *Enterococcus (Streptococcus) durans* adherence in the small intestine of a diarrheic pup, *Vet Pathol* 25:396-398, 1988.
39. Hélie P, Higgins R: Diarrhea associated with *Enterococcus faecium* in an adult cat, *J Vet Diagn Invest* 11:457-458, 1999.
40. Jergens AE and others: Adherent gram-positive cocci on the intestinal villi of two dogs with gastrointestinal disease, *J Am Vet Med Assoc* 198:1950-1952, 1991.
41. Collins JE, Libal MC, Brost D: Proliferative enteritis in two pups, *J Am Vet Med Assoc* 183, 886-889, 1983.
42. Nimmo Wilkie JS, Barker IK: Colitis due to *Bacillus piliformis* in two kittens, *Vet Pathol* 22:649-652, 1985.
43. Hargis AM, Prieur DJ, Blanchard JL: Prevalence, lesions, and differential diagnosis of *Ollulanus tricuspis* infection in cats, *Vet Pathol* 20:71-79, 1983.
44. Van Kruiningen HJ and others: Lipogranulomatous lymphangitis in canine intestinal lymphangiectasia, *Vet Pathol* 21:377-383, 1984.
45. Rogers KS and others: Rectal hemorrhage associated with vascular ectasia in a young dog, *J Am Vet Med Assoc* 200:1349-1351, 1992.
46. Rutgers HC and others: Small intestinal bacterial overgrowth in dogs with chronic intestinal disease, *J Am Vet Med Assoc* 206:187-193, 1995.
47. Willard MD and others: Diarrhea associated with myenteric ganglionitis in a dog, *J Am Vet Med Assoc* 193:346-348, 1988.
48. O'Brien RT and others: Radiographic findings in cats with intranasal neoplasia or chronic rhinitis: 29 cases (1982-1988), *J Am Vet Med Assoc* 208:385-389, 1996.
49. Patnaik AK and others: Canine sinonasal skeletal neoplasms: chondrosarcomas and osteosarcomas, *Vet Pathol* 21:475-482, 1984.
50. Patnaik AK and others: Paranasal meningioma in the dog: a clinicopathologic study of ten cases, *Vet Pathol* 23:362-368, 1986.
51. DiBartola SP and others: Familial renal amyloidosis in Chinese Shar Pei dogs, *J Am Vet Med Assoc* 197:483-487, 1990.
52. Chew DJ and others: Renal amyloidosis in related Abyssinian cats, *J Am Vet Med Assoc* 181:139-142, 1982.
53. Picut CA, Lewis RM: Comparative pathology of canine hereditary nephropathies: an interpretive review, *Vet Res Commun* 11:561-581, 1987.
54. Rha J-Y and others: Familial glomerulopathy in a litter of beagles, *J Am Vet Med Assoc* 216:46-50, 2000.
55. Cole TL and others: Diagnostic comparison of needle and wedge biopsy specimens of the liver in dogs and cats, *J Am Vet Med Assoc* 220:1483-1490, 2002.
56. Loeven KO: Hepatic amyloidosis in two Chinese Shar Pei dogs, *J Am Vet Med Assoc* 204:1212-1216, 1994.
57. Haynes JS, Wade PR: Hepatopathy associated with excessive hepatic copper in a Siamese cat, *Vet Pathol* 32:427-429, 1995.
58. Cooper VL and others: Hepatitis and increased copper levels in a Dalmatian, *J Vet Diagn Invest* 9:201-203, 1997.
59. Twedt DC: Copper chelator therapy. Proceedings of the 10th ACVIM Forum, San Diego, May 1992, pp 53-55.
60. Spangler WL, Culbertson MR: Prevalence, type, and importance of splenic diseases in dogs: 1,480 cases (1985-1989), *J Am Vet Med Assoc* 200:829-834, 1992.
61. Spangler WL, Culbertson MR: Prevalence and type of splenic diseases in cats: 455 cases (1985-1991), *J Am Vet Med Assoc* 201:773-776, 1992.
62. Hardie EM and others: Splenic infarction in 16 dogs: a retrospective study, *J Vet Intern Med* 9:141-148, 1995.
63. O'Brien TD and others: High dose intravenous glucose tolerance test and serum insulin and glucagon levels in diabetic and non-diabetic cats: relationships to insular amyloidosis, *Vet Pathol* 22:250-261, 1985.
64. Wiberg ME, Saari SAM, Westermarck E: Exocrine pancreatic atrophy in German shepherd dogs and rough-coated collies: an end result of lymphocytic pancreatitis, *Vet Pathol* 36:530-541, 1999.
65. Gilson SD and others: Pheochromocytoma in 50 dogs, *J Vet Intern Med* 8:228-232, 1994.
66. Barthez PY and others: Pheochromocytoma in dogs: 61 cases (1984-1995), *J Vet Intern Med* 11:272-278, 1997.
67. Buffington CAT, Chew DJ, Woodworth BE: Feline interstitial cystitis, *J Am Vet Med Assoc* 215:682-687, 1999.
68. Norris AM and others: Canine bladder and urethral tumors: a retrospective study of 115 cases (1980-1985), *J Vet Intern Med* 6:145-153, 1992.
69. Kornblatt AN, Urband PH, Steere AC: Arthritis caused by *Borrelia burgdorferi* in dogs, *J Am Vet Med Assoc* 186: 960-964, 1985.
70. Pedersen NC, Pool R: Canine joint disease, *Vet Clin North Am* 8:465-493, 1978.

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71. Kusba JK and others: Suspected villonodular synovitis in a dog, *J Am Vet Med Assoc* 182:390-393, 1983.
72. Somer T and others: Pigmented villonodular synovitis and plasmacytoid lymphoma in a dog, *J Am Vet Med Assoc* 197:877-879, 1990.
73. Flo GL, Stickle RL, Dunstand RW: Synovial chondrometaplasia in five dogs, *J Am Vet Med Assoc* 191:1417-1422, 1987.
74. Dougherty SA and others: Juvenile-onset polyarthritis syndrome in Akitas, *J Am Vet Med Assoc* 198:849-856, 1991.
75. Pedersen NC, Pool RR, O'Brien T: Feline chronic progressive polyarthritis, *Am J Vet Res* 41:522-535, 1980.
76. Moise NS and others: *Mycoplasma gateae* arthritis and tenosynovitis in cats: case report and experimental reproduction of the disease, *Am J Vet Res* 44:16-21, 1983.

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# 4 Cystoscopy

*Timothy C. McCarthy*

Cystoscopy has been an integral part of urology in human medicine for more than 100 years, but until recently, it has been virtually ignored in veterinary medicine. Lower urinary tract disorders comprise a significant portion of diseases diagnosed and treated in small animal practice, yet this cornerstone of diagnosis and management of human disease has received only limited application in veterinary medicine, even with readily available cost-effective instrumentation.

Cystoscopy in the dog was first reported by Vermooten in 1930 as a technique for use in research.[1] Clinical diagnostic application of cystoscopy in small animals began appearing in the literature in the mid-1980s and has been largely concentrated on female dogs.[2-6] In the same time period, cystoscopy in male dogs was also described transurethrally,[3,4] by percutaneous perineal puncture,[4,7] and by prepubic percutaneous puncture.[8] Clinical use of cystoscopy was not reported in the cat until 1986.[8] Ureteral catheterization in female dogs under transurethral cystoscopic guidance has also been described.[3,5] The first therapeutic application of cystoscopy was evaluated using electrohydraulic shock wave lithotripsy for bladder stone removal in dogs.[9] In human medicine, cystoscopy is routinely used for diagnosing and managing a wide variety of lower urinary tract disease.[10-14] Cystoscopy has also been used in various animal species for research applications.

Many of the cited veterinary publications have originated from university practices where economics have not been a consideration. My experience has evolved from a private small animal surgical referral practice wherein cystoscopy has not only been economically possible but also financially rewarding.

Advantages of cystoscopy over other diagnostic techniques are many. Cystoscopy provides noninvasive direct visualization of the vagina, urethral opening, urethra, bladder, and ureteral openings. Visualization of these structures, even where accessible by surgery, is far superior with cystoscopy because of magnification provided by the instrumentation, excellent lighting, and lack of distortion that occurs with cystotomy or other surgical entry into the urinary tract.

The complete range of male and female dogs and cats encountered in small animal practice can be evaluated via transurethral cystoscopy (TUC) with currently available instrumentation. Prepubic percutaneous cystoscopy (PPC) can also be used for evaluation of the bladder and proximal urethra where TUC is not possible due to an inadequate selection of instrumentation or because of urethral pathology.

My experience with cystoscopy began in 1983, and the techniques, normal anatomy, and abnormal findings described in this chapter are taken from that experience. During this 19-year period, 462 cystoscopic procedures were performed on 389 cases (Table 4-1). TUC was performed in 213 female dogs ranging in size from 2.3 to 50 kg, 102 male dogs ranging in size from 3.5 to 59 kg, 46 female cats, 29 male cats, 33 male cats immediately after perineal urethrostomy surgery had been performed, 1 tortoise, and 1 llama. PPC was used to evaluate

*Table* **4-1** **Cystoscopic Procedures**

(462 Procedures in 389 cases from 8/1/83 to 8/1/02)

**Transurethral Cystoscopy (TUC)**

213 Female dogs (2.3 kg to 50 kg)
102 Male dogs (3.5 kg to 59 kg)
29 Male cats
33 Male cats posturethrostomy
46 Female cats
1 Llama
1 Tortoise

**Prepubic Percutaneous Cystoscopy (PPC)**

17 Male dogs (5.9 kg to 41 kg)
10 Male cats
3 Female dogs (19 kg to 34 kg)
7 Pigs



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*Table* 4-2 Diagnoses with Cystoscopy

(462 Procedures in 389 cases from 8/1/83 to 8/1/02)
Normal: 47 (12%)
Inflammatory disease: 120 (31%)
Neoplasia: 79 (20%)
Anatomic abnormalities: 33 (8%)
Trauma: 62 (16%)
Calculi: 46 (12%)
Renal hematuria: 2 (0.5%)
Foreign body: 1 (0.5%)

17 male dogs varying in size from 5.9 to 41 kg, 3 female dogs ranging in size from 19 to 34 kg, 10 male cats, and 7 pigs. Diagnoses in this series of procedures are listed in Table 4-2.

## INDICATIONS

A wide variety of urinary tract pathology can be assessed by cystoscopy (see Table 4-2). Tumors that originate in or penetrate the mucosa can be visualized, their extent evaluated, and biopsies done. Chronic inflammation can be defined and biopsy samples obtained for histopathology and mucosal culture studies. The extent of inflammatory involvement can be evaluated and the ability of the bladder to distend and contract can be assessed. Small cystic and urethral calculi can be removed therapeutically and for stone analysis. Larger stones can be crushed or exploded with electrohydraulic or laser lithotripsy if necessary before removal. TUC is the procedure of choice for assessment of urinary trauma in that the entire urinary tract can be easily and quickly assessed. TUC is also the procedure of choice for diagnosis and definition of ectopic ureters. Bladder diverticula are assessed effectively by cystoscopy. Use of cystoscopy is limited to lesions that are visible within the lumen of the urethra and bladder, lesions that involve the mucosa, and the ureteral openings.

Any chronic or acute urinary tract disease that is difficult to resolve is an indication for cystoscopy (Box 4-1). Cystoscopy is part of a complete database for assessment of the patient with lower urinary tract disease and is a primary diagnostic tool for urinary tract evaluation. The question is not *if* cystoscopy is indicated in management of lower urinary tract disease, but rather *when* is cystoscopy indicated in management of lower urinary tract disease.

### Chronic Cystitis

Cystitis that has not responded to initial conservative medical treatment or when a definitive diagnosis has not been established by less invasive techniques are indications for cystoscopy. The time in case management when cystoscopy is indicated varies among patients. Selecting cystoscopy as a diagnostic approach is a consideration at the same time as or before contrast cystography or ultrasonography is performed. Cystoscopy provides more information than contrast radiographic studies or ultrasonography in most cases of chronic cystitis. Biopsy specimens can be obtained from the bladder for histopathology and for culture and sensitivity studies.

**Box 4-1 Indications for Cystoscopy**

Chronic cystitis
Hematuria
Tenesmus (stranguria)
Increased urinary frequency (pollakiuria)
Urinary incontinence
Alteration of urinary stream
Trauma
Cystic or urethral calculi
Neoplastic cells in sediment
Abnormal radiographic findings
Abnormal ultrasound findings

### Hematuria

Persistent low-grade hematuria and acute severe hematuria are important indications for cystoscopy or cystourethroscopy. Multiple etiologies of hematuria can be ruled out with endoscopic evaluation and the origin of the bleeding can be localized. In older female dogs a common cause of chronic nonresponsive hematuria is neoplasia. Masses can be found, defined, and biopsied more easily and earlier with cystoscopy than with other diagnostic tools. Renal bleeding can be localized by evaluation of urine character as it comes from the ureters. The involved kidney or kidneys can be determined, and, with catheterization of the ureter, specific samples can be collected. Bladder wall hemorrhage can be determined and appropriate specimens taken to establish an etiology.

### Tenesmus or Stranguria

Straining to urinate is a frequent sign of cystitis and urethritis, but it may also be due to other causes. In addition to cystitis or urethritis, tenesmus can be caused by neoplasia, cystic calculi, urethral calculi, prostatic disease, urethral obstruction due to strictures, and nonurologic diseases. Differentiation of etiologies can be assisted with cystoscopy and urethroscopy. Assessment of the urethra in female dogs demonstrating chronic signs of lower urinary tract disease is important as a more positive outcome may become possible with early diagnosis when managing urethral transitional cell carcinomas.[15-17] A case in point is an 8-year-old female Dachshund

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that had symptoms of straining and difficulty urinating. Cystourethroscopy revealed a small urethral transitional cell carcinoma in situ that was removed surgically. This dog was asymptomatic for 3 years after surgery. This is an individual case and does not imply that surgical removal is an effective treatment in all cases. However, most transitional cell carcinomas are diagnosed when they involve extensive areas of the urethra or bladder and are not resectable. This case simply illustrates the importance of cystoscopy for early diagnosis.

## Increased Frequency of Urination

Pollakiuria can be a sign of lower urinary tract disease but may also be an indication of polyuria. Cystoscopy is beneficial in establishing an etiology of lower urinary tract disease or ruling out its involvement as the cause of the increased frequency of urination.

## Urinary Incontinence

Urine dribbling, particularly in the younger female dog, is a sign that warrants endoscopic assessment of the lower genitourinary tract. A common cause of incontinence in younger female dogs is ectopic ureters. The vagina, urethra, and trigone area of the bladder are accurately and easily assessed using TUC. Magnification provided by endoscopy allows the ureteral openings to be found anywhere in the lower urinary tract and their pathology defined and categorized. Urethral deformities are also commonly found with ectopic ureters and these can be accurately defined. Hydroureters are frequently associated with ectopic ureters and can be assessed because the endoscope can be passed into the dilated ureters in many cases. The prognosis for ectopic ureter surgery is related to the location of entry of the ureters into the lower urinary tract and to ureteral and urethral pathology. Therefore accuracy associated with cystoscopic evaluation is essential to preoperative assessment. Radiographic examinations for ectopic ureters by excretory urography can, in some cases, establish a diagnosis, but accurate placement of the ureteral openings and an understanding of urethral pathology is difficult at best. Ultrasound evaluation of ureteral and urethral pathology is also less rewarding than cystoscopy and is hampered by the presence of the pelvis. Surgical assessment of abnormal ureteral anatomy is extremely difficult in that ectopic ureters can travel for long distances within the urethral wall. Ectopic ureters are commonly found to enter the exterior surface of the bladder wall at a normal location and pass caudally variable distances within the urethral wall before opening into the urethral lumen. They can course the full length of the urethral wall to open at the urethral orifice. At surgery, it may only be possible to determine that the ureter enters the bladder wall at a normal location; it can be very difficult to locate the ureteral openings or extensive dissection may be required to fully define ureteral and urethral pathology. For these reasons TUC is the procedure of choice for evaluation and diagnosis of urinary incontinence in young female dogs.

Incontinence in older female dogs can be due to a variety of causes, both urinary and nonurinary in origin. Assessment of the lower urinary tract is essential to a complete understanding of incontinence and to rule out specific pathology such as urethral tumors.

## Alteration of Urinary Stream

Changes in the size and shape of the urine stream can be an indication of urethral pathology including prostatitis, calculi, strictures, and tumors. These conditions are all easily assessed with TUC.

## Trauma

TUC is the procedure of choice for evaluation of urinary tract trauma in female dogs and cats. Availability of small flexible instrumentation with distal tip deflection control has expanded traumatic indications for TUC to include male dogs. Significant trauma to the entire urinary tract can be effectively ruled out with TUC. Contusions, mucosal tears, penetrating lacerations, bladder ruptures, and ureteral and kidney trauma can be evaluated. Integrity of the kidneys and ureters can be determined by observation of clear urine coming from both ureters. Absence of urine or presence of significant hematuria is an indication for further upper urinary tract assessment. A review of cystoscopic findings in 36 consecutive cases with pelvic fractures revealed a 92% incidence of urinary tract trauma[18] (Table 4-3). This compares with a 39% incidence of urinary tract trauma in 100 consecutive cases with pelvic fractures diagnosed with contrast radiography.[19] A large percentage of cases of urinary tract trauma can be managed conservatively by maintaining bladder decompression until the lesions heal.

Evaluation of the urinary tract can be done as a separate procedure or at the time of anesthesia for orthopedic reconstructions. If bladder trauma requiring surgery is found at this time, the orthopedic procedure is delayed,

*Table* **4-3** Cystoscopic Findings in Dogs and Cats with Pelvic Fractures

| (38 Procedures in 36 cases) |
|---|
| 3 Normal (8%) |
| 22 Contusions, petechia, or ecchymoses (67%) |
| 9 Mucosal disruption or necrosis (27%) |
| 2 Bladder rupture (6%) |
| 33 Clear urine from both ureters (92%) |
| 3 Bloody urine from one ureter (8%) |

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and the urinary system reconstructed. The time and expense involved in endoscopic evaluation of the traumatized urinary tract is less than that required for radiographic assessment either by excretory urography or by cystourethrography. If small flexible instrumentation is not available for evaluation of males, then positive contrast cystourethrography is employed. Normal appearing micturition does not rule out significant urinary tract compromise. The common occurrence of urinary tract damage in caudal abdominal and pelvic trauma, and the severe consequences of delayed diagnosis, both to the patient and for the client in accurate cost estimation and prognostication, make accurate assessment of urinary tract damage critical.

### Cystic and Urethral Calculi

Cystic and urethral calculi may cause tenesmus, hematuria, chronic nonresponsive cystitis, and alteration of the urine stream, all of which are indications for cystoscopy. Calculi seen as incidental findings on radiographs obtained for other reasons are also an indication for cystoscopy. When cystic calculi are diagnosed radiographically or by palpation, cystoscopy may be performed to obtain stone samples for analysis along with mucosal biopsies for histopathology and culture. Appropriate medical and dietary therapy can then be used for responsive calculi based on accurate knowledge of stone composition. Surgery could thus be avoided. Therapeutic removal of smaller stones can be done with foreign body graspers, biopsy forceps, stone removal baskets, or by irrigation and suction. Larger stones require crushing or lithotripsy before removal.

## INSTRUMENTATION

A wide variety of cystoscopes are available for human use but many are too large for small animal patients. Small-bore rigid human cystoscopes are adequate in size for TUC in medium to large size female dogs. To perform TUC in smaller female dogs, female cats, and male cats that have had a perineal urethrostomy performed, pediatric cystoscopes or rigid endoscopes designed for other applications are used. Specific instrumentation is also available for performing suprapubic percutaneous cystoscopy in human medicine but is again too large for most small animal applications. Arthroscopes are ideally suited for PPC in dogs and cats. Small flexible endoscopes from human urogenital endoscopy and from applications other than cystoscopy are available for performing TUC in male dogs and male cats. Instrumentation for obtaining biopsy specimens, lithotripsy and stone removal, tumor and polyp removal, and stricture dilation are available in sizes that can be used with this instrumentation in small animal patients.

### Instrumentation for Transurethral Cystoscopy in Female Dogs and Cats

Cystoscopy systems for transurethral procedures in female dogs and cats include telescopes, cannulae, sheaths or sleeves, trocars and obturators, bridges, and operative instrumentation.

#### Telescopes (Fig. 4-1)

For TUC, the telescopes that apply most effectively to small animal practice include a 1.9-mm diameter, 30-degree cystoscope (Karl Storz Model #63017BA) with a working length of 18.5 cm; the 2.7-mm diameter, 30-degree multipurpose telescope (Karl Storz Model #64018BS) with a working length of 18.5 cm; and a 4-mm diameter, 30-degree cystoscope (Karl Storz Model #63005BA) with a working length of 30 cm. A 30-degree viewing angle has been found to be the optimum angle for rigid cystoscopes in small animal applications. This angulation greatly increases the area that can be examined because the telescope can be rotated 360 degrees to evaluate structures not directly in line with the axis of the instrument.

#### Cannulae or Sheaths (Fig. 4-2)

Cystoscopy cannulae for the telescopes that are applicable to small animal patients are 10 French (2.6 mm × 3.8 mm) for the 1.9-mm diameter cystoscope (Karl Storz Model #67031E), 14 French (3.8 mm × 5.5 mm) for the 2.7-mm diameter multipurpose telescope (Karl Storz Model #67065C), and the 4-mm diameter cystoscope, which has multiple cannulae that range from 17 French to 25 French. Size 17 French (5 mm × 6.5 mm) (Karl Storz Model #63026U) and 20 French (6 mm × 8 mm) (Karl Storz Model #63026C) have been commonly used. The 10-French

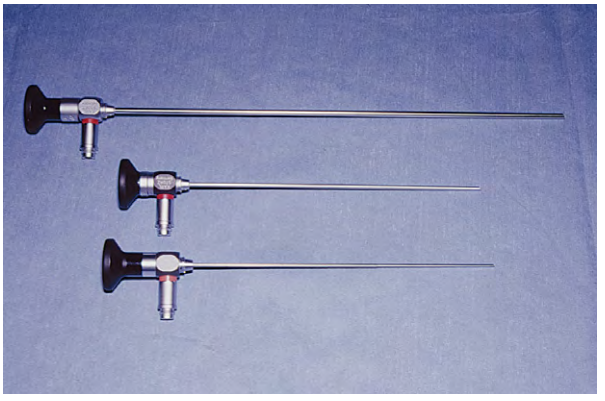


**Fig. 4–1**
Rigid endoscopic telescopes used for transurethral cystoscopy in female dogs and cats. From top to bottom: 4-mm diameter cystoscope with 30-degree viewing angle, 2.7-mm diameter multipurpose telescope with 30-degree viewing angle, and 1.9-mm diameter cystoscope with 30-degree viewing angle.

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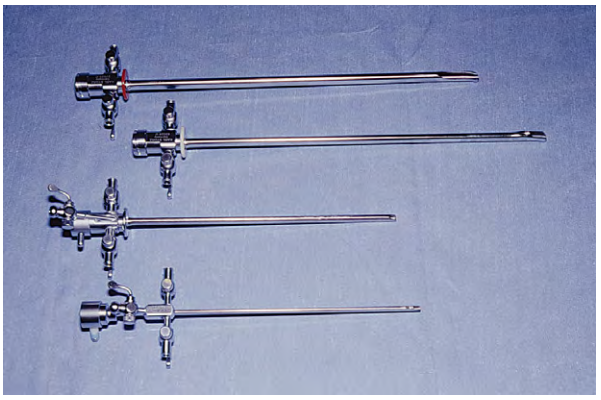


**Fig. 4–2**
Cannulae for the telescopes that are used for transurethral cystoscopy in female dogs and cats. From top to bottom: 20-French (6 mm × 8 mm) cannula and 17-French (5 mm × 6.5 mm) for use with the 4.0-mm diameter cystoscope, 14-French (3.8 mm × 5.5 mm) cannula for the 2.7-mm diameter multipurpose telescope, and the 10-French (2.6 mm × 3.8 mm) cannula for the 1.9-mm diameter cystoscope. Cannulae for the 4-mm diameter cystoscope have a working length of 23 cm and are available with one or two fluid connection ports. These cannulae are used with bridges having one, two, or three channels for passage of operative instrumentation. The 14-French cannula for the 2.7-mm multipurpose telescope has a 16.3 cm working length, two fluid ports, and a single 1.7-mm diameter (5 French) biopsy channel. The 10-French cannula has a working length of 14.3 cm, two fluid ports, and a single 1.2-mm diameter (3.5 French) biopsy channel. These two bottom cannulae are one-piece construction without a separate bridge.

cannula for use with the 1.9-mm diameter cystoscope has a working length of 14.3 cm, two fluid ports, and a single 1.2-mm diameter (3.5 French) biopsy channel. The 14-French cannula for the 2.7-mm multipurpose telescope has a 16.3 cm working length, two fluid ports, and a single 1.7-mm diameter (5 French) biopsy channel. These two cannulae are one-piece construction without a separate bridge. Cannulae for the 4-mm diameter cystoscope have a working length of 23 cm and are used with a bridge between the telescope and cannula. These cannulae are available with one or two fluid connection ports and bridges having one, two, or three channels for passage of operative instrumentation ranging from one 5-French instrument for the 17-French cannula up to one 12-French instrument or multiple smaller instruments for the 25- French cannula.

A cystoscopy cannula (Karl Storz Model #61029D) is also available for the short 1.9-mm arthroscope with a working length of 7 cm, an oval cross-sectional configuration with dimensions of 2.5 mm × 3.6 mm (9 French), and a biopsy channel that accepts 1-mm diameter (3 French) biopsy forceps. This cannula is too short for examination of anything more than the distal urethra and is not recommended.

## Obturators

Blunt obturators are available for use while passing the cannulae into and through the urethra with a blind passage technique rather than by direct visualization. This technique is used in human medicine but has not been used by the author in small animal patients. The obturators are therefore not needed.

## Bridges

Adaptors or bridges are used to connect the 4-mm telescopes to the cystoscope cannulae. Bridges are available that are straight with no instrument access port for examination only or with one, two, or three instrument access ports. Cannulae for the 1.9-mm and 2.7-mm telescopes, because of their smaller size, do not use a bridge but use a one-piece cannula with biopsy and irrigation ports. A special type of bridge, with a biopsy or catheter deflecting mechanism, called an *Albarran lever*, has an extension that runs the full length of the cannula with a lever at the tip that bends the biopsy forceps, grasping instrumentation, catheters, or stone baskets to allow working out of the axis of the rigid endoscope (Karl Storz Model #63026E) (Fig. 4-3). The 30-degree telescope allows visualization within the deflection range of the Albarran lever. Operating bridges are also available that bend instrumentation into the visual range of 70- and 110-degree telescopes. Channels in cystoscopy bridges and cannulae allow passage of flexible instrumentation from 3 French with the smaller systems up to one 12-French instrument or multiple smaller instruments depending on the size of the cannula and configuration of the bridge.

## Accessory Instrumentation (Fig. 4-4)

Flexible biopsy forceps (Karl Storz Model #61071ZJ [3 French], #67161Z [5 French], and #63177A [7 French]), stone or foreign body graspers (Karl Storz Model #61071TJ [3 French], #67161T [5 French], and #27175A [7 French]), stone baskets (Karl Storz Model #67023VV [5 French] and Microvasive #300-311 [3 French], and #300-104 [5 French]: multiple sizes and configurations available), polypectomy snares (Karl Storz Model #26159L [5 French] and Microvasive #550-180 [7 French]), cytology brushes (Cook Veterinary Products V-ECB-5-180-3-S [5 French] and Microvasive 510-104 [3 French] and 510-100 [5 French]), balloon dilation catheters (Microvasive #218-110 [3 French], #221-200 [5 French], and #217-200 [6 French]: multiple sizes and configurations

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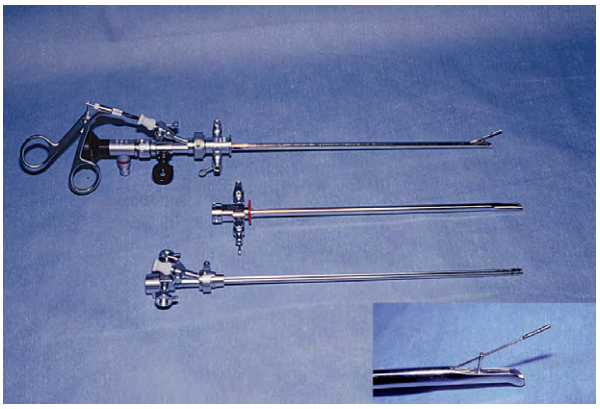


**Fig. 4-3**
A deflecting bridge or Albarran lever is available for use with the 4-mm cystoscope with a single 2.3-mm diameter (7 French) biopsy channel. At the top of the figure is an assembled cystoscope with telescope, 20-French cannula, Albarran lever bridge, and biopsy forceps passing through the instrument channel. In the center of the figure is the cannula, and at the bottom is the Albarran lever bridge. The insert is a close-up view of the tip of the Albarran deflector shown bending a flexible biopsy forceps.

available), laser fibers (AccuVet #BFHF-403 [400 micron], #BFHF-603 [600 micron], and #BFHF-1003 [1000 micron]: multiple sizes and configurations available), and many other operative instruments are available for use with these cystoscopy cannula systems. This instrumentation ranges in size from 3 French for use with the smallest systems to 12 French for the largest cystoscope sheaths. Applications in small animal patients have most commonly used 3- to 7-French biopsy forceps, stone and foreign body graspers, balloon dilation catheters, stone baskets, and laser fibers.

Arthroscopy instrumentation is primarily used for PPC but can also be used for TUC. This instrumentation has the primary advantage of smaller cannula size relative to telescope size, allowing transurethral examination of smaller female dogs and female cats, and facilitating examination of male cats after perineal urethrostomy surgery has been performed. The primary disadvantage of using arthroscopy cannulae for cystoscopy is that they do not have instrument channels. Arthroscopy systems used for cystoscopy include the telescopes, cannulae or sleeves, sharp trocars, second puncture cannulae with their trocars, and instrumentation for obtaining biopsy specimens, removing stones, performing lithotripsy, removing tumors and polyps, and dilating strictures.

Rigid telescopes have limited applications for TUC in male dogs and cats. Male cats can be examined transurethrally with a 1-mm diameter semirigid telescope and with either the 1.9-mm diameter cystoscope or the

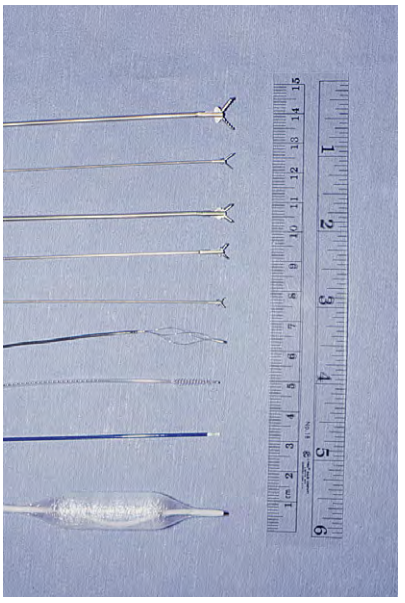


**Fig. 4-4**
Accessory instrumentation for use with rigid endoscopes for transurethral cystoscopy in female dogs and cats. From top to bottom: Alligator-type foreign body or stone graspers in 7-French and 3-French sizes, apposing cup biopsy forceps in 7-French, 5-French, and 3-French sizes, a 3-French three-wire stone basket, a 5-French cytology brush, a 1000-micron laser fiber, and a 6-French balloon dilation catheter. All these instruments are flexible to allow passage through the curved portion of the channel in the cystoscope bridges and for deflection by the Albarran lever.

2.7-mm diameter multipurpose rigid telescope after a perineal urethrostomy has been performed. The distal straight portion of the urethra of some giant male dogs can also been examined with these small rigid endoscopes.

The three sizes of cystoscope systems effectively cover the size range of patients seen in small animal practice. The 4-mm telescope and its cannulae (Fig. 4-5) have been used for TUC in female dogs larger than 40 lb. Cystoscopy is performed in small female dogs weighing less than 40 to 50 lb and in some larger female cats with the 2.7-mm multipurpose rigid telescope (Fig. 4-6). Most female cats and the smallest female dogs and puppies can be examined with the 1.9-mm cystoscope (Fig. 4-7). The cutoff between the different size cystoscopes depends on urethral size and length.

## Instrumentation for Prepubic Percutaneous Cystoscopy in Dogs and Cats

Instrumentation systems for PPC include the rigid telescopes, cannulae with sharp trocars, second puncture cannulae and trocars, and operative instrumentation.

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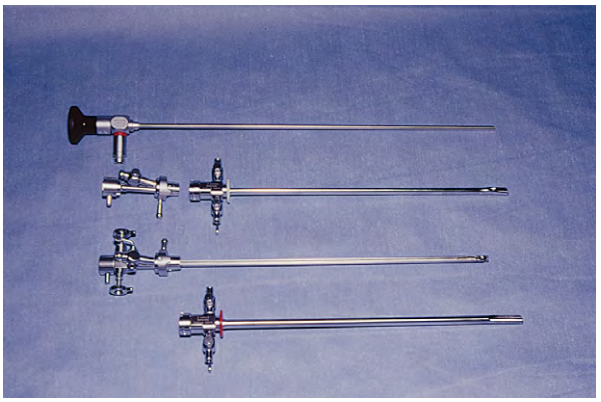


**Fig. 4–5**
Cystoscopy set for the 4-mm Storz cystoscope. From top to bottom: The telescope with an overall length of 35.5 cm, a working length of 30 cm, and a 30-degree viewing angle. The top cannula shown for this set has dimensions of 17 French (5 mm × 6.5 mm), a working length of 23 cm, two fluid ports, and a biopsy channel that is large enough to allow passage of one 5-French or two 4-French instruments. The bridge shown for use with this cannula has a single biopsy channel that allows passage of one 5-French (1.7-mm diameter) instrument. The second bridge shown for use with the 20-French cannula is a deflecting bridge or Albarran lever with a single 2.3-mm diameter (7 French) biopsy channel. The bottom cannula shown has dimensions of 20 French (6 mm × 8 mm), a working length of 23 cm, two fluid ports, and a biopsy channel that allows passage of one 7-French or two 5-French instruments.

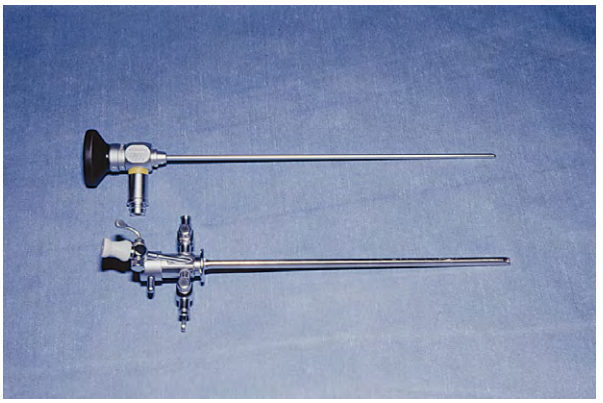


**Fig. 4–6**
Cystoscopy set for the 2.7-mm Storz multipurpose telescope. From top to bottom: The telescope, which has an overall length of 23.2 cm, a working length of 18 cm, and a 30-degree angle of view. The one-piece cannula has outside dimensions of 14 French (3.8 mm × 5.5 mm), a working length of 16.3 cm, two fluid ports, and a single biopsy channel that allows passage of one 5-French (1.7-mm diameter) instrument.

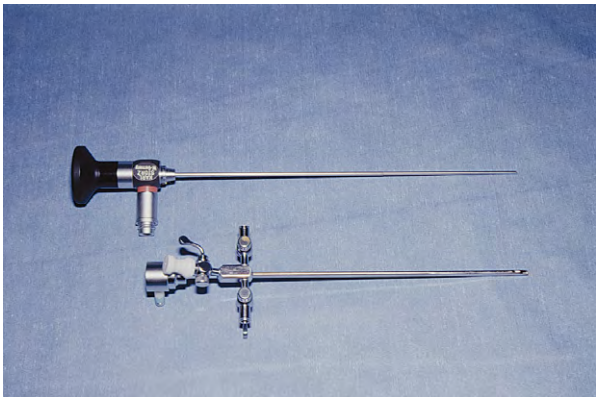


**Fig. 4–7**
Cystoscopy set for the 1.9-mm Storz cystoscope. From top to bottom: The telescope with an overall length of 24 cm, a working length of 18.5 cm, and a 30-degree angle of view. The distal 7.5 cm of the tip of this telescope is 1.9 mm in diameter and the remaining 11.5 cm is 2.2 mm in diameter. A one-piece cannula with outside dimensions of 10 French (2.6 mm × 3.8 mm), a working length of 14.3 cm, two fluid ports, and a single instrument channel allow passage of one 3.5 French (1.2-mm diameter) instrument.

## Telescopes (Fig. 4-8)

Rigid telescopes that are used for PPC are 1.9-mm (Karl Storz Model #64301B) and 2.4-mm (Karl Storz Model #64300BA) diameter, 30-degree arthroscopes with 10-cm working lengths; the 2.7-mm diameter, 30-degree multipurpose rigid telescope (Karl Storz Model #64018BS) with an 18.5 cm working length; the 4-mm diameter, 30-degree cystoscope (Karl Storz Model #63005BA) with a working length of 30 cm; and a 5-mm, 0-degree laparoscope (Karl Storz Model #62006AA) with a working length of 29 cm. The 2.7-mm diameter multipurpose rigid telescope can be used effectively for PPC in the full size range of small animal patients. The two smaller arthroscopes work well in cats and in very small dogs. In larger dogs the 4-mm diameter cystoscope and the 5-mm diameter laparoscope allow more light transmission and facilitate examination.

## Cannulae (Fig. 4-9)

Cannulae used with these telescopes for PPC do not have an instrument channel and are circular rather than the oval shape of the TUC cannulae. Outside diameters range in size from 8.4 French (2.8 mm) for the 1.9-mm arthroscope cannula (Karl Storz Model #64302BN [54302BS sharp trocar for 64302BN]), 9.6-French (3.2 mm) for the

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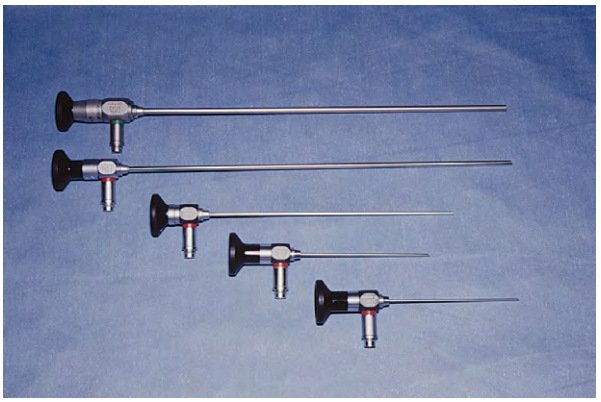


**Fig. 4–8**
Rigid telescopes used for prepubic percutaneous cystoscopy in the dog and cat. From top to bottom: A 5-mm diameter Storz laparoscope with 0-degree viewing angle, a 4-mm diameter Storz cystoscope with 30-degree viewing angle, a 2.7-mm diameter Storz multipurpose telescope with 30-degree viewing angle, a 2.4-mm diameter Storz arthroscope with 30-degree viewing angle, and a 1.9-mm diameter Storz arthroscope with 30-degree viewing angle.

2.4-mm arthroscope cannula (Karl Storz Model #64303BM [64302BU sharp trocar for 64303BM]), 12 French (4 mm) for the 2.7-mm multipurpose rigid telescope arthroscopy (Karl Storz Model #64128AR [64122AS sharp trocar for 64128AR]) and laparoscopy (Karl Storz Model #62155KP) cannulae, and 18 French (6 mm) for the laparoscopy cannula (Karl Storz Model #62160FZ) used with the 4-mm cystoscope and the 5-mm laparoscope. Arthroscopy cannulae connect and lock directly to the endoscope without an adaptor or bridge and do not have instrument ports or channels. Laparoscopy cannulae for use with the 2.7-mm multipurpose telescope, the 4-mm cystoscope, and the 5-mm laparoscope do not lock to the telescope but slide freely on the telescope. A valve and gasket system prevents leakage around the telescope during the procedure. A guard sheath (Karl Storz Model #64018US) is strongly recommended to protect the 2.7-mm multipurpose rigid telescope when used with the laparoscopy cannula. Arthroscopy and laparoscopy cannulae are ideally suited for PPC. All of these cannulae have single or double luer connectors for fluid instillation.

## Trocars

Sharp trocars are available for the arthroscopy and laparoscopy cannulae and are used to penetrate the abdominal and bladder walls for PPC. The arthroscopy trocars lock directly to the cannulae and laparoscopy trocars slide freely into the cannulae, both with a watertight seal.

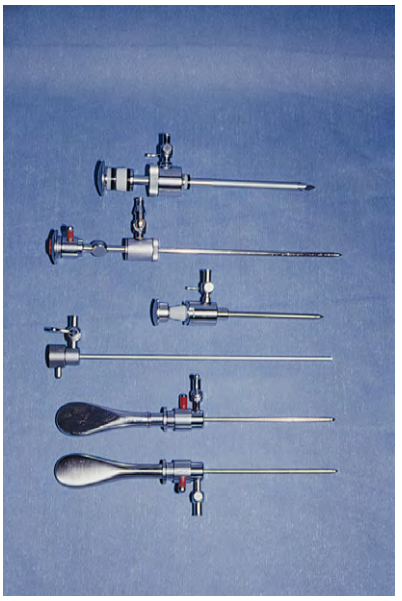


**Fig. 4–9**
Cannulae for the telescopes that are used for prepubic percutaneous cystoscopy in the dog and cat. The cannulae shown are for the telescopes in Fig. 4-8 and are shown with their trocars. From top to bottom: 18-French (6-mm diameter) laparoscopy cannula for use with the 5-mm laparoscope and the 4-mm cystoscope, 12-French (4-mm diameter) arthroscopy cannula for use with the 2.7-mm multipurpose telescope, 12-French (4-mm diameter) laparoscopy cannula for use with the 2.7-mm multipurpose telescope, guard sheath to protect the 2.7-mm multipurpose telescope when using the laparoscopy cannula, 9.6-French (3.2-mm diameter) arthroscopy cannula for use with the 2.4-mm arthroscope, and an 8.4-French (2.8-mm diameter) arthroscopy cannula for use with the 1.9-mm arthroscope. Arthroscopy cannulae connect and lock directly to the endoscope without an adaptor or bridge and do not have instrument ports or channels. The laparoscopy cannulae do not lock to the telescope but slide freely on the telescope with a gasket and valve system to prevent leakage around the telescope during the procedure. The guard sheath locks to the multipurpose telescope, and this sheath then slides through the laparoscopy cannula. All these cannulae have single or double luer connectors for fluid instillation.

## Second Puncture Cannulae (Fig. 4-10)

Separate trocars and cannulae are used for obtaining access to the bladder as a second puncture when performing PPC for sample collection, stone removal, or operative procedures. A second portal is required because the primary telescope cannulae do not have biopsy

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**Fig. 4–10**
Second puncture cannulae for performing prepubic percutaneous cystoscopy in dogs and cats. Separate trocars and cannulae used for access to the bladder when performing prepubic percutaneous cystoscopy are shown. From top to bottom: 10-mm diameter laparoscopy cannula, 5-mm diameter laparoscopy cannula, 3.5-mm diameter laparoscopy cannula, and 2-mm arthroscopy instrument portal cannula. These cannulae all have a sharp trocar for abdominal wall and bladder penetration. These cannulae, except for the 2-mm arthroscopy cannula, also have a gasket and valve system to prevent fluid leakage during the procedure.

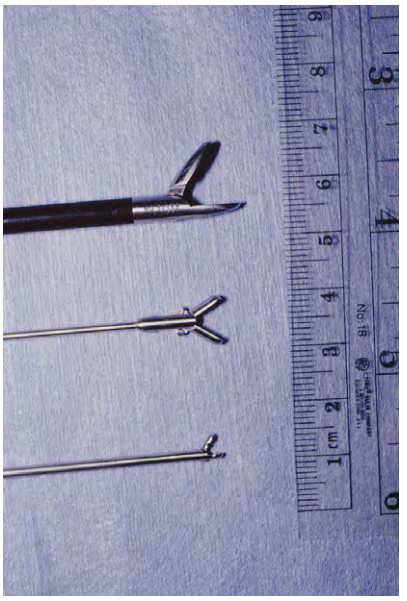


**Fig. 4–11**
Accessory and operative instrumentation for prepubic percutaneous cystoscopy in dogs and cats. Rigid biopsy forceps for use with the second puncture cannulae shown in Fig. 4-10. From top to bottom: 5-mm diameter laparoscopy biopsy forceps, 3.5-mm diameter apposing cup biopsy forceps, and 2-mm diameter apposing cup arthroscopy biopsy forceps.

channels. This technique can also be used as a single percutaneous puncture when TUC is performed using cannulae without a biopsy channel. Arthroscopy and laparoscopy cannulae in 2-mm (Karl Storz Model #64032X), 3.5-mm (Karl Storz Model #62115KP), 5-mm (Karl Storz Model #62160FZ), and 10-mm (Karl Storz Model #62103FZ) diameters can be used. These cannulae have a sharp trocar for abdominal wall and bladder penetration. The cannulae have a valve to prevent fluid leakage and collapse of the bladder when an instrument is not in the cannula and a gasket to form a seal around the instrumentation when it is in the cannula.

## Accessory and Operative Instrumentation (Fig. 4-11)

Biopsy forceps for PPC include rigid 5-mm diameter laparoscopy biopsy forceps with apposing cups or cutting jaws (Karl Storz Model #34221DZ [cup] and #34221DH [punch]), rigid 3-mm diameter apposing cup biopsy forceps (Karl Storz Model #723033), and rigid 2-mm diameter apposing cup arthroscopy biopsy forceps (Karl Storz Model #64302L). Stone or foreign body graspers, arthroscopy rongeurs, stone baskets, cytology brushes, balloon dilation catheters, coagulating electrodes, lithotriptors, laser fibers, and minimally invasive operative instruments can also be used for PPC.

## Instrumentation for Transurethral Cystoscopy in Male Dogs and Cats

Two flexible endoscopes and a semirigid telescope are used for TUC in male dogs and cats. A 1.2-mm diameter (3.6 French) flexible cystourethroscope (Mitsubishi Model #AS-011/1.2) (Fig. 4-12) has been used primarily for TUC in male cats and has also been used occasionally in very small male dogs. Fused silica technology used in this endoscope produces excellent image quality with a 12,000 fiber image bundle in a small enough size to be passed easily through the male cat urethra. The 0.3-mm diameter (1 French) infusion channel in this endoscope allows passage of gas or liquid for urethral and bladder distention, but it is too small for passage of biopsy or other operative instrumentation. This endoscope has a working length of 50 cm, which is more than adequate for TUC in male cats and small male dogs. Easy and

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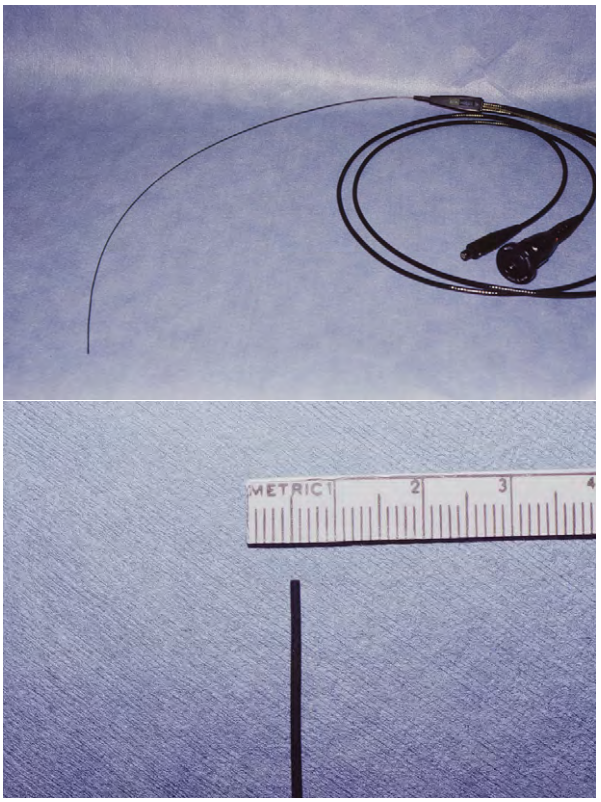



**Fig. 4–12**
A, Flexible fiberoptic endoscope used for transurethral cystoscopy in male cats: 1.2-mm diameter (3.5 French) Mitsubishi cystourethroscope with a 50-cm working length and a 0.3-mm diameter (1 French) infusion channel. This endoscope does not have tip deflection control. B, Tip of 1.2-mm diameter flexible fiberoptic endoscope used for transurethral cystoscopy in male cats.

effective examination of the urethra is possible with excellent image clarity and sufficient light for photographic and video documentation. Examination of the bladder is more difficult because this endoscope does not have distal tip deflection control. This limitation can be overcome by external manipulation of the bladder to move areas of the wall in front of the endoscope field of view. Light transmission is adequate for direct observation of the bladder, but photographic documentation and video applications are limited. Samples of generalized bladder disease can be taken by passing small biopsy forceps transurethrally, without the endoscope in place, to obtain blind mucosal biopsies for histopathology and for cultures. Localized lesions can be sampled by combining transurethral placement of this endoscope with a prepubic percutaneous puncture for passing biopsy instruments.

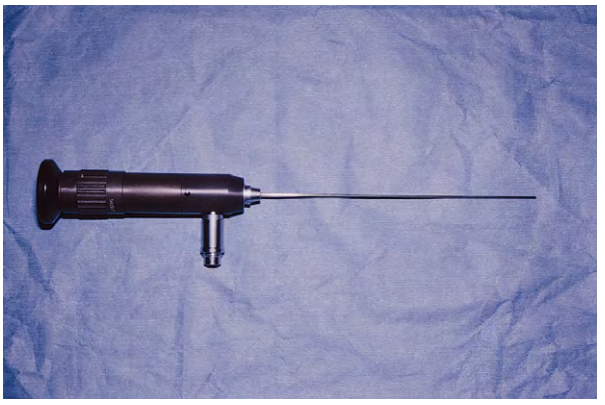


**Fig. 4–13**
Storz 1-mm diameter semirigid telescope with 0-degree viewing angle.

A 1-mm diameter (3 French) semirigid telescope (Karl Storz Model #11512) can also be used for TUC in male cats (Fig. 4-13). This telescope has a working length of 20 cm and a 0-degree angle of view. The image is transmitted through a fused silica bundle giving excellent image quality. There is no instrument or fluid channel in this telescope. The semirigid construction of this telescope allows it to be used without a cannula because mild bending of the instrument does not cause damage, but it cannot be bent like a flexible fiberoptic endoscope.

A 2.5-mm/2.8-mm diameter (7.5 French/8.5 French) flexible veterinary specialty fiberscope (Karl Storz Model #60003VB) is used for TUC in male dogs (Fig. 4-14). This endoscope has a working length of 100 cm, two-way distal tip deflection control with a range of up 170 degrees and down 90 degrees, and an instrument channel that accommodates 1-mm diameter (3 French) instrumentation. The two diameters listed for this endoscope refer to the more flexible and slightly smaller (2.5 mm) distal controlled tip portion of the endoscope and the larger diameter (2.8 mm) major portion of the insertion tube. Two-way tip deflection control of this endoscope significantly enhances its application, making examination of the urinary bladder and urethra much easier, faster, and more complete. Instrumentation available for use with this flexible endoscope includes flexible 3-French biopsy forceps (Karl Storz Model #60275ZE), alligator-type stone or foreign body graspers (Karl Storz Model #60275FE), cytology brushes (Microvasive #510-104 [3 French], stone retrieval baskets (Microvasive #300-311), balloon dilators (Microvasive #218-110), and laser fibers (AccuVet #BFHF-403 [400 micron] and #BFHF-603 [600 micron]) (Fig. 4-15).

Other flexible endoscopes in the 2.3-mm diameter (7 French) to 3-mm diameter (9 French) sizes are also suitable for TUC in male dogs. Working lengths of

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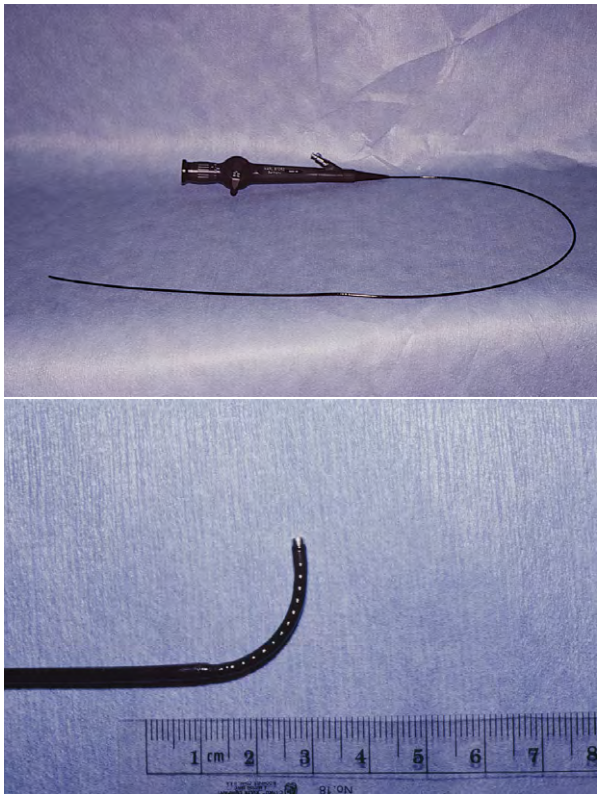



**Fig. 4–14**
A, Flexible fiberoptic endoscope used for transurethral cystoscopy in male dogs: 2.5-mm/2.8-mm diameter (7.5 French/8.5 French) Storz veterinary specialty fiberscope with a working length of 100 cm, a biopsy channel that accommodates 1-mm diameter (3 French) instrumentation, and two-way tip deflection control with a range of 170 degrees up and 90 degrees down. B, The flexible controlled tip of the 2.5-mm/2.8-mm diameter flexible veterinary specialty fiberscope used for transurethral cystoscopy in male dogs. The two sizes refer to the difference between the smaller 2.5-mm diameter distal controlled tip portion of the endoscope and the larger 2.8-mm diameter major portion of the insertion tube.

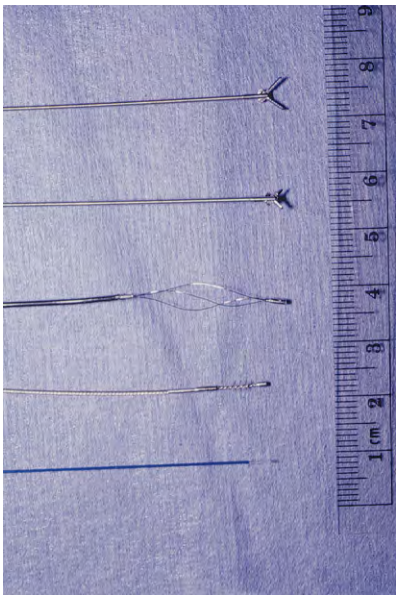


**Fig. 4–15**
Three-French instrumentation for use with the 2.5-mm/2.8-mm diameter flexible cystourethroscope. From top to bottom: Graspers for foreign body and/or stone removal, biopsy forceps, stone retrieval basket, cytology brush, and a 550-micron laser fiber.

80 to 100 cm, operating channels with diameters of 1- to 1.3-mm diameter (3 to 4 French), and two-way tip deflection control are suggested criteria for application to TUC in small animals. Endoscopes with an outside diameter of greater than 4 mm (12 French), an operating channel smaller than 1 mm (3 French), a working length of less than 80 cm, and less than two-way distal tip deflection control are inadequate for TUC in male dogs.

There is little correlation between male dog size and urethral diameter. The small, 2.3- to 3-mm diameter flexible cystoscopes have been used for transurethral examination of male dogs weighing 3.5 kg or more. The 2.5-mm/2.8-mm diameter flexible veterinary specialty fiberscope has been used successfully in dogs as small as 3.5 kg but could not be passed in dogs larger than 35 kg. Application of the 1.2-mm flexible endoscope has been primarily for TUC in male cats, but it has also been used in some very small male dogs.

Application of endoscopes for cystoscopy is not limited to those listed here. There is an almost endless variety of options available in that any small-diameter rigid telescope system or small flexible fiberoptic endoscope with adequate length and capability for fluid or air passage through the scope for urethra and bladder distention can be used.

An important consideration in using cystoscopy, or any endoscopic procedure, in private small animal practice is the ability to adapt and use an individual endoscope for different procedures other than that for which it was designed. For example, the 2.7-mm diameter arthroscope has been used for TUC, percutaneous cystoscopy, rhinoscopy, frontal sinoscopy, otoscopy, bronchoscopy, thoracoscopy, laparoscopy, fistuloscopy, anal sacoscopy, endoscopy of bite wounds and lacerations, endoscopic examination of cavitated or cystic tumors, ocular examinations, and arthroscopy. Application of this telescope for

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this wide range of procedures is the reason for its designation as a multipurpose rigid telescope. This makes the economics of endoscopy not only feasible but financially rewarding.

## DOCUMENTATION SYSTEMS

Video endoscopy can be used for cystoscopy by attaching an endoscopic video camera to any of the rigid or flexible endoscopes. Video endoscopy is a more comfortable examination technique, and more than one person can observe the procedure. A disadvantage is that a video camera requires more light than direct visualization endoscopy. Documentation of endoscopic procedures is facilitated with a video camera. Still images can be saved from video using direct video printers or through electronic video capture techniques.

## PATIENT PREPARATION

General anesthesia is recommended for TUC and is required for percutaneous cystoscopy. A standard preanesthetic fast is employed. A preanesthetic database is collected before anesthesia based on patient age and medical needs. If a urinalysis and culture have not been done recently, samples are collected before cystoscopic examination because fluid irrigation used for the procedure invalidates urinalysis and culture results.

TUC has not been performed as an aseptic procedure, but techniques to prevent urinary tract contamination are used. In females, the perivulvar area of long-haired animals is clipped but this has not been necessary for short-haired patients. The perivulvar area is then cleaned to remove any exudate or debris, but an aseptic surgical scrub is not done nor is draping of the patient. In male dogs, the tip of the penis is exposed by retraction of the prepuce and the tip of the penis is cleaned as would be done for passing a urinary catheter. Prepuce retraction is maintained until the endoscope is at its deepest point of insertion. Patient positioning for females is usually either right or left lateral recumbent, but ventral and dorsal recumbent positions have also been used. In male dogs either a lateral recumbent position or a dorsal recumbent position has been used.

PPC is performed using aseptic technique. With the patient under general anesthesia, the ventral abdomen is clipped as would be done for a cystotomy and an indwelling urinary catheter is placed. The patient is positioned in dorsal recumbency, and the abdomen is scrubbed and draped for aseptic surgery. Sterile instrumentation is used, and the surgical team is properly attired. Sterilization of endoscopic instrumentation can be done with cold sterilization solutions (glutaraldehyde) or ethylene oxide, or by autoclaving. The instrument manufacturers' recommendations for sterilization are strictly followed to prevent instrument damage.

## TECHNIQUE

### Transurethral Cystoscopy in Female Dogs and Cats

The technique employed in female dogs and cats by this author differs in several major aspects from that which has been reported in the literature.[3,4,6] Aseptic preparation and draping are not used. Passage of the endoscope is done with direct visualization using continuous fluid irrigation as opposed to blind passage with a blunt obturator. A liter of sterile saline or Ringer's solution is placed approximately 40 cm (5 to 80 cm) above the patient and connected to the endoscope irrigation port with a standard intravenous fluid administration set (Fig. 4-16). Fluid flow is initiated, the endoscope is passed through the vulva into the vagina, the vulva is pinched closed so that fluid flow distends the vagina, and the urethral opening is visualized. The scope is advanced into the urethra and the urethral lumen is followed visually as it is distended by the flow of fluid. This technique is faster, easier, and safer than blind, digital, or speculum passage, and it allows urethral examination as the endoscope is advanced. Safety of the procedure is greatly enhanced because any pathology can be identified and avoided, thus reducing the chance of urethral wall damage or penetration during passage of the endoscope.

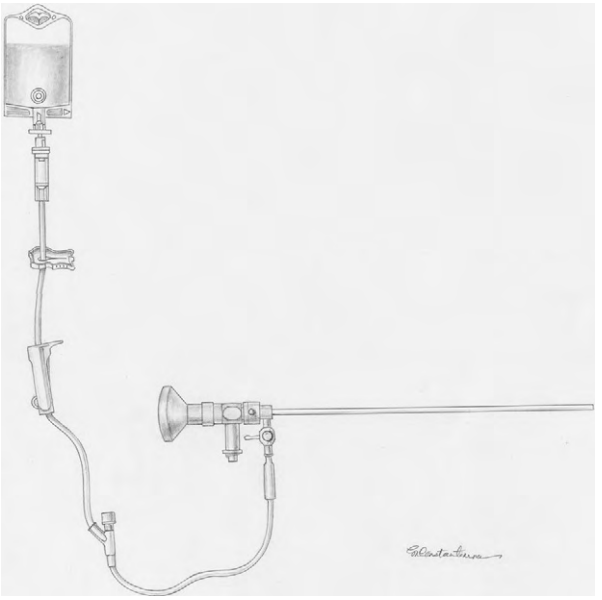


**Fig. 4–16**
Irrigation system for transurethral cystoscopy using a liter bottle of sterile saline or Ringer's solution and an intravenous fluid administration set that is connected to the endoscope irrigation port.

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Once the bladder is entered, fluid flow is arrested and the bladder is completely drained through the endoscope cannula. Fluid flow is reinstituted and examination is carried out while the bladder is filling. If the urine is concentrated or contains blood, cloudiness of bladder irrigation fluid may persist. One or two additional fluid exchanges is usually sufficient to obtain a clear viewing field. The bladder may also be distended with air, nitrous oxide, or carbon dioxide. Gas distention has been used only when a clear viewing field cannot be achieved through liquid. This occurs most commonly when bleeding produces a continuously cloudy viewing field. When gas distention is used, occasional small amounts of fluid irrigation may be needed to keep the endoscope lens clean. Air embolism is a potential complication when room air is used for bladder distention. This danger can be avoided by using nitrous oxide or carbon dioxide.

When adequate bladder size has been achieved for examination, fluid or gas flow is discontinued. Caution must be used to prevent overdistention of the bladder and subsequent damage. Rupture of the bladder is an uncommon complication of cystoscopy but can occur with marked overdistention or if there is significant bladder wall pathology. Partial rupture with tearing of the mucosal layers but with the seromuscular layers remaining intact can also occur. The most common form of bladder wall damage during cystoscopy is microscopic mucosal tears that cause bleeding that interferes with examination. This form of damage is more common in bladders with significant chronic inflammation that have secondary scar tissue formation, which prevents normal bladder wall stretching.

The entire urethra and bladder wall can be evaluated with a 30-degree angle-of-view telescope. The urethra is evaluated for tumors, calculi, ectopic ureteral openings, strictures, contusions, mucosal lacerations, and wall penetrations or disruption. The bladder mucosa is evaluated for contour, texture, and color. Blood vessel number, size, and configuration are also assessed. The entire bladder is examined for the presence of tumors, calculi, diverticula, mucosal tears, and bladder wall lacerations or penetrations. Both ureteral openings are located in the trigone area of the bladder and are examined for anatomic position, configuration, and flow and character of urine.

Biopsy samples are obtained of tumors or of abnormal appearing bladder or urethral mucosa for histopathology. Mucosal samples can also be obtained for culture and sensitivity studies. Small stones can be removed as a therapeutic procedure or for stone analysis as a strictly diagnostic procedure. The ureters can be individually catheterized for retrograde pyelography, single kidney function studies, or localized sample collection to identify the source of renal bleeding or infection.

When an arthroscopy cannula is used, biopsy collection is complicated by the absence of an instrument channel. Several options are available for collecting samples with this cannula. For localized urethral lesions, rigid biopsy forceps can usually be passed outside and parallel to the endoscope cannula. This is done with the tip of the biopsy instrument slightly in front of the endoscope so that it can be visualized as it is passed. Urethral lesions can then be identified, and accurately placed representative biopsy specimens can be obtained. This technique can be difficult, but with practice it can be done quickly and effectively in most cases. For generalized bladder wall lesions where the location of the biopsy site is not important, a biopsy forceps can be passed blindly through the endoscope cannula. For this technique, the endoscope and cannula are placed into the bladder under direct visualization as previously described. After examination is completed, the telescope is removed leaving the cannula in position, a biopsy forceps is passed through the cannula, and samples are collected. This technique is only used when the lesion is generalized and location of the samples to be collected is not important because the sites of sampling cannot be visualized or controlled.

A third alternative is to perform a prepubic percutaneous puncture and to pass biopsy or stone removal instrumentation through the percutaneous cannula (Fig. 4-17). This technique is more complicated and requires more equipment, supplies, and personnel, but it is necessary for localized lesions within the bladders of patients that are too small for passage of the 2.7-mm telescope cystoscopy sheath, if a cystoscopy sheath is not available, or if a 1.9-mm telescope with cystoscopy sheath is not available. To perform this procedure, the endoscope is removed after it has been determined that localized samples are required and that they cannot be collected transurethrally. The patient is clipped as would be done for a cystotomy and is positioned in dorsal recumbency at the end of the surgery table so that the perineal area is accessible for TUC. An aseptic field is prepared on the ventral abdominal area over the bladder as would be done for a cystotomy. The endoscope is placed into the bladder transurethrally and the bladder is distended until it can be easily palpated through the abdominal wall and is firm but not hard. A small skin incision is made over the bladder, and the bladder is stabilized between the fingers and thumb of one hand while the biopsy cannula and trocar are inserted vertically through the abdominal and bladder walls. Once in position, the trocar is removed and biopsy or other instrumentation is inserted. Sample collection is done through this percutaneous cannula while instrumentation is guided to the sample collection sites with a transurethrally placed endoscope.

When TUC has been completed, the bladder is emptied and instrumentation removed. If a percutaneous puncture has been performed, an indwelling urinary catheter is inserted and kept in place for 48 to 72 hours to maintain

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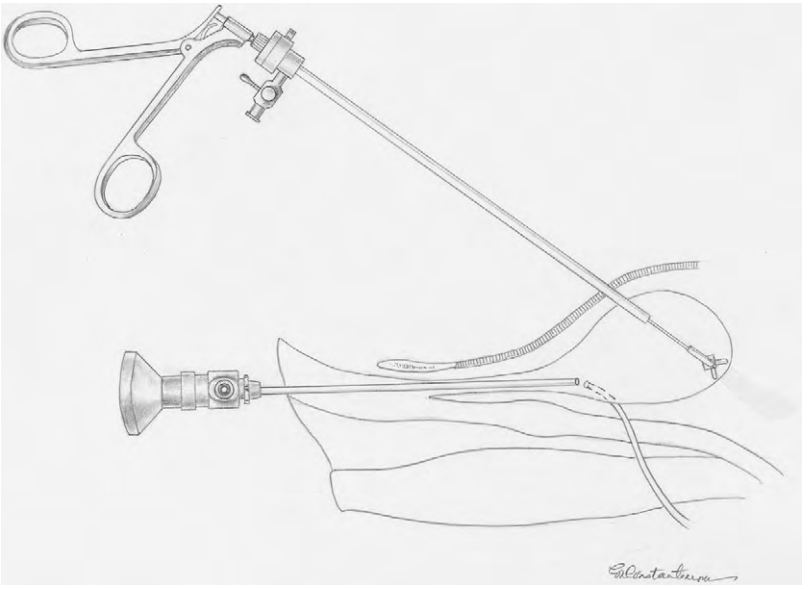


**Fig. 4–17**
Percutaneous prepubic puncture technique for biopsy collection combined with transurethral cystoscopy.

bladder decompression and allow the bladder puncture wounds to seal. Depending on instrument size, the abdominal wall puncture wound may be closed with single fascial and skin sutures.

## Urethroscopy and Transurethral Cystoscopy in Male Dogs

Passage of flexible endoscopes is performed by retraction of the prepuce, exposing the tip of the penis to allow endoscope introduction into the urethra. To minimize bladder and urethral contamination, the tip of the penis is cleaned before passage of the endoscope and prepuce retraction is maintained until the endoscope is in the bladder at its deepest point of insertion. Before passing the endoscope, a urethral catheter is passed and the bladder emptied. This is easier than emptying the bladder through the endoscope because the small diameter of the operating channels of the small flexible endoscopes makes it difficult and time consuming, if not impossible, to adequately remove urine. Continuous fluid irrigation or air insufflation provides urethral distention for examination and allows endoscope passage under direct visualization. Liquid irrigation is most commonly used and is done by attaching an intravenous fluid administration set to the operating channel port of the endoscope. Sterile saline or Ringer's solution is used for the irrigant.

Examination of the urethra can be done as the endoscope is being advanced into the urethra or as it is being withdrawn. If the primary area of interest is the urethra, then a careful examination is conducted as the endoscope is inserted. When the bladder is the primary area of interest, endoscope insertion is done more quickly with sufficient examination only to guide passage. A more careful and complete urethral examination is carried out as instrumentation is being withdrawn. Resistance to passage of the endoscope tip may be encountered in some male dogs at the caudal end of the os penis. This is normally the narrowest point of the urethra and gentle pressure with manipulation may be required to pass the endoscope through this portion of the urethra. Excessive force is not used because it may damage the urethra, endoscope, or both. When the endoscope cannot be passed, a smaller size endoscope may be used or the urethra can be dilated by passing increasing sizes of well-lubricated, soft, blunt-tipped urinary catheters or urethral dilators through this area. There is little correlation between dog size and urethral size, with a wide variation in the size of endoscopes that can be passed relative to dog size. The Storz 2.5-mm/2.8-mm flexible veterinary specialty fiberscope has been passed in dogs weighing as little as 3.5 kg and could not be passed in dogs as large as 50 kg.

Examination of the urethra during withdrawal of the endoscope eliminates the need for maintaining prepuce retraction during this portion of the procedure. Retraction is continued until the endoscope has been placed to its deepest point in the bladder, then the prepuce can be allowed to return to its normal position without concern for urinary tract contamination.

Examination of the urethra and bladder is greatly facilitated by endoscope tip deflection control. Two-way tip control is far superior to one-way tip deflection control and is a major consideration in selecting an endoscope for cystourethroscopy. The distal segment of the urethra from

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the tip of the penis to just below the ischial arch is relatively straight and can be followed and examined easily with minimal manipulation. Above this point, the endoscope tip and corresponding field of view is deflected to follow the curve of the urethra and to examine areas of interest.

To use the 1.2-mm diameter flexible cystourethroscope without tip deflection control, the endoscope and urethra or bladder with the surrounding tissues must be manipulated digitally to accomplish urethral and bladder examination. In male dogs, manipulation of the urethra from the tip of the penis to the area of the ischial arch is done by grasping the urethra and surrounding tissues between the thumb and fingers and pulling them from the body while pushing the more proximal urethra toward the body with the index finger. This procedure is repeated as the hand is moved proximally and distally relative to the tip of the endoscope. Side to side movement is also required to complete the examination. As the endoscope passes into the pelvic urethra, manipulation is continued by rectal palpation as far cranially as can be reached. Depending on dog size and extent of cranial displacement of the prostate, the entire urethra may or may not be reached by this technique. Evaluation of the bladder is carried out using transabdominal manipulation of the bladder to move various portions of the bladder wall in front of the endoscope until the entire bladder has been examined.

Biopsy specimens can be obtained with forceps through the operating channel of the flexible 2.5-mm cystourethroscope. This small, flexible cystoscope has a biopsy channel that accommodates 1-mm (3 French) instrumentation. The presence of a biopsy channel is an important consideration in selecting an endoscope.

If the endoscope does not permit passage of instrumentation or if larger biopsy samples are required, other techniques can be used. Biopsy specimens of generalized bladder lesions may be obtained blindly by transurethral passage of flexible biopsy forceps. This technique allows larger biopsy forceps to be used than what can be passed through the endoscope channels and it allows specimens to be obtained from patients that are too small for passage of the 2.8-mm flexible endoscope with an adequate sized biopsy channel. Instrumentation used in this application has included flexible apposing cup biopsy forceps from the rigid small-bore cystoscope set (5 French) and gastrointestinal endoscopy biopsy forceps. Biopsy specimens of localized urethral lesions may also be obtained by blind passage of flexible biopsy forceps. Distance to the urethral lesion can be determined by measuring how far the endoscope is inserted to reach the lesion and then placing the biopsy forceps in the same distance. Palpation of the lesion and tip of the biopsy forceps facilitate this procedure. Localized bladder lesions can be reached for biopsy by single percutaneous prepubic puncture for placement of the biopsy forceps combined with transurethral endoscopy for visualization as described for application in female dogs and cats.

## Urethroscopy and Transurethral Cystoscopy in Male Cats

TUC in male cats is the most difficult of the transurethral techniques to perform. This difficulty comes from the small urethral size in male cats and the lack of tip deflection control of the 1.2-mm diameter cystourethroscope. Addition of tip deflection control to this endoscope would greatly facilitate examination of both the urethra and bladder. Male cats that have had a perineal urethrostomy performed can be examined with rigid instrumentation and their examination is similar to cystoscopy in the female.

Without tip deflection control, the endoscope, urethra, and bladder with their surrounding tissues must all be manipulated to perform cystourethroscopy. To introduce the endoscope into the urethra in male cats, the penis is extended to expose the urethral opening and to straighten the urethra. The penis may be maintained in the extended position by grasping the base of the penis between the thumb and index finger using a gauze sponge to improve grip and decrease the amount of force required, by grasping the loose tissue at the base of the penis with a mosquito hemostat or with thumb forceps, or by placing two 4-0 stay sutures in the tissue at the reflection of the prepuce and penis. The first techniques are used when the endoscope enters the urethra easily, passes through the distal portion of the urethra with minimal difficulty, and the urethra is visualized with a minimum of manipulation. If any difficulty is encountered, then stay sutures are placed to facilitate the procedure and to minimize trauma to the penis and urethra. The tip of the penis is cleansed with an antiseptic solution before passage of the endoscope. The tip of the flexible cystourethroscope is introduced into the urethra and fluid flow is initiated. The 0.3-mm diameter of the infusion channel of this endoscope is too small to allow adequate gravity flow of liquids so a 3- to 12-ml syringe is attached to the injection port and the fluids are injected manually during the procedure. Air passes through this endoscope more easily than liquids and is used most frequently. Visualization of the urethra from the tip of the penis to the area of the ischial arch is done by grasping the tissue proximal to the tip of the endoscope and moving it dorsally, ventrally, and to each side to position the urethral lumen in front of the field of view of the endoscope. This procedure is repeated as the endoscope is advanced and the fingers are moved proximally and distally relative to the tip of the endoscope. As the cystourethroscope passes into the pelvic urethra, the endoscope is moved dorsally, ventrally, from side to side,

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and rotated to keep the urethra in view. Manipulation may also be continued by rectal palpation if needed. Evaluation of the abdominal portion of the urethra and bladder is performed by using transabdominal manipulation of the urethra and bladder to visualize the urethral lumen and to move various portions of the bladder wall in front of the endoscope until the entire bladder has been examined.

Biopsy specimens cannot be obtained through the operating channel of this flexible cystoscope. The small 0.3-mm (1 French) channel in this 1.2-mm endoscope does not permit passage of instrumentation. Biopsy specimens of generalized bladder lesions may be obtained blindly by transurethral passage of flexible 1-mm (3 French) biopsy forceps. Urethral lesions may also be biopsied blindly by measuring the distance to the lesion with the endoscope and then placing the biopsy forceps in the same distance. Palpation of the lesion and tip of the biopsy forceps, if possible, may facilitate this procedure. Biopsy of localized bladder lesions can be performed by using a single percutaneous prepubic puncture for placement of the biopsy forceps combined with transurethral endoscopy for visualization as is previously described.

Urethroscopy and TUC of male cats can be performed with rigid instrumentation after perineal urethrostomy surgery. The 2.7-mm diameter multipurpose rigid telescope with the arthroscopy sheath or the 1.9-mm diameter cystoscope with the modified cystoscopy sheath can be used for this procedure. Each has advantages and disadvantages. Examination of the distal urethra can also be performed with the 1.9-mm diameter arthroscope, but this instrument is too short to reach the proximal urethra or the bladder. Endoscopy can be performed immediately after urethrostomy surgery or can be delayed until the stoma is healed.

Advantages of immediate examination are that additional information is available for postoperative management and a second administration of anesthesia is not required. When performed at this time, the procedure must be done with great care to avoid damage to the surgery site. The endoscope sheath is lubricated with sterile water-soluble gel and the endoscope is introduced slowly and gently. Fluid flow is initiated to distend the urethra and the endoscope is passed while visualizing the urethra. If any resistance is encountered, the procedure is discontinued. If excessive force is used to pass the telescope, the surgery site can be damaged, increasing the chance for stricture formation, or the urethra can be avulsed from the surgery site. If care is used, most patients can be examined at this time without adverse affects. The alternative technique, waiting until the stoma is healed, can be performed any time after 2 weeks but is usually delayed for 4 weeks. Otherwise, the technique is no different than when performed immediately after surgery. Once the proximal urethra has been reached, this technique and the findings are the same as in female cats.

## Prepubic Percutaneous Cystoscopy

A surgical plane of general anesthesia is required for PPC. Once this has been achieved, the patient is placed in dorsal recumbency and is clipped, prepared, and draped for aseptic surgery in the same manner as would be used to perform a cystotomy. The bladder is catheterized and emptied, and the catheter is fixed in place. Sterile soft red rubber urinary catheters have been used. Foley or bulb catheters have not been required. The bladder is filled with sterile saline, Ringer's solution, or Ringer's lactate solution until it is moderately distended. This can be achieved by connecting the urinary catheter to an intravenous fluid administration set so that continuous fluid flow can be maintained (Fig. 4-18) or to a three-way valve with a syringe attached to allow intermittent injection of fluid. The first technique works better in larger dogs and the latter is better in smaller dogs and in cats because it allows more precise control of fluid flow and reduces the risk of bladder overdistention. The bladder is filled until it is easily palpated and firm but not hard; it must be easily held and stabilized for instrument penetration. The surgeon and patient are appropriately prepared for aseptic surgery, and the patient is draped to allow exposure of the distended bladder. If a single puncture is to be performed, a small skin incision is made on the ventral midline over the most prominent portion of the bladder (Fig. 4-19). For double puncture sample collection, two incisions are made equidistant from the midline and far enough apart to allow instrument triangulation (see Fig. 4-19). Double puncture technique is required because the instruments lack biopsy channels.

The endoscope cannula with a sharp trocar in place is pushed through the abdominal and bladder walls with continuous, gradually increasing pressure and oscillating rotation until the bladder lumen is entered. Instrumentation is held perpendicular to the bladder wall at the penetration site during this maneuver (Fig. 4-20). For a single puncture, the cannula is vertical. For a double puncture, the bladder can be shifted laterally directly under the incision to be used for endoscope placement, in which case the cannula is vertical during placement (Fig. 4-21) or the bladder may be kept on the midline and the cannula angled to the side of the puncture until it is perpendicular to the bladder wall at the point of penetration (see Fig. 4-20). Once the tip of the trocar cannula assembly has entered the bladder lumen, forward movement is stopped to prevent penetration of the opposite bladder wall. This is easily accomplished in larger patients, because their bladders are of sufficient size to allow an adequate margin of safety for trocar entry, but it becomes more difficult and critical in smaller dogs and in cats wherein bladder size allows little room for error. If the trocar is inserted too far,

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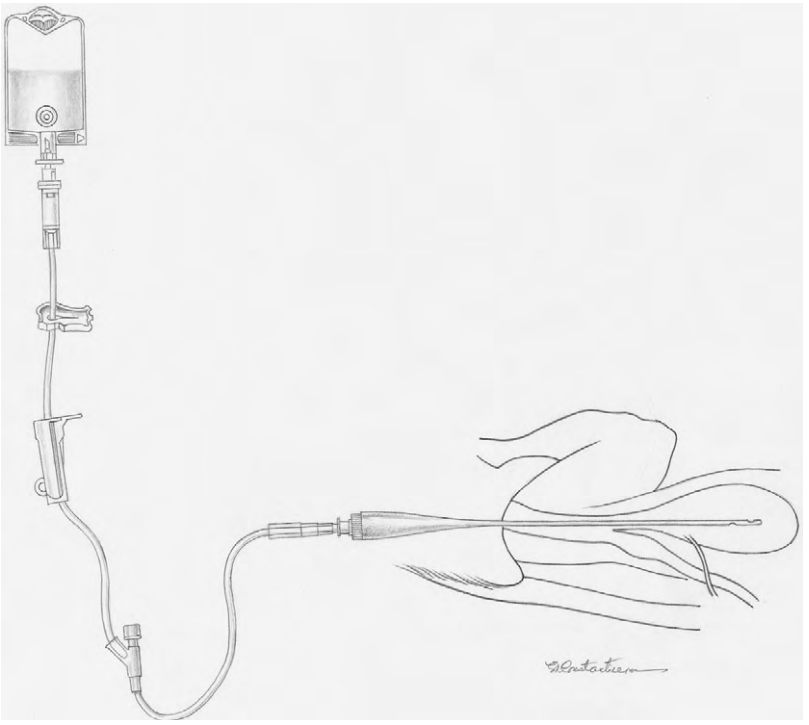


**Fig. 4–18**
Irrigation system used to achieve initial bladder distention for prepubic percutaneous cystoscopy with a liter of sterile saline or Ringer's solution connected to a urethral catheter using an intravenous fluid administration set.

damage can occur to the bladder mucosa, bladder wall, and structures outside the bladder. Damage to the mucosa alone is not desirable but has not been found to be detrimental to the patient. This can, however, make examination more difficult because bleeding clouds irrigation fluid and interferes with examination. If the opposite bladder wall is penetrated, fluid leakage can make it difficult to maintain bladder distention for examination or for placement of second puncture instrumentation. Penetration of the opposite bladder wall should be avoided but may not be significant for the patient because this hole seals in the same amount of time as the desired puncture site. Significant damage to structures outside the bladder that are detrimental to the patient can occur if the trocar penetrates beyond the opposite bladder wall. The large and small intestines, ureters, aorta, and vena cava are all in the area where penetrations could occur. Damage resulting in fecal or ingesta contamination of the peritoneum, urine leakage, ureteral strictures due to scar formation, and hemorrhage are possible. In my experience, damage to structures outside the bladder has not occurred, penetration of the opposite bladder wall that prevented adequate bladder distention for examination has occurred only once, and damage to the opposite wall mucosa without penetration has occurred rarely.

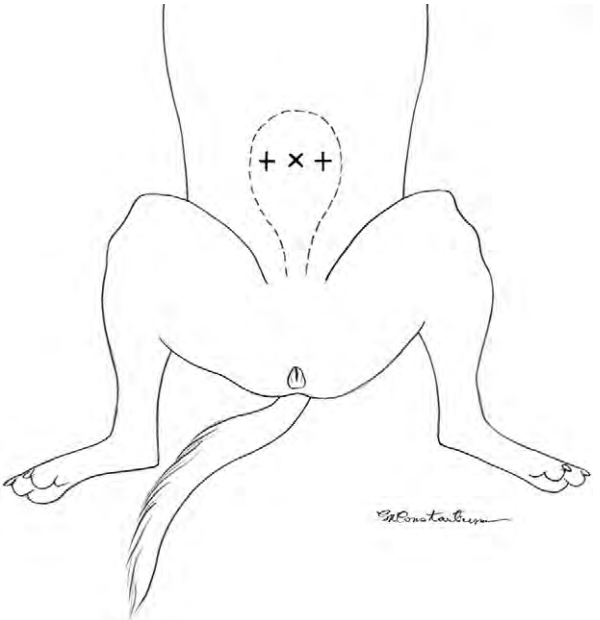


**Fig. 4–19**
Incision positions for single puncture (×) and for double puncture (+) prepubic percutaneous cystoscopy.

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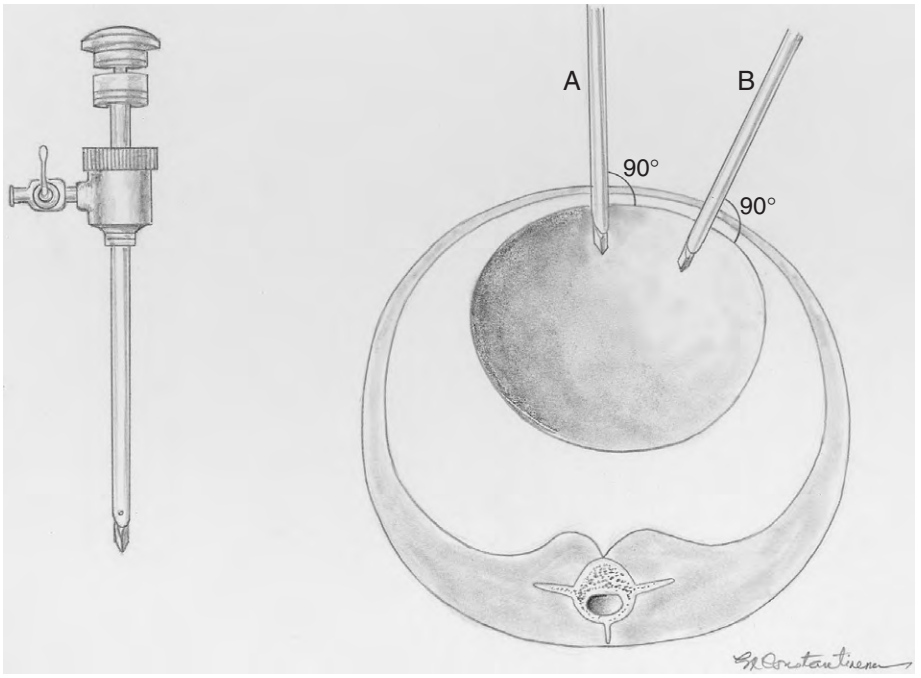



**Fig. 4–20**
Endoscope cannula and trocar position for penetration of the bladder wall for single puncture **(A)** and double puncture **(B)** prepubic percutaneous cystoscopy with the bladder maintained in the midline.

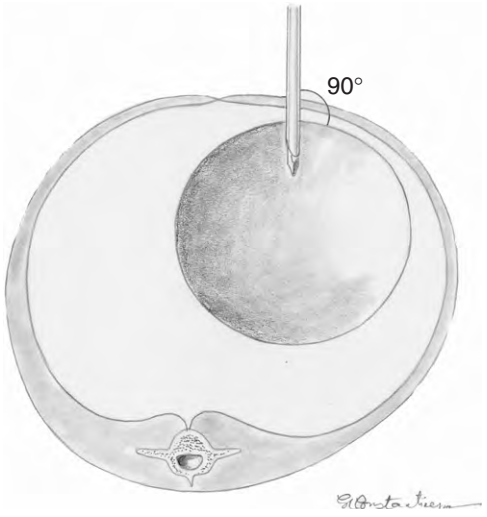



**Fig. 4–21**
Endoscope cannula and trocar position for penetration of the bladder wall for double puncture prepubic percutaneous cystoscopy with the bladder shifted laterally.

Once the trocar and cannula assembly is appropriately placed in the bladder, the trocar is removed and replaced with the telescope. The urethral fluid infusion system is then converted to a drainage system by disconnecting the intravenous administration set from the fluid container and connecting it to an empty container that is placed below the patient. A second sterile intravenous administration set is attached to the endoscope fluid irrigation port with the other end being passed out of the sterile field and connected to the container of sterile saline or Ringer's solution (Fig. 4-22). This system allows control of the rate of fluid inflow and outflow to control bladder distention. The rate of fluid inflow is used to maintain a clear visual field and is controlled by the surgeon with the variable control adjustment on the intravenous set or the stopcock on the endoscope. Bladder distention is maintained by adjustment of a continuous fluid flow that balances inflow and outflow or by intermittent fluid administration as needed.

Once the endoscope is appropriately placed and the bladder is adequately distended, examination is performed. The entire mucosal surface of the bladder wall can be visualized except for an area immediately surrounding the puncture site. Ureteral openings can be evaluated for location, configuration, and presence and character of urine flow. The proximal portion of the urethra can be evaluated usually to the caudal end of the prostatic urethra in male dogs and cats and to the midpelvic area in female dogs and cats.

For sample collection, a second puncture instrument cannula is placed through a separate skin incision. Placement technique is similar to that used for placement of the endoscope cannula. With the endoscope in place,

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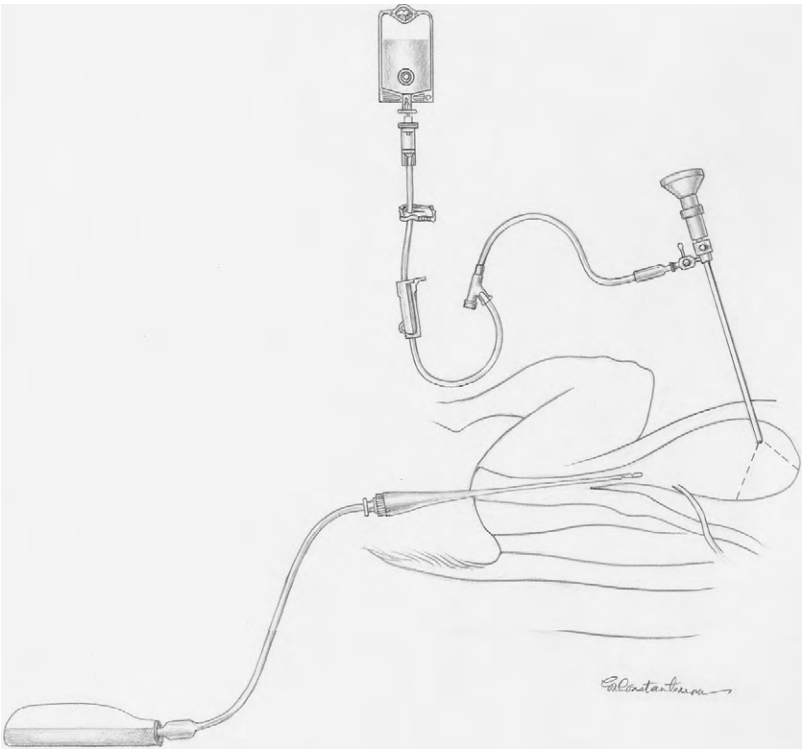


**Fig. 4–22**
Fluid flow system for prepubic percutaneous cystoscopy with inflow through the endoscope and drainage through the urethral catheter. A sterile intravenous administration set has been connected to the endoscope cannula infusion port and to a liter bottle of sterile saline or Ringer's solution. The intravenous administration set previously used for fluid inflow to initially distend the bladder has been left connected to the urethral catheter and the other end has been placed below the patient to provide bladder drainage.

the bladder's location is fixed and the angle of the trocar cannula assembly must be perpendicular to the bladder wall as dictated by bladder location (Fig. 4-23). Although a second puncture skin incision may have been made at the same time the endoscope placement incision was made, it may occasionally be necessary to make an additional incision at a more appropriate location over the bladder. Once the cannula is in the bladder, the trocar is removed and appropriate instrumentation passed through the cannula. Biopsy of the mucosa or other manipulative procedures are performed under direct visualization.

Leakage of fluid around puncture sites can occur. An increased rate of fluid flow is used to maintain bladder distention when needed. Minimal movement of the cannulae helps minimize leakage. Percutaneous cystoscopy can be performed by one person, but this requires laying the cannulae down on the abdominal wall periodically during the procedures, creating an acute angle with the bladder wall and increasing leakage. If a second person assists, instrument movement is decreased, greatly facilitating completion of the procedure, and operation time is reduced. Maintenance of adequate distention can be difficult, especially in a small bladder and with double punctures.

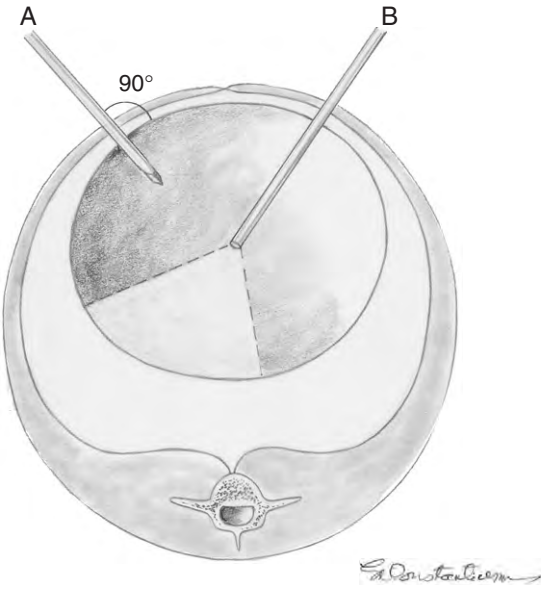



**Fig. 4–23**
Biopsy cannula and trocar **(A)** position for second puncture penetration of the bladder wall for prepubic percutaneous cystoscopy with the endoscope **(B)** already in position.

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When the procedure has been completed, the bladder is emptied and instrumentation removed. Skin incisions may be closed with single, interrupted nonabsorbable sutures. If larger instrumentation is used, 5-mm diameter or greater, a single fascial suture and a skin suture are placed.

An indwelling urethral catheter is left in place for 48 to 72 hours to maintain bladder decompression and allow for sealing of the bladder wall puncture sites. This time interval was established by convention and has not been studied to determine the actual time period that decompression must be maintained to ensure bladder puncture closure.

## PROBLEMS, COMPLICATIONS, AND CONTRAINDICATIONS

There are several limiting factors in selecting cases for cystoscopy, but there are no defined contraindications in veterinary medicine. Animal size and sex are limiting factors only in that they dictate instrumentation requirements and techniques to be used, but they are not contraindications. In human medicine it is suggested that severe bladder infections be controlled before cystoscopy. Bladder rupture, traumatic in origin or due to other causes, makes percutaneous cystoscopy difficult or impossible depending on ability to distend the bladder, but trauma with suspected bladder or urethral damage is an indication for TUC. Urethral lesions such as tumors that produce obstruction may limit or prevent passage of an endoscope transurethrally into the bladder but access to the significant lesion can be achieved transurethrally and biopsy specimens obtained. Bladder access can then be achieved percutaneously if necessary. Small bladders with a very thick wall that cannot be distended adequately may be difficult or impossible to enter with the percutaneous technique, or, if entered, sufficient distention may not be possible to keep the endoscope in place during examination or for placement of second puncture instrumentation. These are all factors that are technically limiting or increase the technical difficulty but are not contraindications.

The most common problem encountered during cystoscopy is obscured visibility due to hematuria or highly concentrated urine. Concentrated urine can be cleared by repeated irrigation fluid exchanges combined with rapid intravenous fluid administration during the examination, causing production of dilute urine. Hematuria interfering with visualization can also be overcome by repeated drainage and filling of the bladder with clean solution or by using gas for distention of the bladder. Air, nitrous oxide, or carbon dioxide may be used. Bleeding can originate from the disease process, or it can be iatrogenic from overdistention of the bladder, instrument placement, biopsy sites, or excessively rough instrument manipulation. Overdistention can occur as a result of excessive filling of the normal bladder or with normal filling of a diseased bladder that causes tearing of mucosal scar tissue.

Significant complications that have occurred with transurethral and percutaneous cystoscopy techniques in 462 procedures performed over a 19-year period include two bladder ruptures, one case of persistent urine leakage from percutaneous puncture wounds, two cases of urethritis causing temporary functional obstruction, and one urethral laceration. Ruptured bladders were in female dogs in which TUC was used. In one case, the bladder ruptured during removal of a large number of stones, which was an inappropriate application of cystoscopy wherein surgery was indicated. The other case was being evaluated for severe hematuria, and air insufflation was employed using a mechanical pump with inadequate control. In both cases, the bladders were reconstructed with no adverse consequences. Persistent urine leakage occurred in one male cat following percutaneous cystoscopy and biopsy collection. The indwelling urinary catheter obstructed and adequate postoperative bladder decompression was not maintained. Urethritis causing a temporary functional obstruction occurred in two female cats following TUC. One of these cases was a smaller cat and endoscope fit in the urethra was tight with significant resistance to passage. The other case required multiple instrument passages for completion of examination and sample collection. Both cases were resolved with placement of an indwelling catheter. Urethral laceration occurred in a female cat with a urethral stricture that was too small for passage of the endoscope. Overzealous attempts to dilate the stricture resulted in laceration of the urethral mucosa immediately caudal to the stricture. A catheter was passed into the bladder to bypass the damaged area of urethra and left in place until healing was complete. Careful application of cystoscopic techniques minimizes these complications.

## NORMAL APPEARANCE OF THE LOWER URINARY TRACT

### Female Dogs and Cats

Beginning at the caudal end of the urethra in a female dog or cat examined with TUC, the first structure visualized is the urethral opening on the ventral wall or floor of the vagina. In spayed female dogs and cats, the urethral stoma is located on the dorsal to caudodorsal aspect of the urethral papilla and most commonly appears as a longitudinal slit (Figs. 4-24 and 4-25). Intact female dogs have larger and more numerous vaginal mucosal folds or ridges than do spayed females with a different appearance of the urethral papilla and opening of the urethra. A transverse ridge or projection of tissue is present in intact female dogs dorsal to the urethral opening. This

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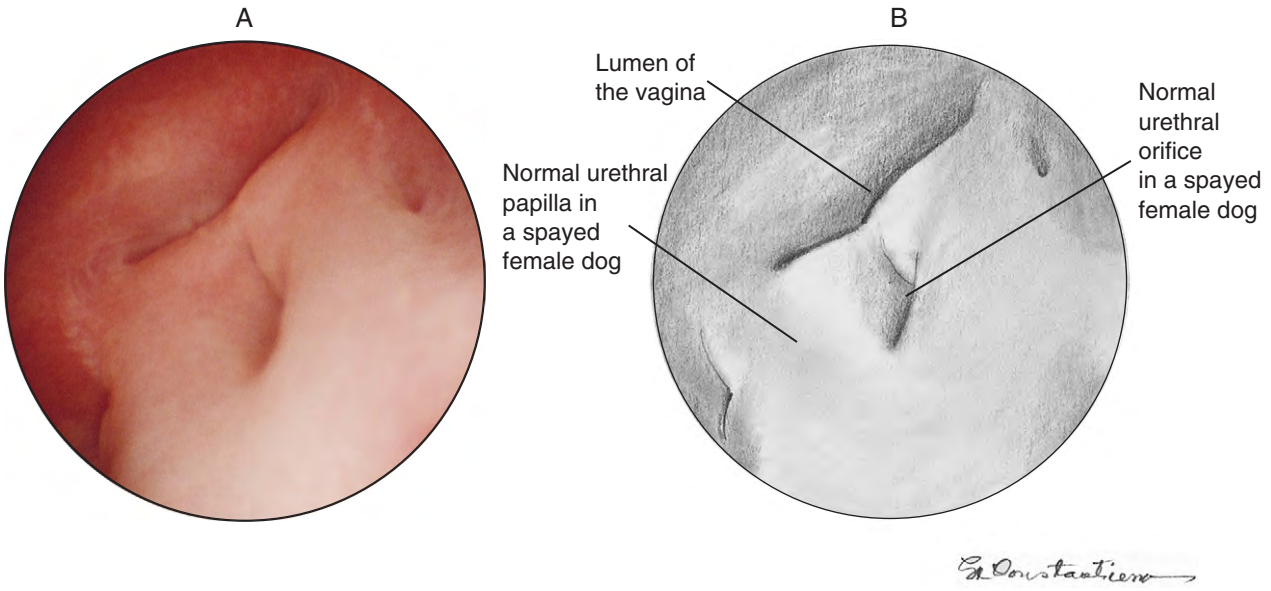



**Fig. 4–24**
Normal papilla and urethral opening in a spayed female dog visualized during transurethral cystoscopy.

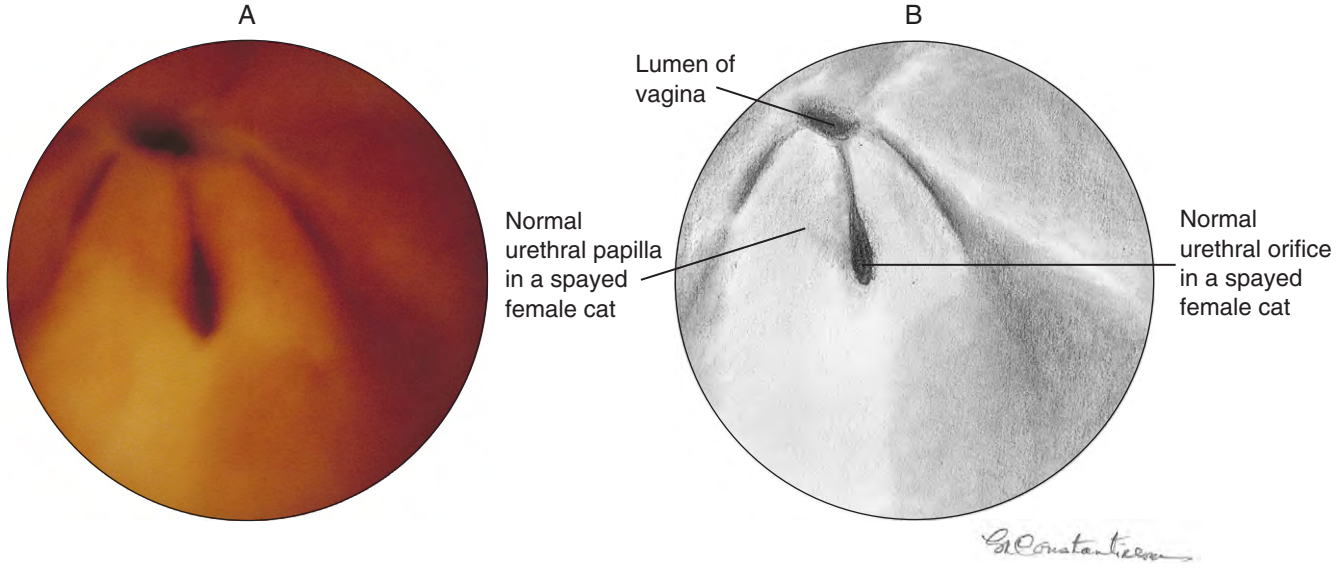



**Fig. 4–25**
Normal urethral stoma in a spayed female cat seen with transurethral cystoscopy.

tissue becomes more prominent during estrus and may completely cover the true urethral opening to create the appearance of a transverse false opening where the tissue contacts the vaginal floor caudal to the true urethral opening. This tissue is the site of origin of the mass that forms with vaginal hyperplasia.

Small openings or indentations are normally found around the base of the urethral papilla in female dogs and cats (Fig. 4-26). These openings vary greatly in size and number from a few scattered indentations to multiple large deep cavities. These have not been previously named to my knowledge and may now be called the "crypts of

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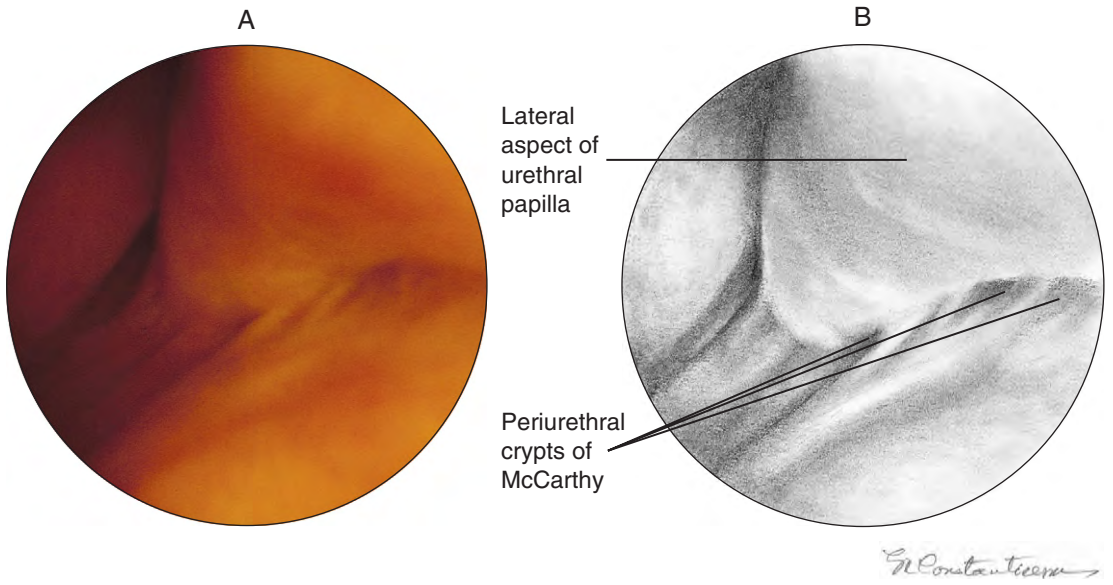



**Fig. 4-26**
Normal periurethral indentations (crypts of McCarthy) in a female dog visualized during transurethral cystoscopy. These are not to be confused with the openings of ectopic ureters.

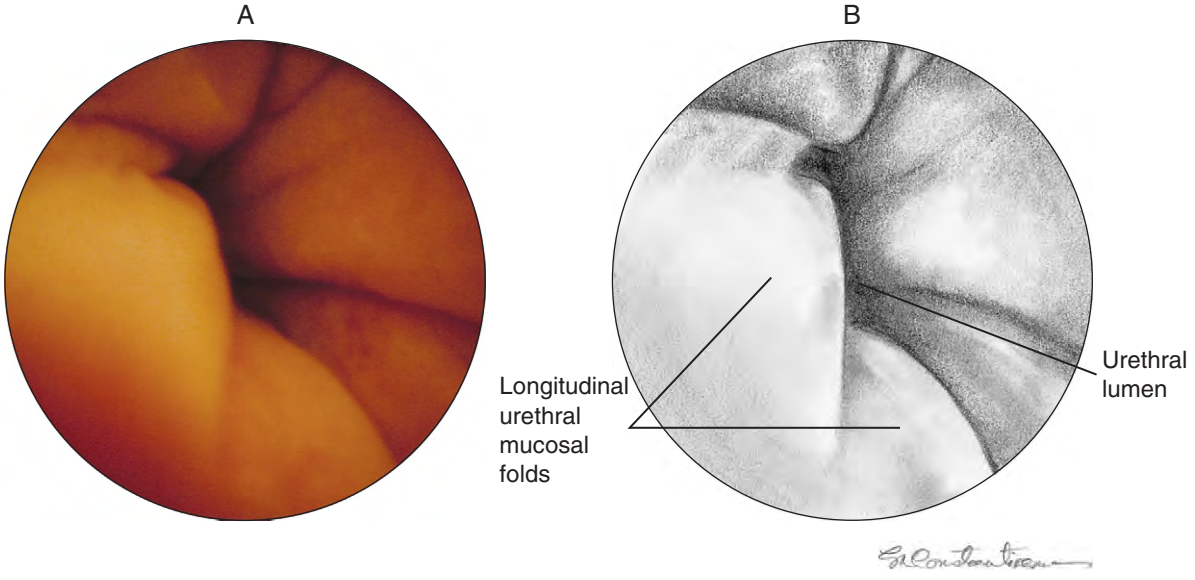



**Fig. 4-27**
Normal longitudinal mucosal folds in a collapsed urethra of a female dog examined by transurethral cystoscopy.

McCarthy." Their significance or function is unknown, but their importance is that they be differentiated from the openings of ectopic ureters.

When the female urethra is initially entered, or if it is not distended, multiple longitudinal folds are present (Fig. 4-27). As the urethra is allowed to distend with fluid, the longitudinal folds disappear and the urethra becomes a smooth, round tube (Fig. 4-28). The urethral mucosa appears light pink through liquid and is darker pink to red when viewed through gas. Blood vessels are normally visible in the urethral mucosa and are more prominent progressing cranially. A dorsal fold or ridge is normal in cats even with complete urethral distention. This ridge may vary from a flat white or lighter colored band (Fig. 4-28) to a prominent ridge (Fig. 4-29). Mucosal indentations or diverticula are common in the urethra of female dogs and cats (Fig. 4-30). Their significance is unknown, but their importance is the same as for the

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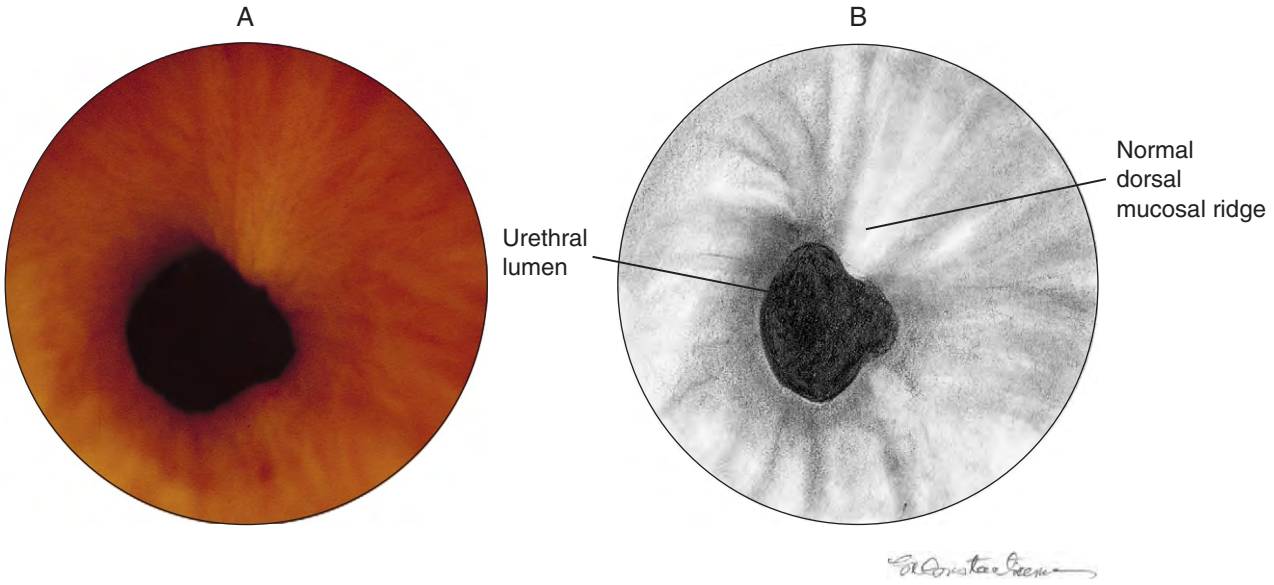



**Fig. 4-28**
Normal distended urethra in a female cat seen with transurethral cystoscopy. The urethral mucosa becomes a brighter red and the blood vessels become more prominent in the cranial portion of the urethra.

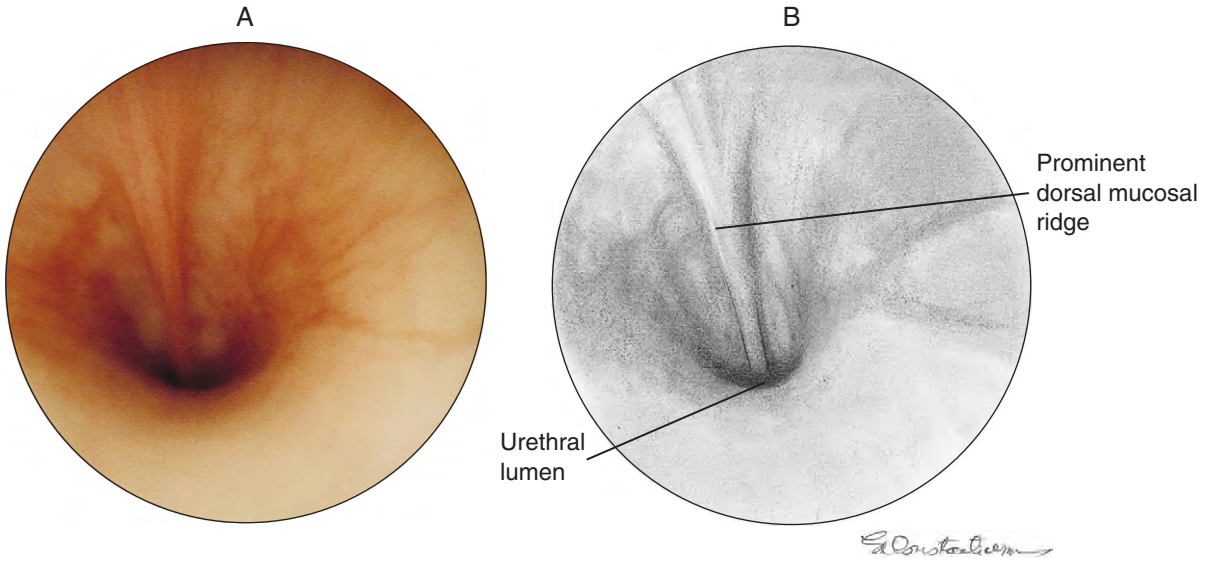



**Fig. 4-29**
Normal dorsal mucosal ridge in the urethra of a male cat seen with transurethral cystoscopy immediately after a perineal urethrostomy had been performed. This ridge is a common finding and varies from a flat white or lighter colored band (see Fig. 4-28) to a prominent ridge as seen here.

crypts of McCarthy in that they need to be differentiated from the openings of ectopic ureters.

The male dog urethra has a smooth light pink mucosal lining and is relatively uniform in diameter from the ischial arch distally (Fig. 4-31). There is limited dilation or stretching of this part of the urethra. The male urethra commonly closes by flattening from a round open structure to a flat slit with minimal constriction or may close with uniform constriction producing mucosal folds similar to those seen in the female urethra. The narrowest portion of the male dog urethra is normally at the caudal end of the os penis. In some cases this can be appreciated visually and in others it is only appreciated as difficulty passing the endoscope. The urethra caudal to the os penis is slightly larger than the penile urethra and runs in a gentle dorsal curve to the ischial arch. As the ischial arch

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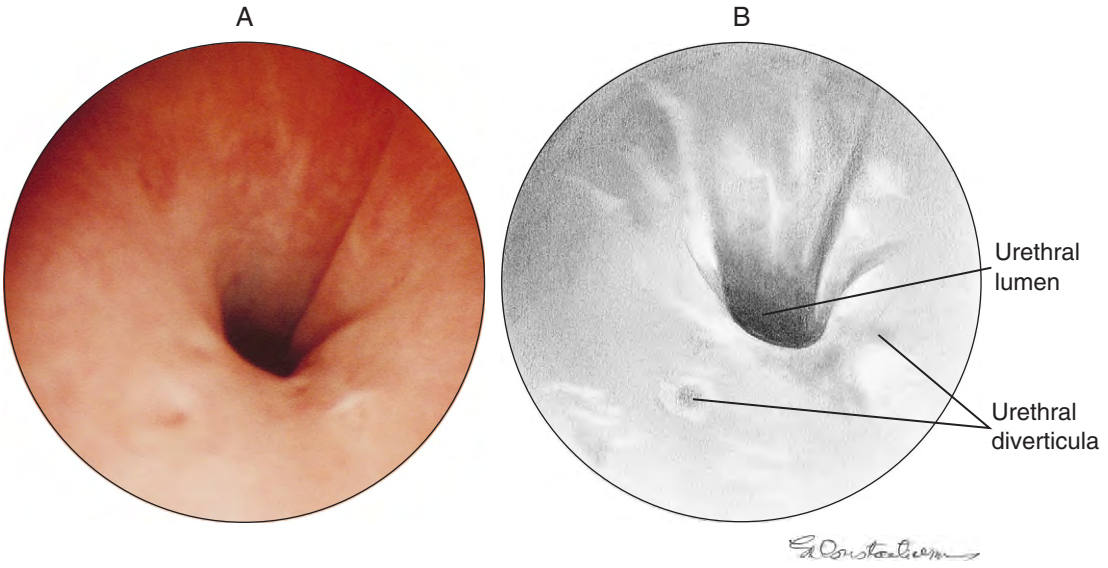



**Fig. 4–30**
Normal mucosal indentations or diverticula in the urethra of a female dog seen with transurethral cystoscopy.

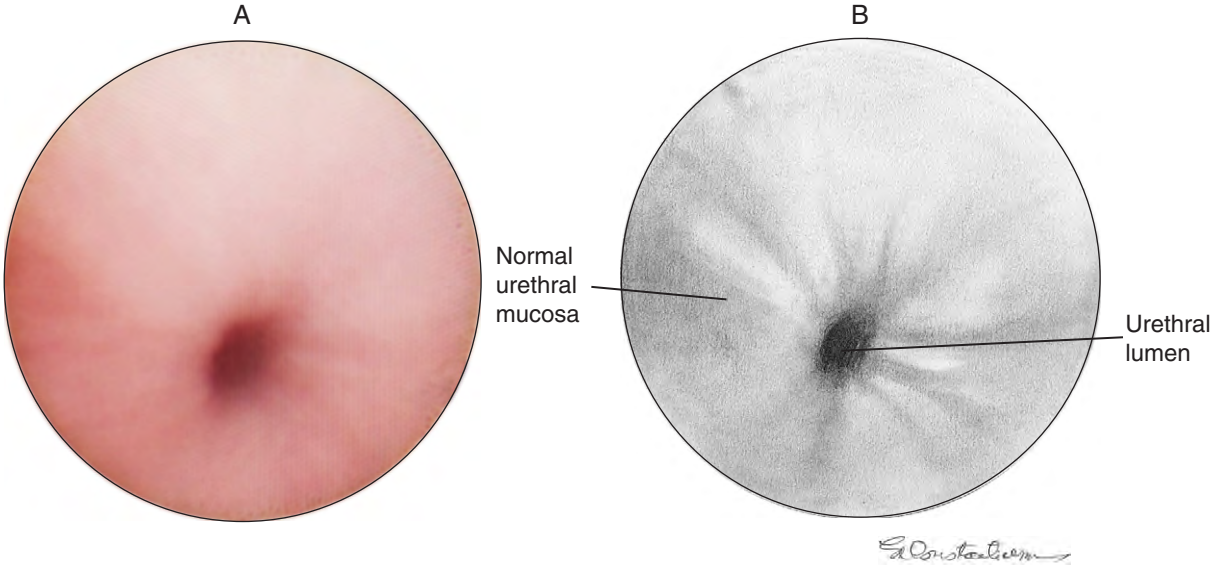



**Fig. 4–31**
Normal urethra of a male dog immediately caudal to the os penis seen through a flexible cystourethroscope employed for transurethral cystoscopy.

is approached, urethral curvature becomes more acute, reaching its maximum curvature as the urethra passes over the ischial arch (Fig. 4-32). The pelvic urethra is significantly larger than the more distal urethra and appears to dilate more with fluid distention. Urethral narrowing is present at the caudal end of the prostate with enlargement of the normal prostatic urethra. The colliculus seminalis is visible on the dorsal aspect of the prostatic urethra of cats (Fig. 4-33) and dogs (Fig. 4-34) and varies in size from a small lump to a prominent pendulous structure. Openings of the ducts deferens can sometimes be seen on or lateral to the colliculus seminalis, and multiple prostatic ducts can be seen scattered over the prostatic urethral surface (Fig. 4-35). Narrowing of the urethra occurs again at the cranial end of the prostate.

Angulation of the bladder wall from the urethra at the trigone can vary from a gradual curve to an abrupt edge depending on individual anatomy and on bladder distention. At a moderate level of distention, the bladder mucosa is smooth, without folds or corrugations, and is a light pink color. Blood vessels are easily visible under the mucosa and their branching pattern is easily defined

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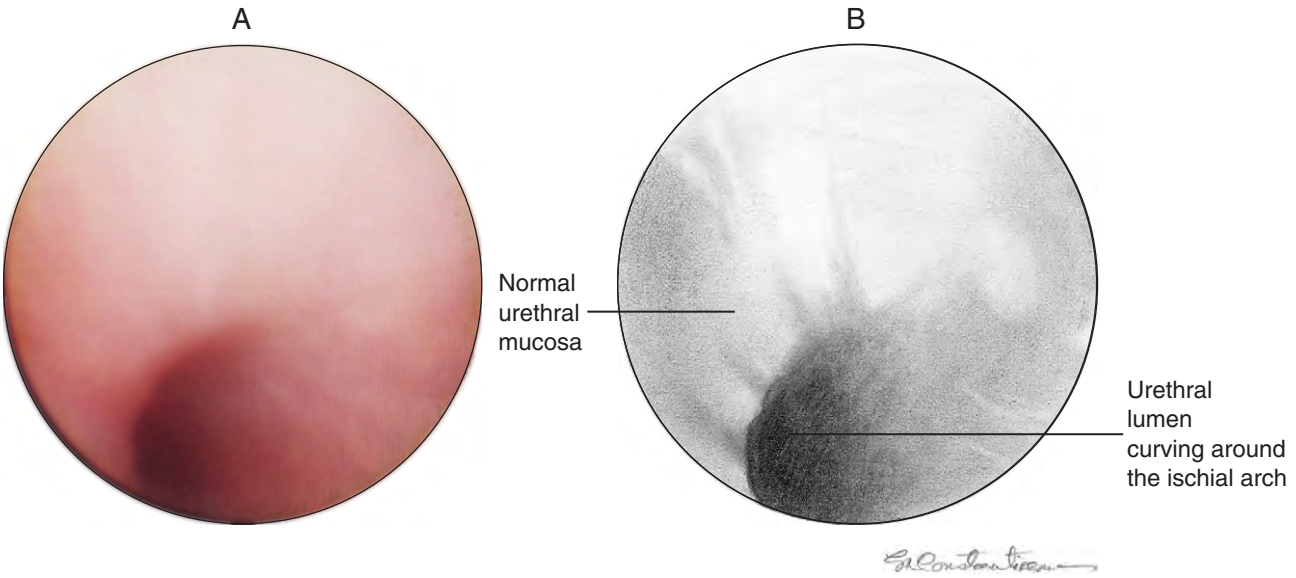



**Fig. 4–32**
Normal urethra of a male dog showing the curvature distal to the ischial arch with transurethral cystoscopy using a flexible cystourethroscope.

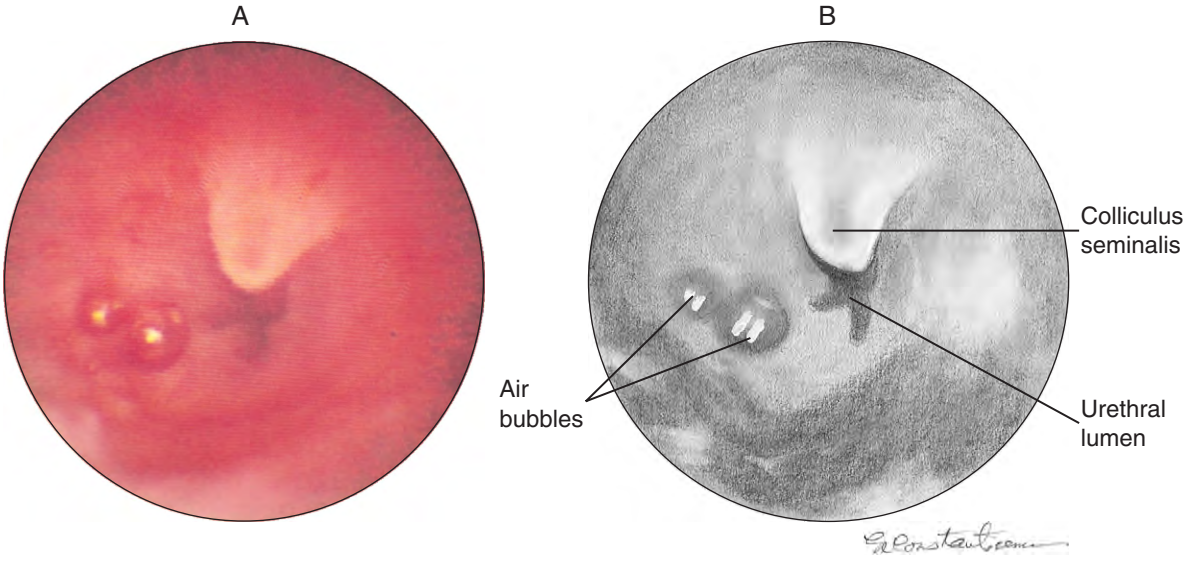



**Fig. 4–33**
Normal colliculus seminalis in a neutered male cat visualized from the caudal aspect with transurethral cystoscopy using a 1.2-mm diameter flexible cystourethroscope.

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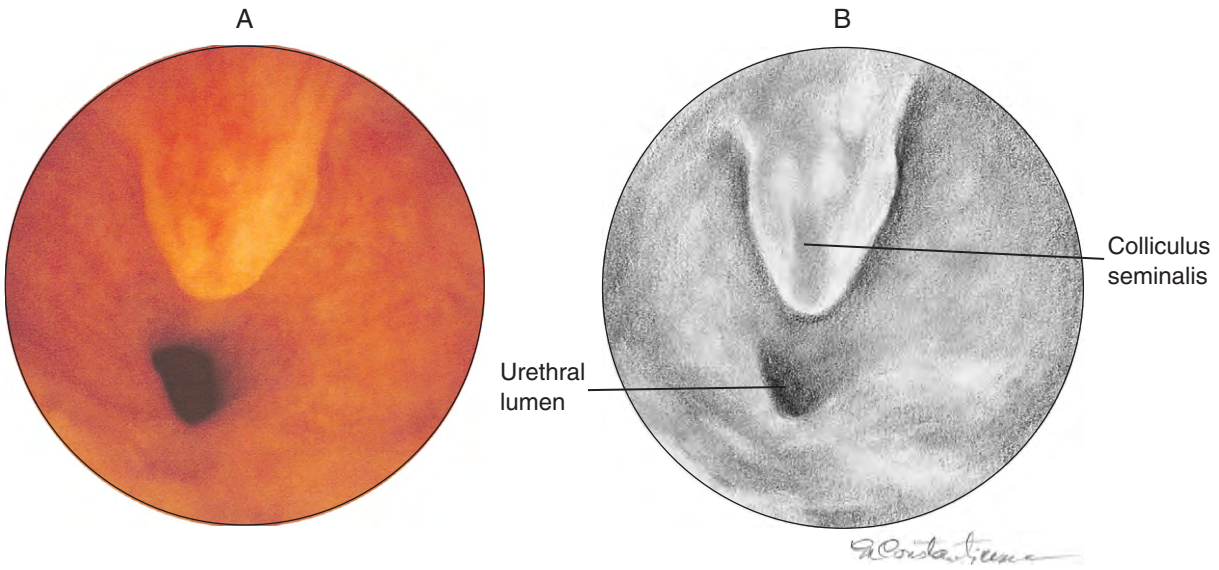



**Fig. 4–34**
Normal colliculus seminalis in an intact male dog visualized from the cranial aspect during prepubic percutaneous cystoscopy.

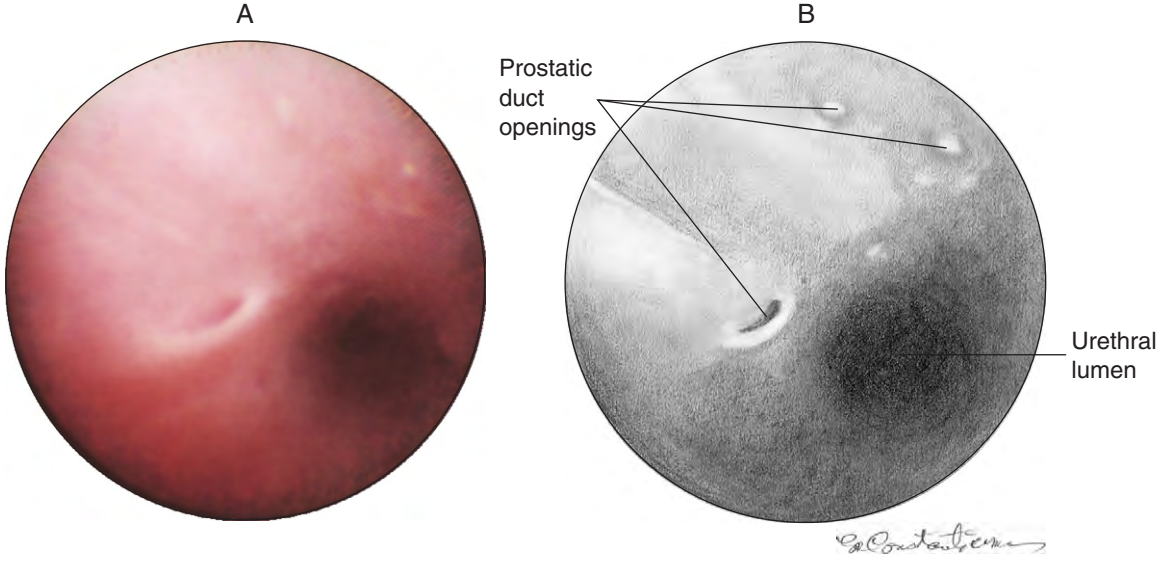



**Fig. 4–35**
Prostatic duct opening in the prostatic urethra of a male dog seen with transurethral cystoscopy using a flexible cystourethroscope.

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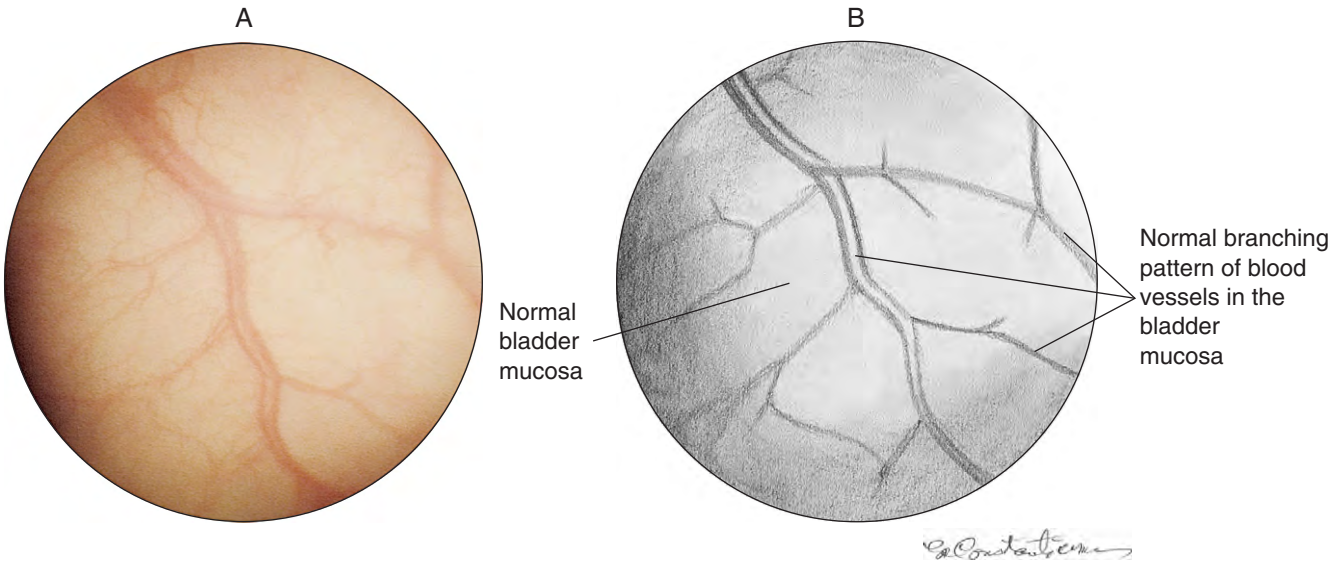



**Fig. 4–36**
Transurethral cystoscopy in a female dog showing normal bladder mucosa with the normal branching pattern of blood vessels.

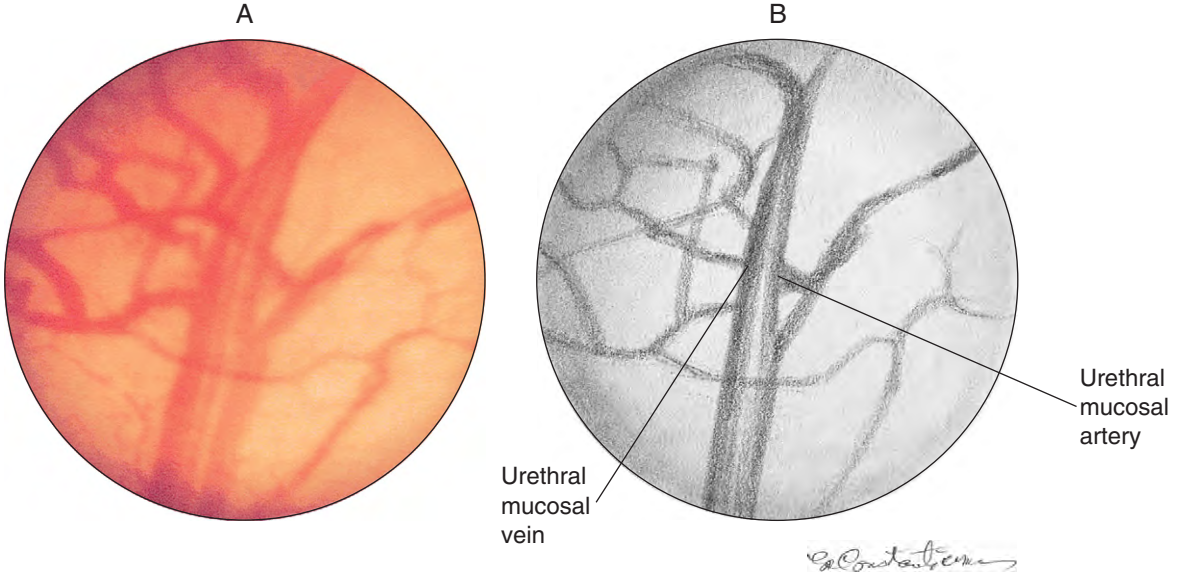



**Fig. 4–37**
Close-up view of the blood vessels in the bladder viewed during prepubic percutaneous cystoscopy in a male dog.

(Figs. 4-36 and 4-37). Blood vessels are relatively straight without convolutions or tortuosity, appearing to be in the mucosa and are not raised. As bladder distention occurs, the mucosa appears thinner and vessels are more easily seen. With bladder collapse, the vessels disappear and the mucosa develops folds or mucosal corrugations, or the bladder may flatten without significant folding or corrugation.

The ureteral openings are found dorsolaterally on both sides of the trigone area of the bladder. They change position and configuration with bladder distention. In dogs with a collapsed or minimally distended bladder, they are close to the junction of urethra and bladder and appear as straight longitudinal or slightly oblique slits on papillae (Fig. 4-38). With increasing distention, the ureteral stomas move cranially, away from the junction of the bladder and urethra, the papilla flattens and disappears, and the stomas appear as curved slits with a raised, thickened free margin. In the distended bladder, the free margins of the ureteral openings become thinner and the curve of the slit increases with eventual separation of the slit margins (Fig. 4-39). In cats, the ureteral openings are round and are on a papilla in the collapsed or only mildly distended bladder (Fig. 4-40). With

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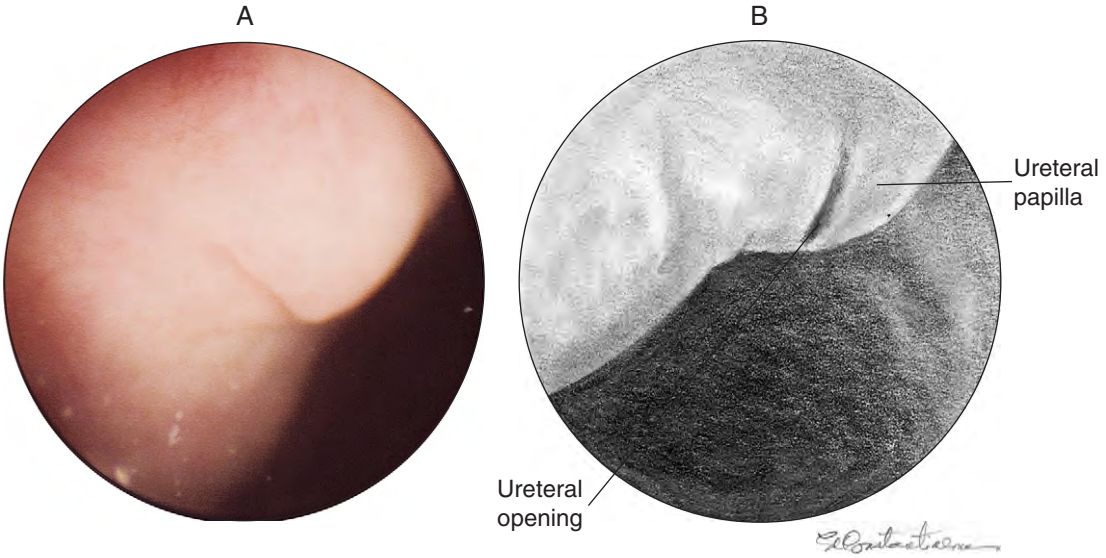



**Fig. 4–38**
Normal ureteral opening in a nondistended bladder seen with transurethral cystoscopy in a female dog.

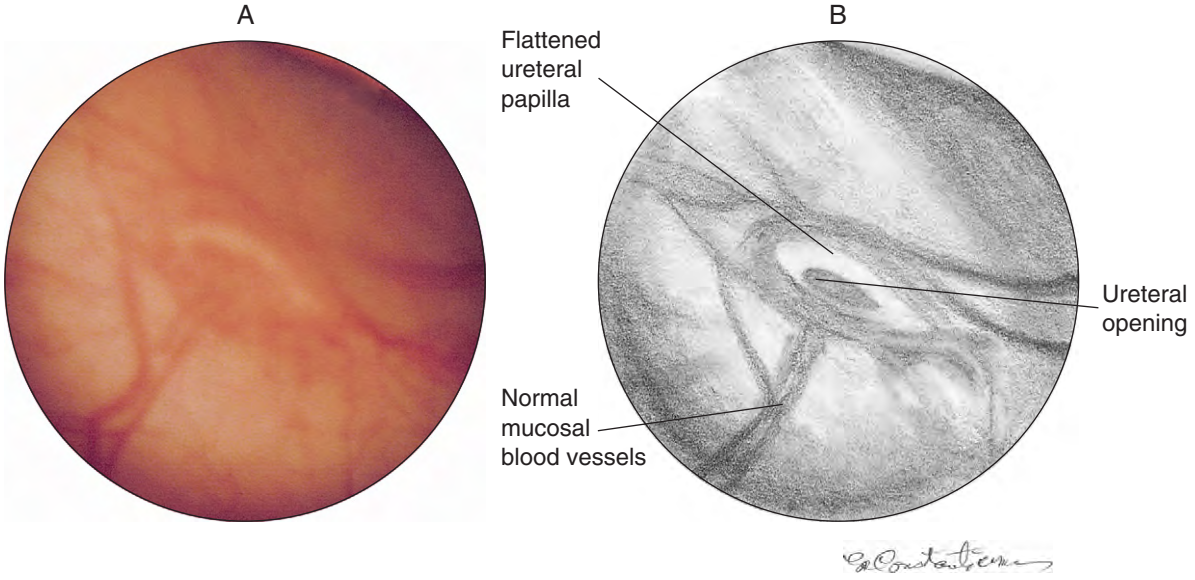



**Fig. 4–39**
Normal ureteral opening in an overdistended bladder seen with prepubic percutaneous cystoscopy in a male dog. With bladder distention, the ureteral papilla flattens and disappears. Overdistention of the bladder results in distortion of the ureteral opening from a straight slit to a "C" shape as is seen here.

increasing distention, the papilla disappears like it does in the dog but the ureteral stoma maintains its round shape. Urine can be seen coming from the ureters (see Fig. 4-40) as pulses of variable frequency dependent on the rate of urine production; the frequency of peristaltic waves ranges from being almost continuous to being widely spaced. Concentrated urine is easier to see but the frequency of impulses is decreased. With an increased volume of dilute urine, its production is more frequent but the urine is more difficult to visualize.

## PATHOLOGY

### Neoplasia

Bladder and urethral tumors occur most frequently in female dogs, making cystoscopy a particularly useful diagnostic tool.[15,20,21] Bladder and urethral tumors can also be seen in male dogs and in cats.[20,21] Transitional cell carcinomas are the most common canine bladder and urethral tumor.[15,20,21] They can be found in the body of the bladder, in the trigone area, or at any level of the

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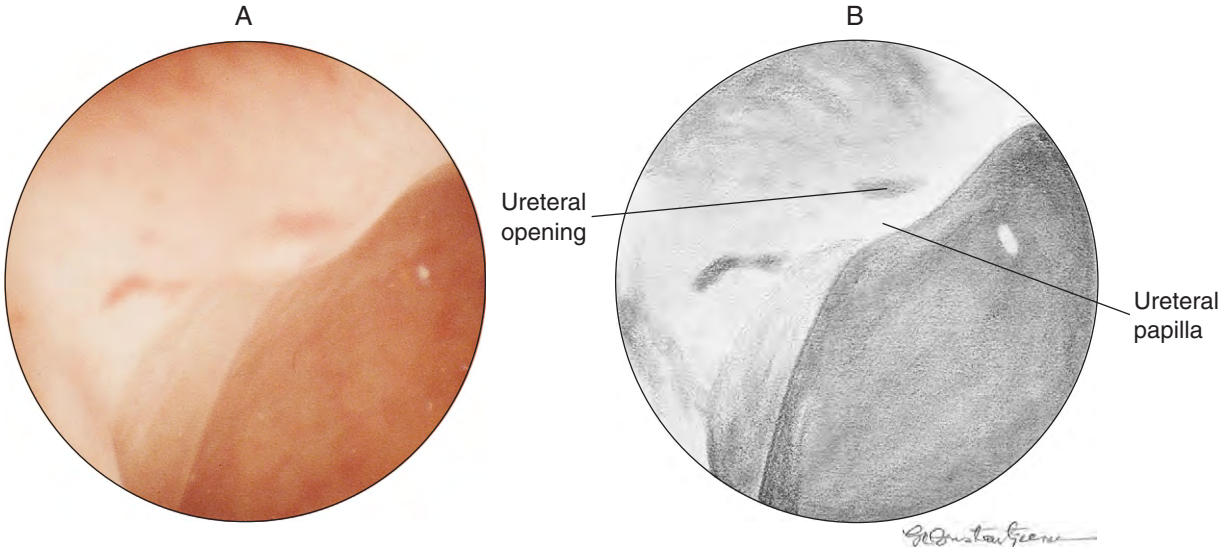



**Fig. 4–40**
Normal round ureteral opening on the papilla in a nondistended bladder of a female cat seen with transurethral cystoscopy. A pulse of urine can be seen coming from the ureteral opening.

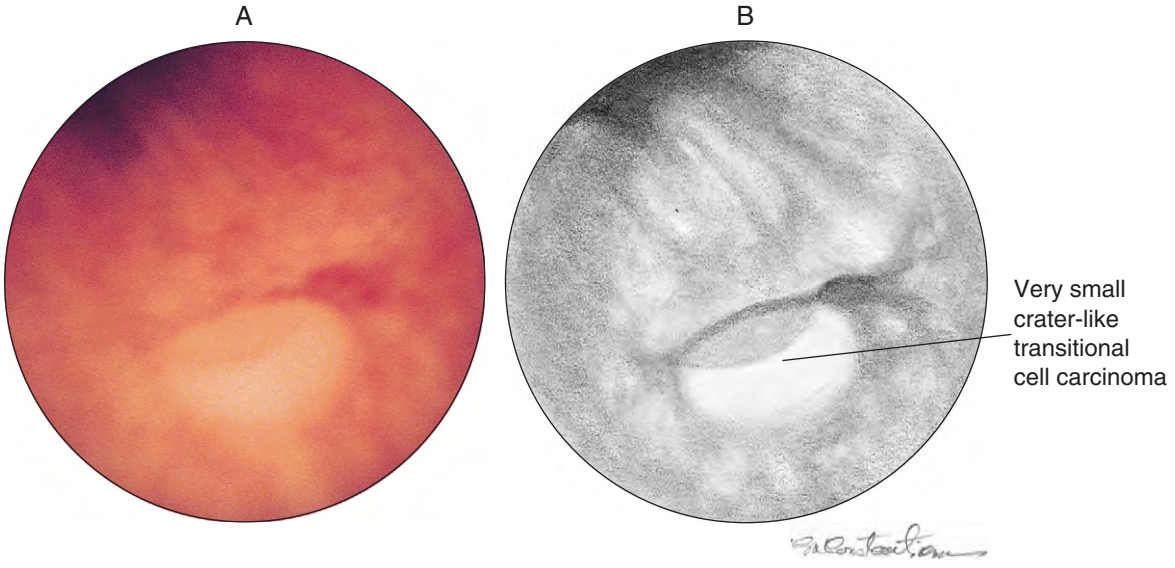



**Fig. 4–41**
A very small transitional cell carcinoma in the urethra of a female dog observed during transurethral cystoscopy. This is the crater-like shape seen with some smaller urethral lesions.

urethra. A large percentage are found in the urethra and present with signs of partial or complete urethral obstruction. Their position within the urethra makes assessment by other diagnostic techniques difficult. Positive, negative, or double contrast cystography do not show urethral lesions unless special attention is given to including the urethra within the study. This may be done by placing a Foley or other bulb type catheter in the caudal portion of the urethra and distending the urethra with contrast material. Placement of the catheter to image as much of the urethra as possible without having the catheter dislodge can be difficult. Placement of the catheter can be done most easily under endoscopic visualization. Ultrasonography can be used to image the bladder, but access to the urethra is limited by presence of the surrounding pelvis. Surgical access for exploration of the urethra is also hampered by the pelvis.

Transitional cell carcinomas differ in appearance depending on their size and location. Small urethral tumors may be flat or crater-like (Fig. 4-41), raised (Fig. 4-42), or,

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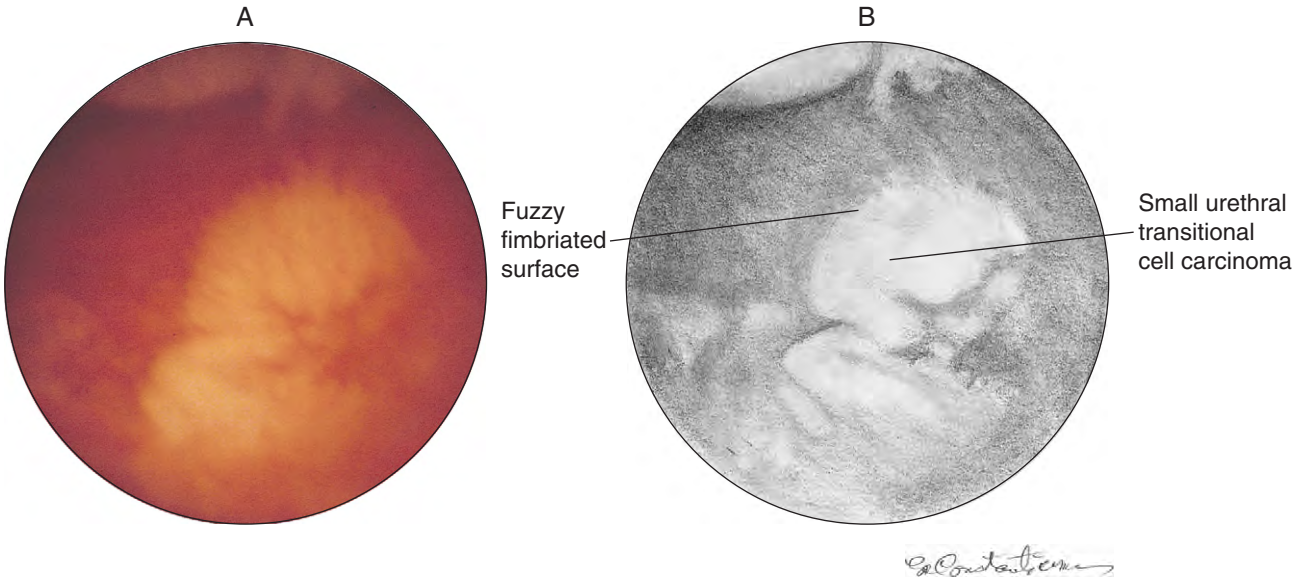



**Fig. 4–42**
A small raised transitional cell carcinoma lesion in the urethra of a female dog seen with transurethral cystoscopy. This lesion is beginning to show fimbriation, which was clearly visible at the time of examination but is not shown clearly on documentation. Fimbriation is the classic appearance for urethral transitional cell carcinomas.

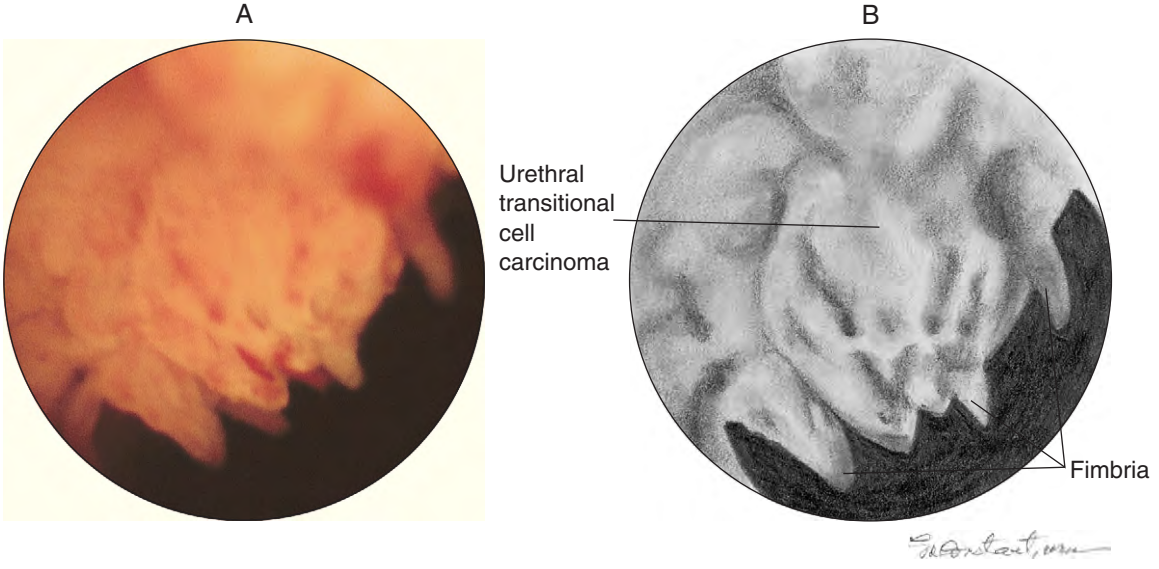



**Fig. 4–43**
A larger transitional cell carcinoma with easily visible fimbria seen in the cranial urethra of a female dog with transurethral cystoscopy. This fimbriation is characteristic of urethral transitional cell carcinomas.

most commonly, fimbriated (Fig. 4-43). Blood vessels are frequently visible within individual fimbria (Fig. 4-44). This fimbriated appearance is classic for urethral transitional carcinomas and when seen is diagnostic. As the urethral lesions become larger, they become irregular lobulated masses (Fig. 4-45) and can completely replace part or all of the urethra with obliteration of the lumen (Fig. 4-46). The tissue of larger transitional cell carcinomas is white and friable, and has minimal vasculature. With growth and expansion they can extend cranially into the bladder and caudally out of the urethral orifice (Fig. 4-47).

Appearance of transitional cell carcinomas in the bladder is more variable than in the urethra and can mimic some inflammatory lesions, making diagnoses based on gross findings less predictable. Small bladder lesions are most frequently smooth and raised (Fig. 4-48) but may also

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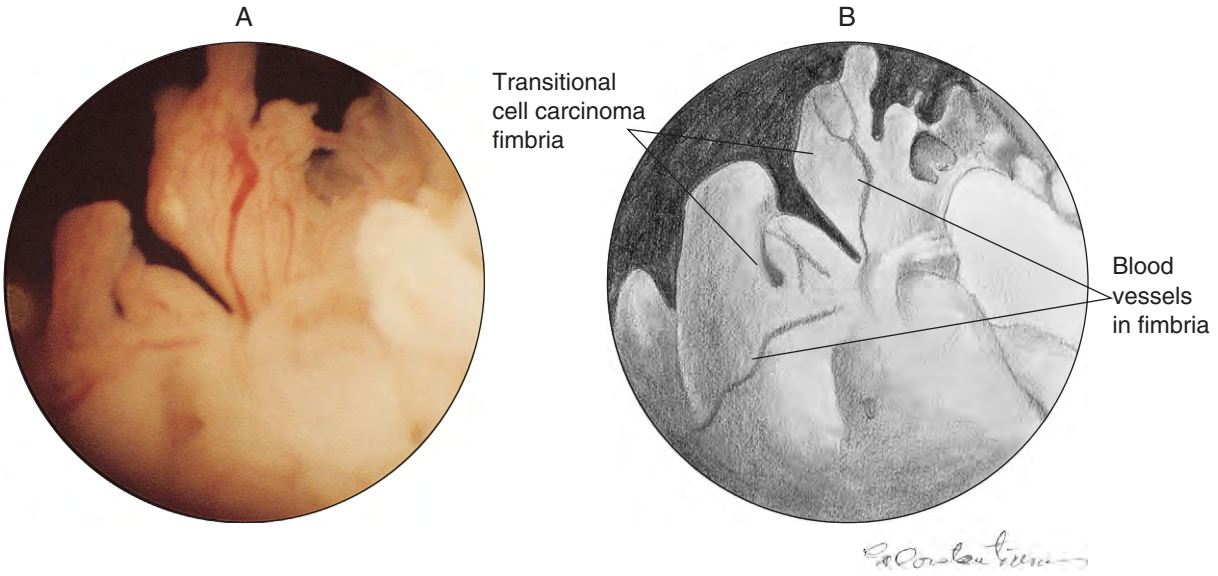



**Fig. 4–44**
Transurethral cystoscopy showing a urethral transitional cell carcinoma with large fimbria and easily visualized blood vessels within individual fimbria. This lesion was seen in the cranial urethra of a female dog.

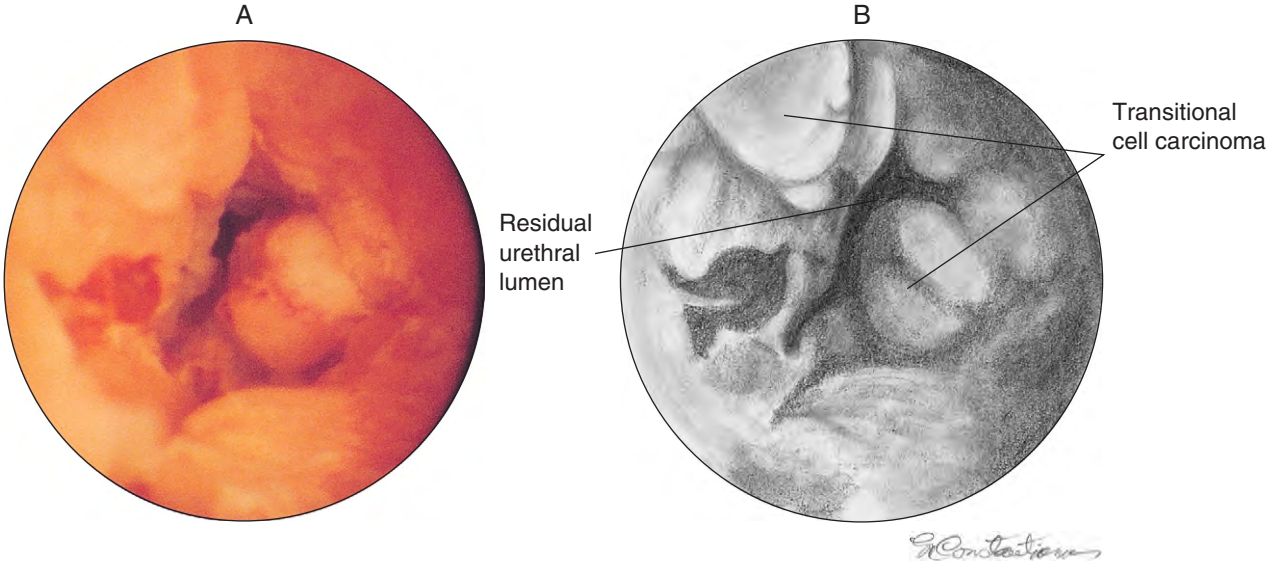



**Fig. 4–45**
A large, irregular, lobulated transitional cell carcinoma in the urethra of a female dog seen with transurethral cystoscopy. With increasing size, urethral transitional cell carcinomas lose the classic fimbriation, becoming lobulated or irregular and white in color with limited blood supply. This lesion involves the full circumference of the urethra and has completely replaced a segment of the urethra.

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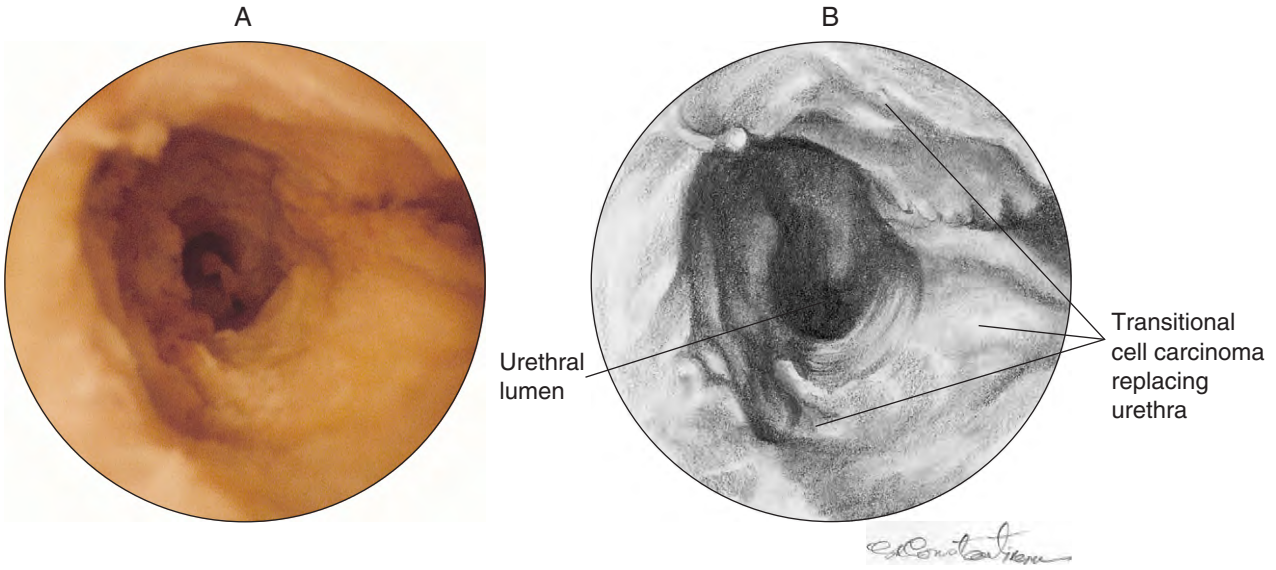



**Fig. 4–46**
Transurethral cystoscopy shows an extensive urethral transitional cell carcinoma in a female dog that is completely filling the urethral lumen and that has completely replaced the urethral mucosa.

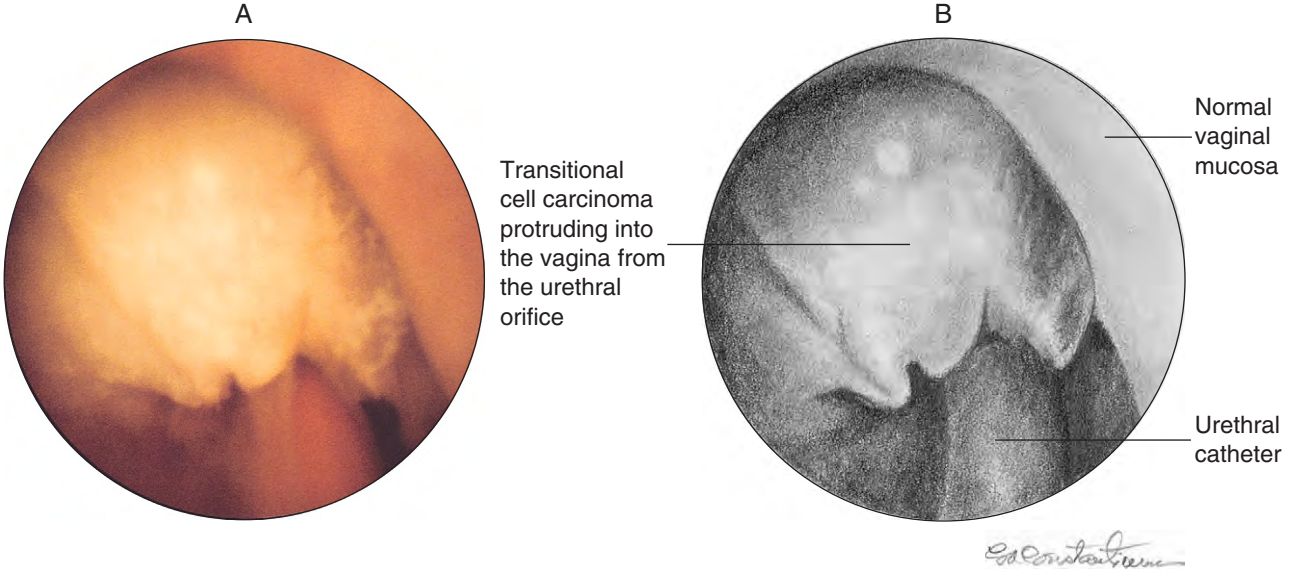



**Fig. 4–47**
A transitional cell carcinoma extending caudally out of the urethral orifice into the vagina of a female dog seen with transurethral cystoscopy. In this case, the urethra was completely replaced with neoplastic tissue. The tumor had also completely filled the urethra, producing an obstruction, and had extended cranially into the bladder and caudally into the vagina as seen here.

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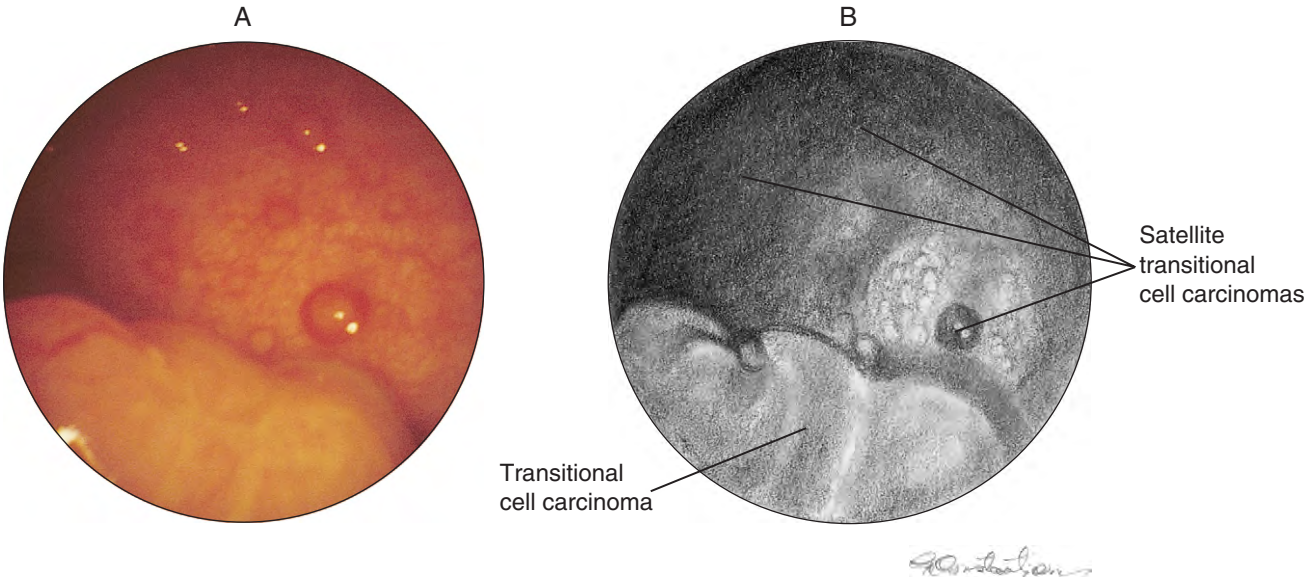



**Fig. 4-48**
Multiple transitional cell carcinomas in a female dog examined with transurethral cystoscopy showing several small smooth raised lesions and a large smooth tumor mass. This case demonstrates a large primary tumor and multiple satellite lesions. The small satellite lesions are too small to be seen without the magnification of the cystoscope.

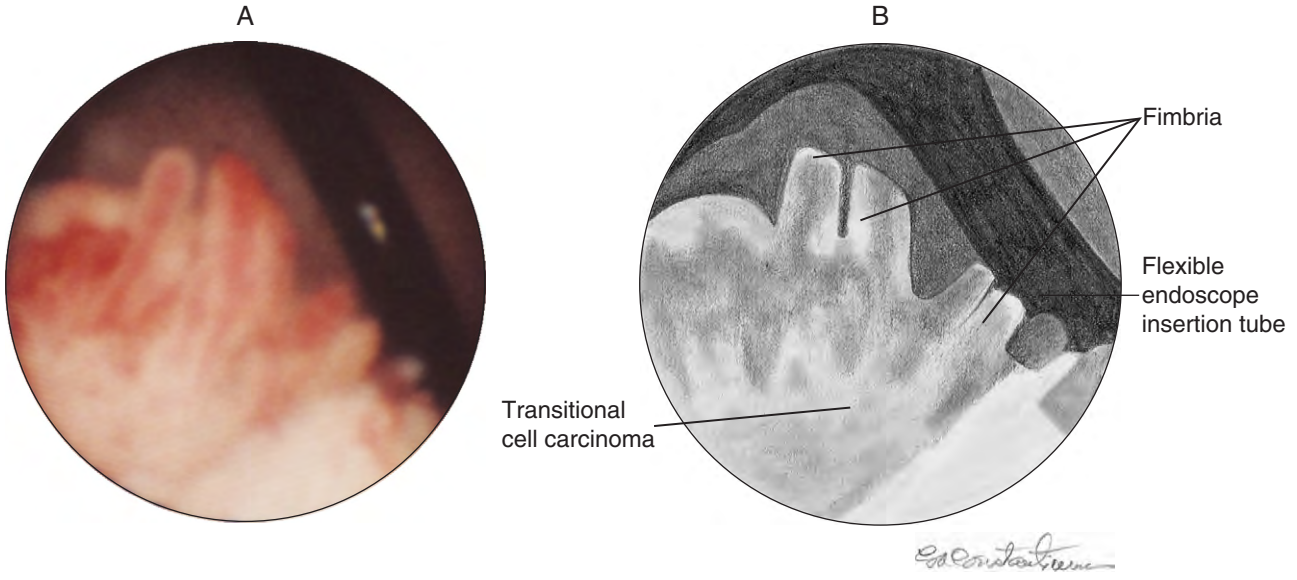



**Fig. 4-49**
A fimbriated transitional cell carcinoma in the bladder of a male dog seen with transurethral cystoscopy using a flexible cystourethroscope. This fimbriated appearance is less common in the bladder than in the urethra.

be fimbriated (Fig. 4-49) or appear polyp-like (Fig. 4-50). As bladder lesions enlarge, they may remain smooth (see Fig. 4-48), become lobulated (Fig. 4-51), become necrotic and ulcerated (Fig. 4-52), or develop fimbriae (Fig. 4-53). If hemorrhage occurs, they may be covered with fresh blood or with a mature, well-organized, purple to black blood clot that can be confused with tumor tissue. When broken open while obtaining biopsy specimens, bladder transitional cell carcinomas appear white and friable similar to larger urethral lesions. Trigonal lesions may take on the fimbriated appearance of urethral lesions (Fig. 4-54) or the appearance of bladder lesions, being smooth (Fig. 4-55) or lobulated (Fig. 4-56). If fimbriae develop on trigonal transitional cell carcinomas, they tend to be larger than on urethral lesions

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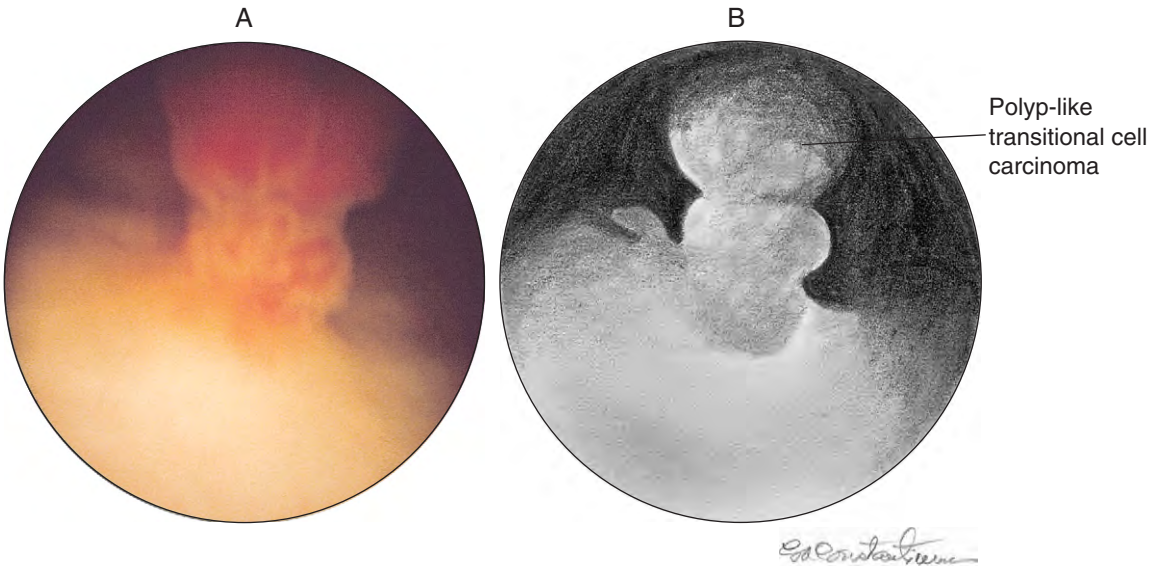



**Fig. 4–50**
A small polyp-like transitional cell carcinoma in the bladder of a female dog seen with transurethral cystoscopy. This is an uncommon appearance for transitional cell carcinomas and differentiation must be with histopathology.

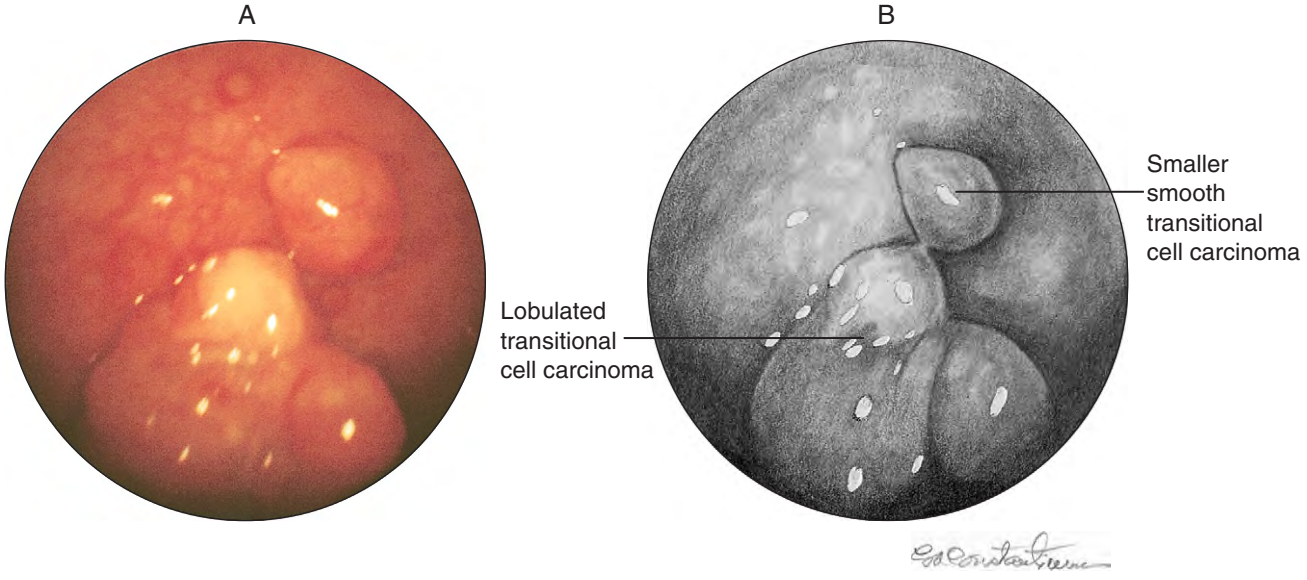



**Fig. 4–51**
A large lobulated transitional cell carcinoma and a smaller smooth satellite lesion in the bladder of a female dog seen with transurethral cystoscopy.

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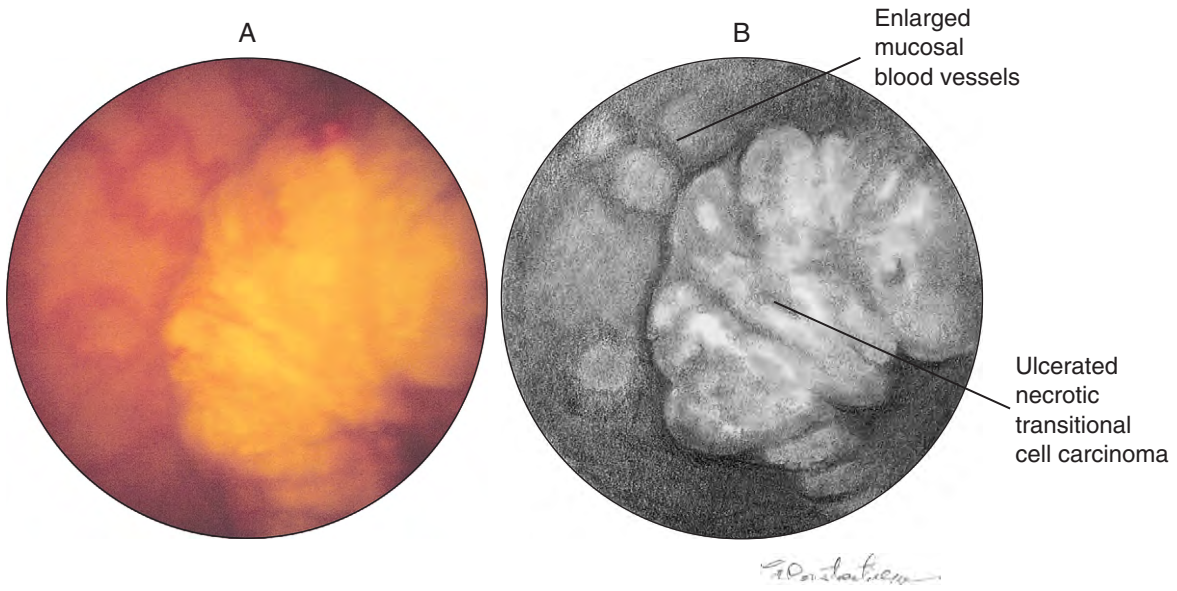



**Fig. 4–52**
A large necrotic transitional cell carcinoma with ulceration in the bladder of a female dog examined with transurethral cystoscopy.

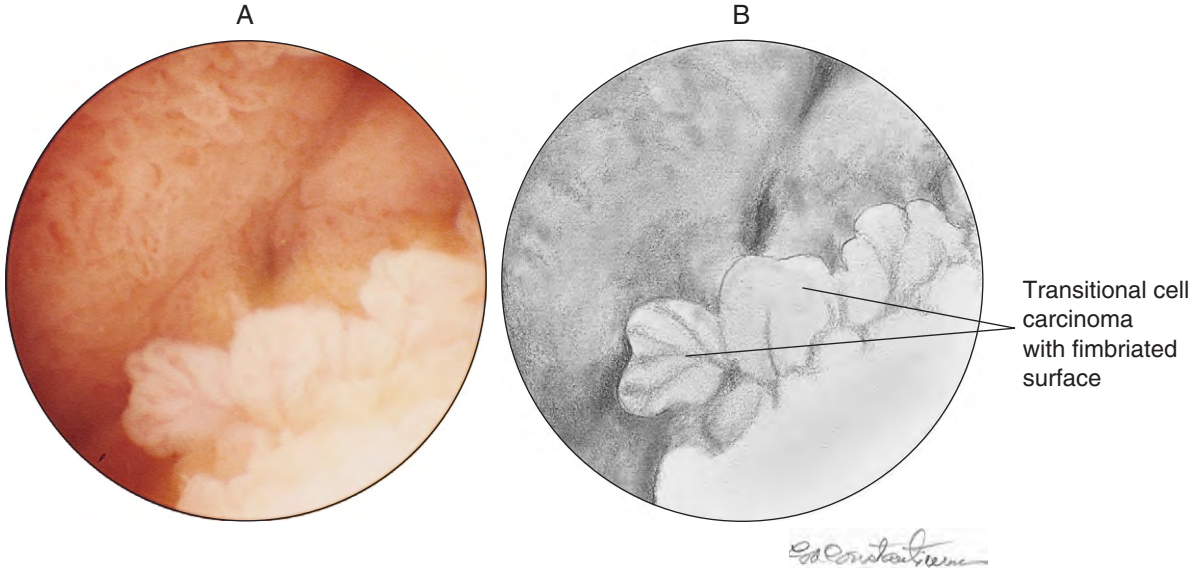



**Fig. 4–53**
A fimbriated transitional cell carcinoma found by transurethral cystoscopy in the bladder of a female dog. This fimbriated appearance is less common in the bladder than in the urethra.

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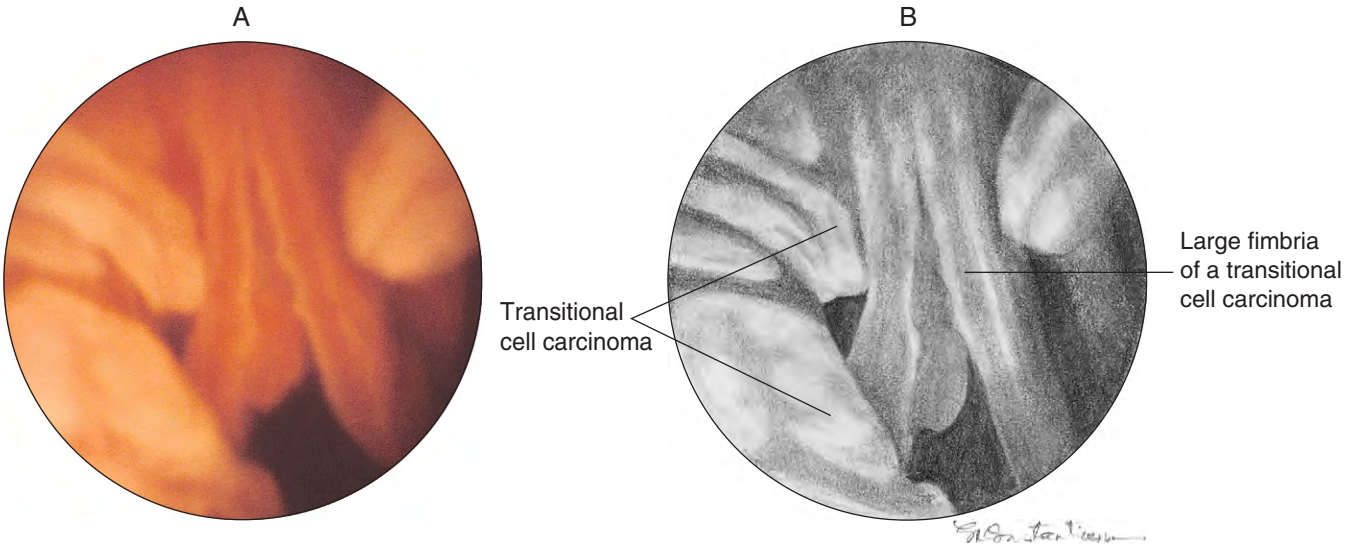



**Fig. 4–54**
Large fimbria of a trigonal transitional cell carcinoma found in a female dog by transurethral cystoscopy. Trigonal transitional cell carcinomas can be fimbriated or smooth. When fimbriated, the fimbria tend to be larger than those found in the urethra.

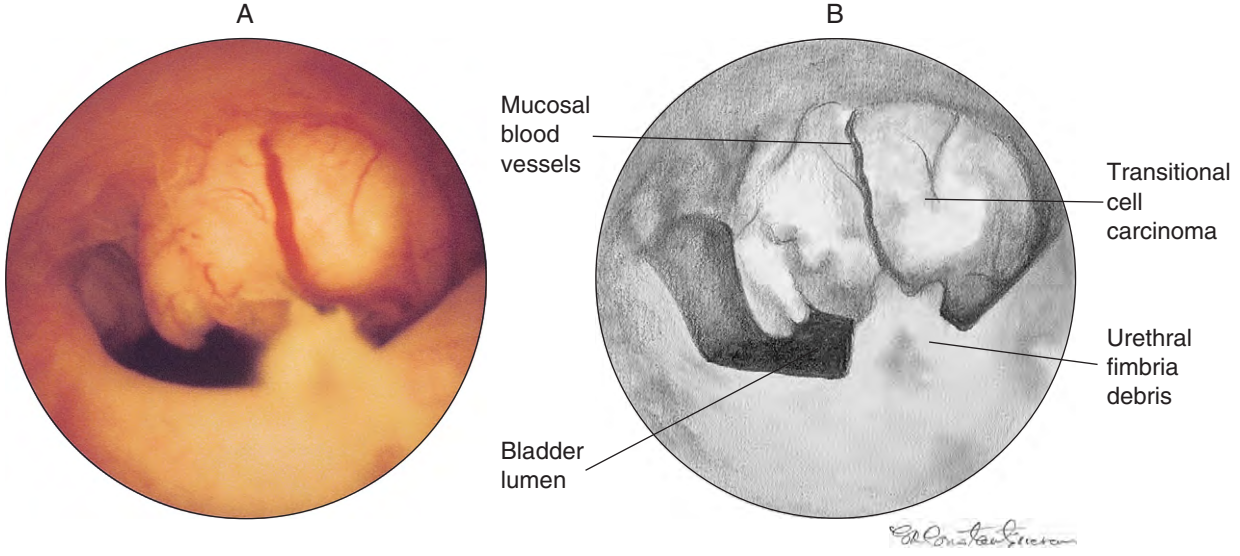



**Fig. 4–55**
A smooth trigonal transitional cell carcinoma in a female dog seen with transurethral cystoscopy.

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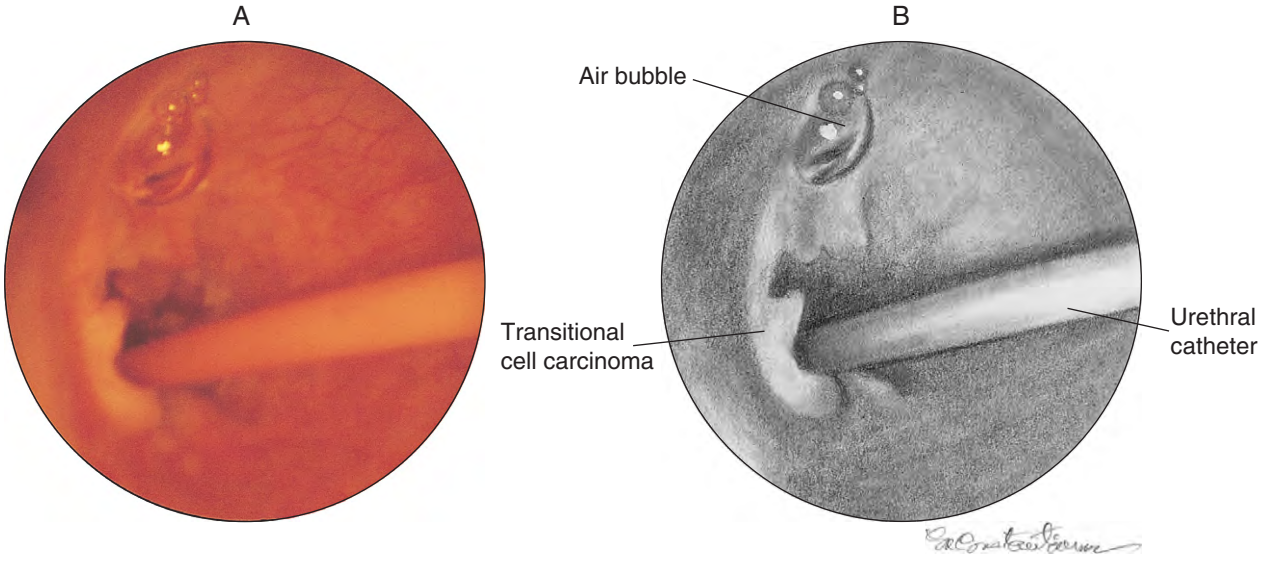



**Fig. 4–56**
A lobulated transitional cell carcinoma in the trigone area of a male dog seen by prepubic percutaneous cystoscopy.

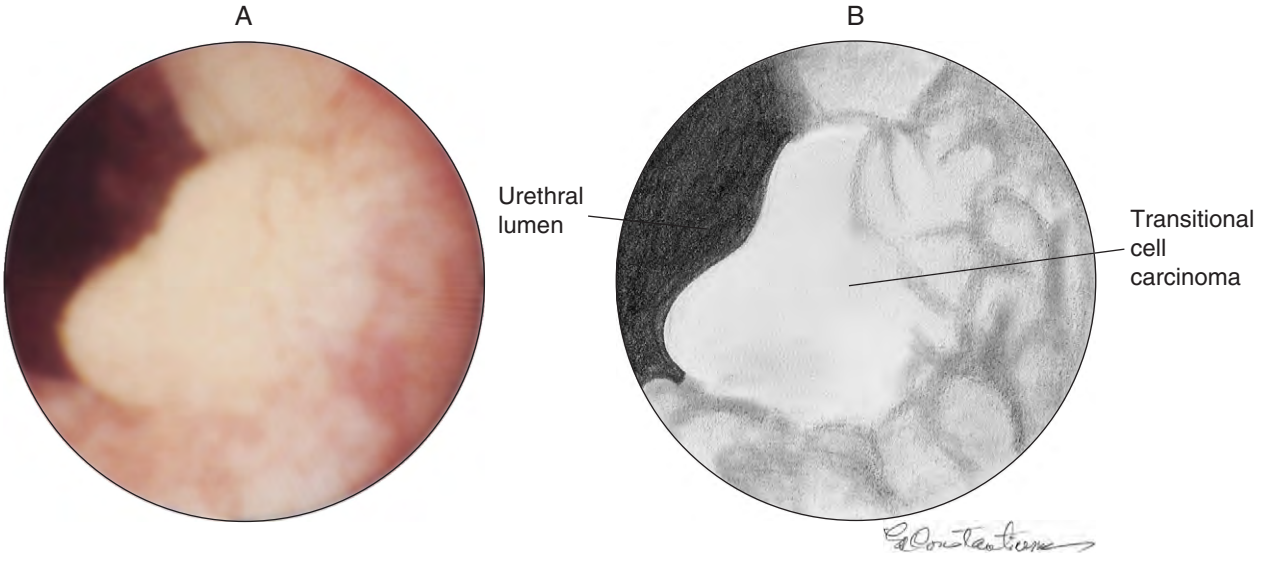



**Fig. 4–57**
A urethral transitional cell carcinoma in a male dog found with transurethral cystoscopy using a flexible cystourethroscope.

(see Fig. 4-54). Transitional cell carcinomas may be seen as solitary lesions (see Figs. 4-50 and 4-52), as a primary mass with satellite lesions (see Figs. 4-48 and 4-51), or as what appear to be multiple primary lesions.

Transitional cell carcinomas are found most commonly in female dogs but can also occur in the urethra (Fig. 4-57) and bladder of male dogs (see Figs. 4-49 and 4-56) and in the bladder of cats (Figs. 4-58 and 4-59). Prostatic carcinomas can also be seen endoscopically (Fig. 4-60). An insufficient number of cases have been evaluated cystoscopically to allow accurate gross description of these tumors in male dogs or in cats. Prostatic carcinomas that have been examined did not show fimbriation and have appeared to be more within the urethral or bladder walls and penetrating the mucosa rather than originating on the mucosal surface. Feline

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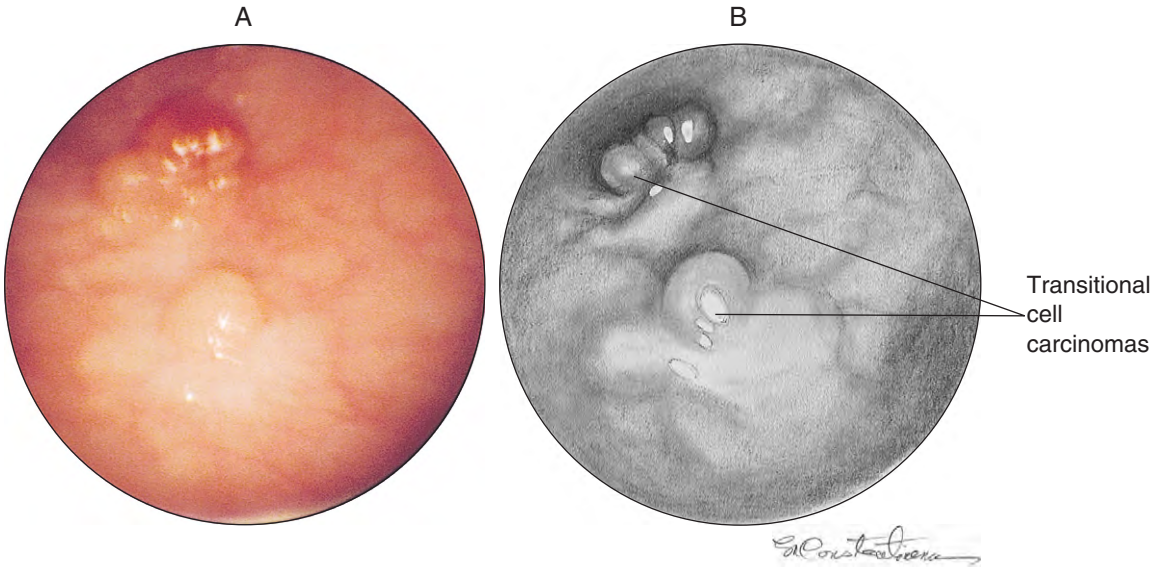



**Fig. 4–58**
Multiple small transitional cell carcinomas in the bladder of a female cat seen with transurethral cystoscopy and showing both smooth and lobulated forms.

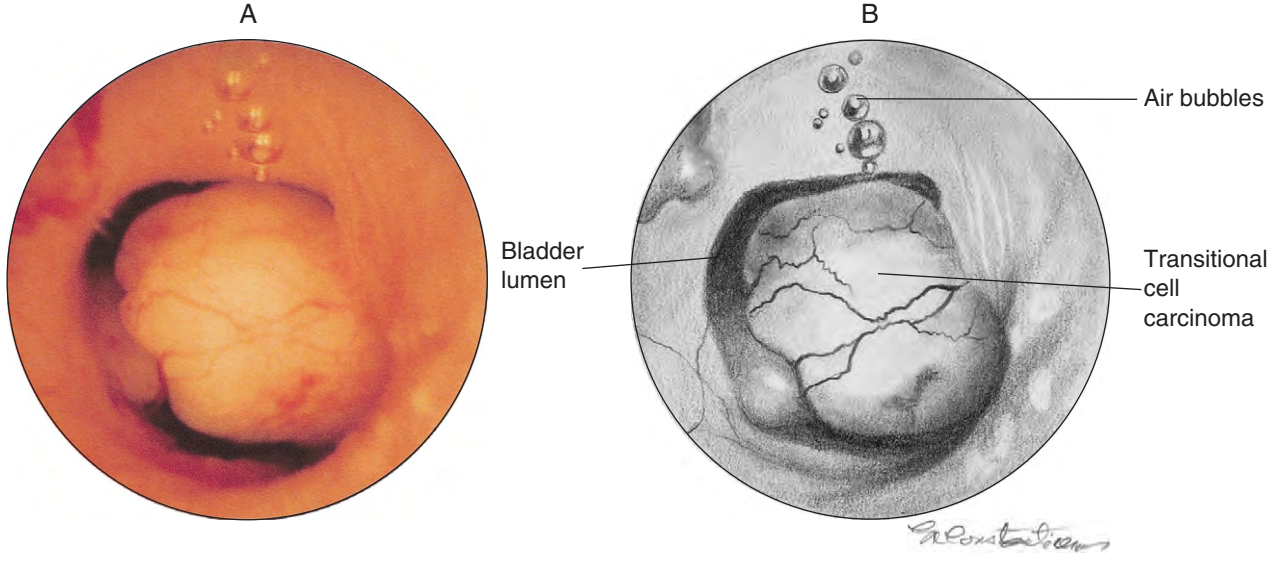



**Fig. 4–59**
Transitional cell carcinoma in the trigone area of a female cat seen with transurethral cystoscopy. Feline transitional cell carcinomas appear to be consistently smooth or lobulated and do not tend to show the fimbriation seen in dogs.

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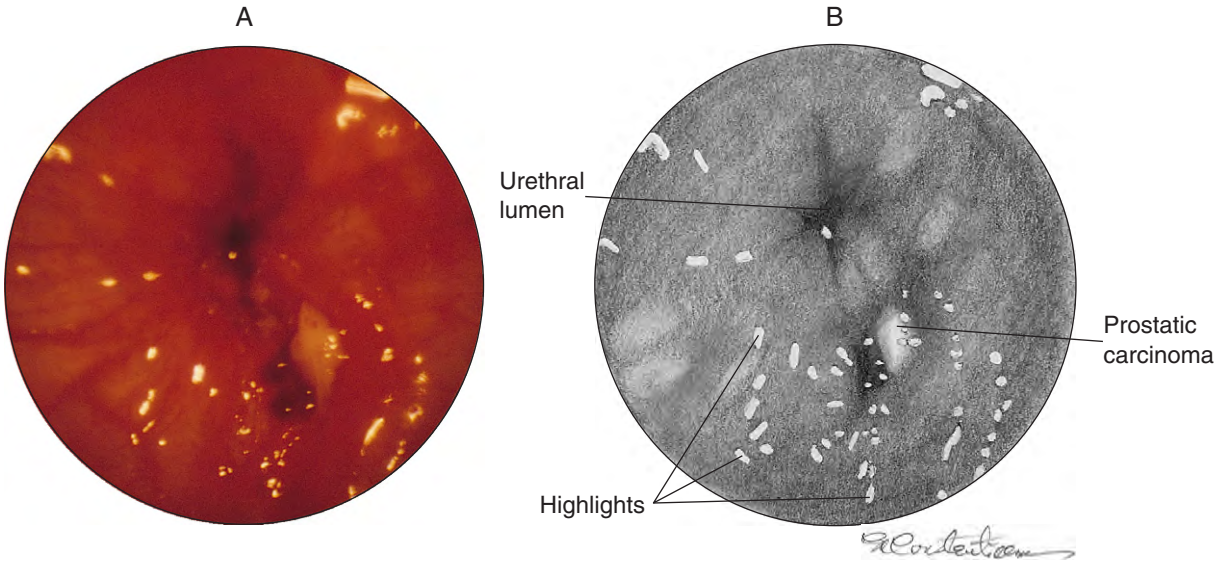



**Fig. 4–60**
A prostatic carcinoma penetrating the bladder mucosa seen by prepubic percutaneous cystoscopy in a male dog.

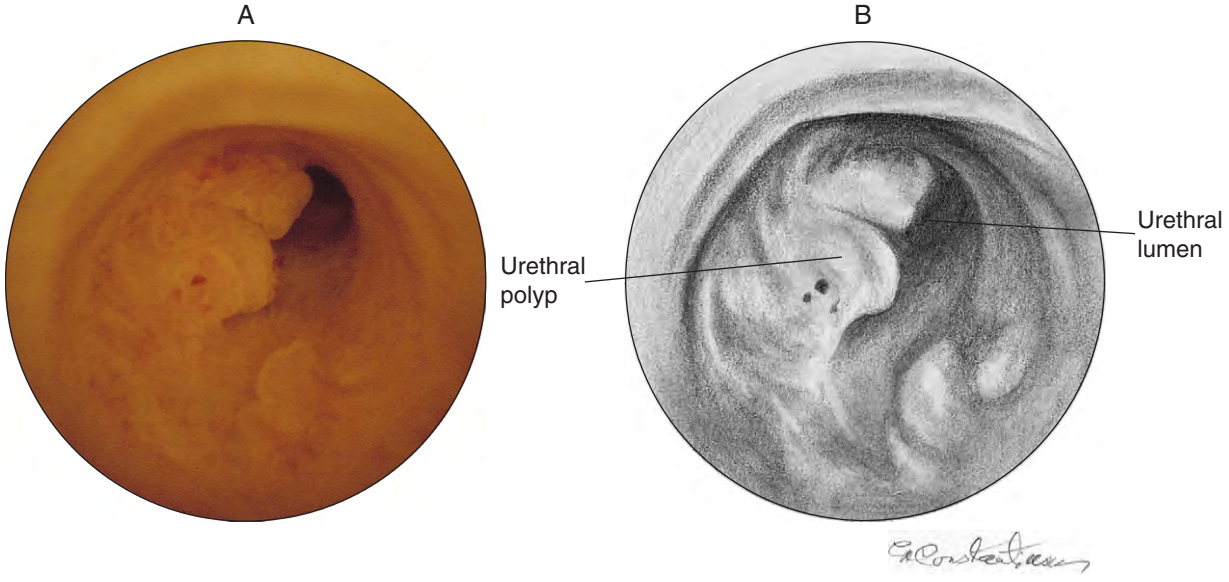



**Fig. 4–61**
Benign urethral polyps in a male cat seen with transurethral cystoscopy immediately after a perineal urethrostomy had been performed.

transitional cell carcinomas have appeared to be consistently smooth or lobulated, without a tendency to show fimbriation, and have only been seen in the bladder.

Other tumor types are seen much less frequently than transitional cell carcinomas and include smooth muscle tumors (leiomyomas and leiomyosarcomas), squamous cell carcinomas, and adenocarcinomas. Smooth muscle tumors occurring in the bladder wall may not be visible with cystoscopy. Benign inflammatory polyps mimicking neoplasia may be seen in the urethra (Fig. 4-61) and in the bladder (Figs. 4-62 and 4-63). Histopathology is often necessary to differentiate inflammatory from neoplastic lesions. The fimbriated appearance of urethral transitional cell carcinomas is characteristic and has not been seen with other tumor types. Large urethral transitional cell carcinomas lose the fimbriation and have a characteristic

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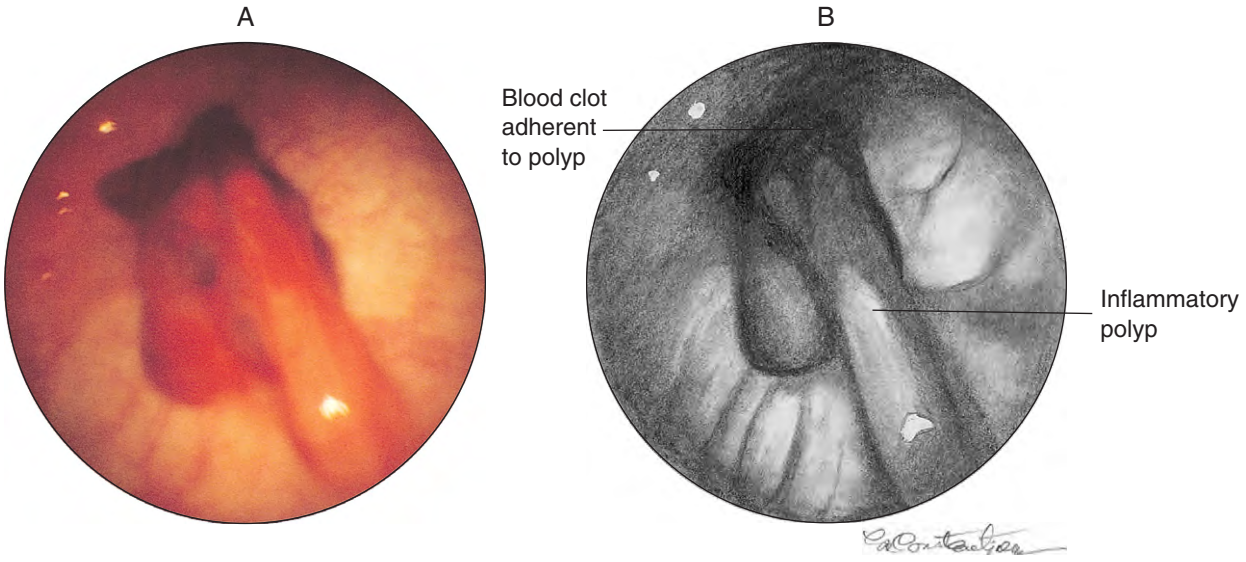



**Fig. 4–62**
A benign inflammatory polyp in the bladder of a male dog seen during prepubic percutaneous cystoscopy.

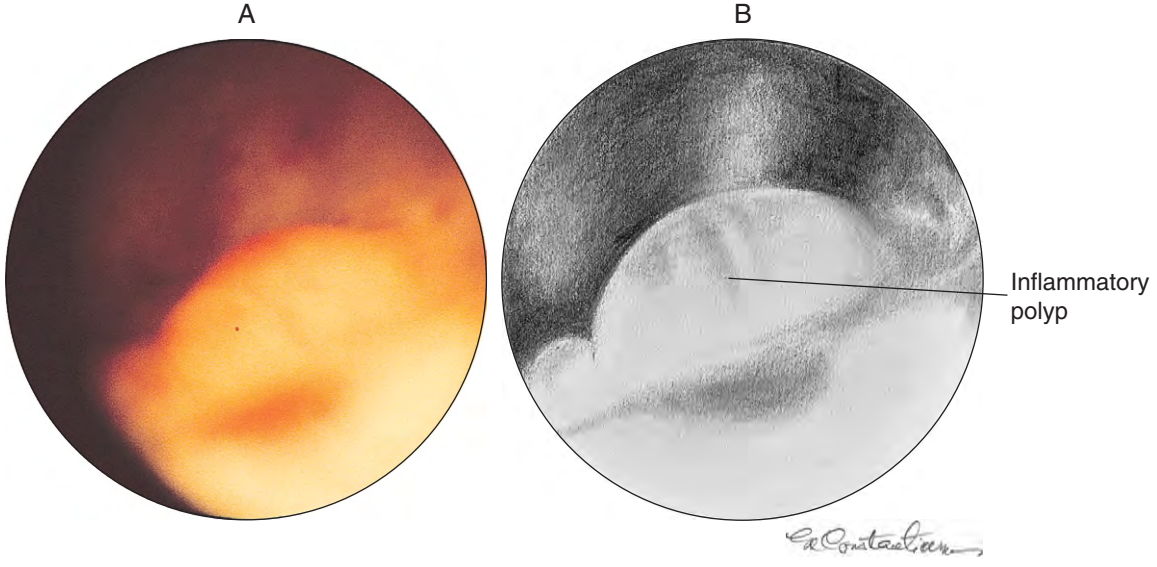



**Fig. 4–63**
An inflammatory polyp in the bladder of a male cat found using transurethral cystoscopy performed immediately after perineal urethrostomy surgery.

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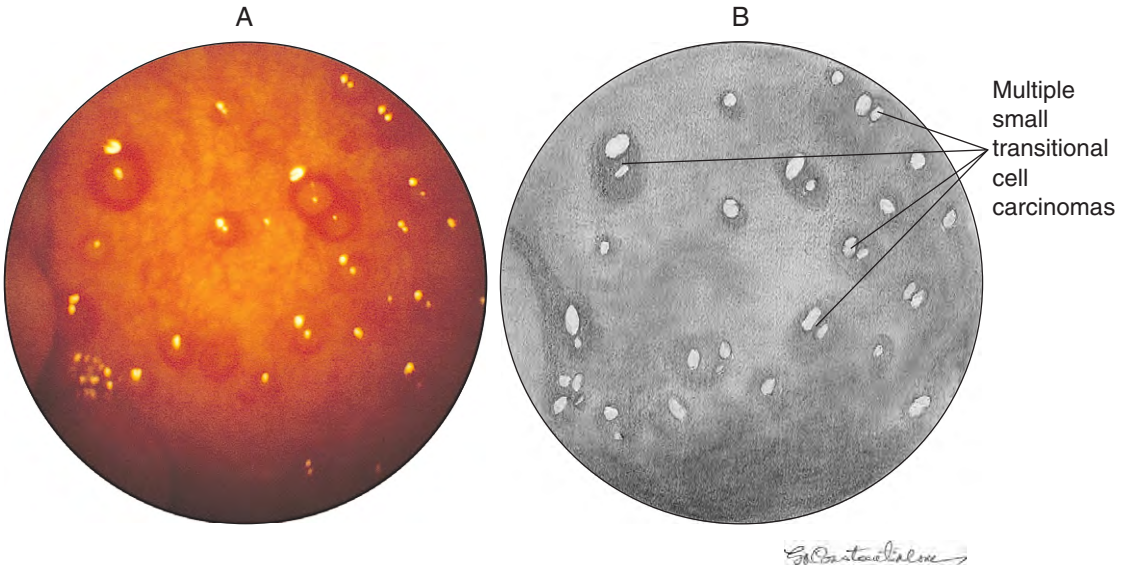



**Fig. 4-64**
Multiple small transitional cell carcinomas in the bladder of a female dog seen through air by transurethral cystoscopy. When viewed through air, these lesions appear raised.

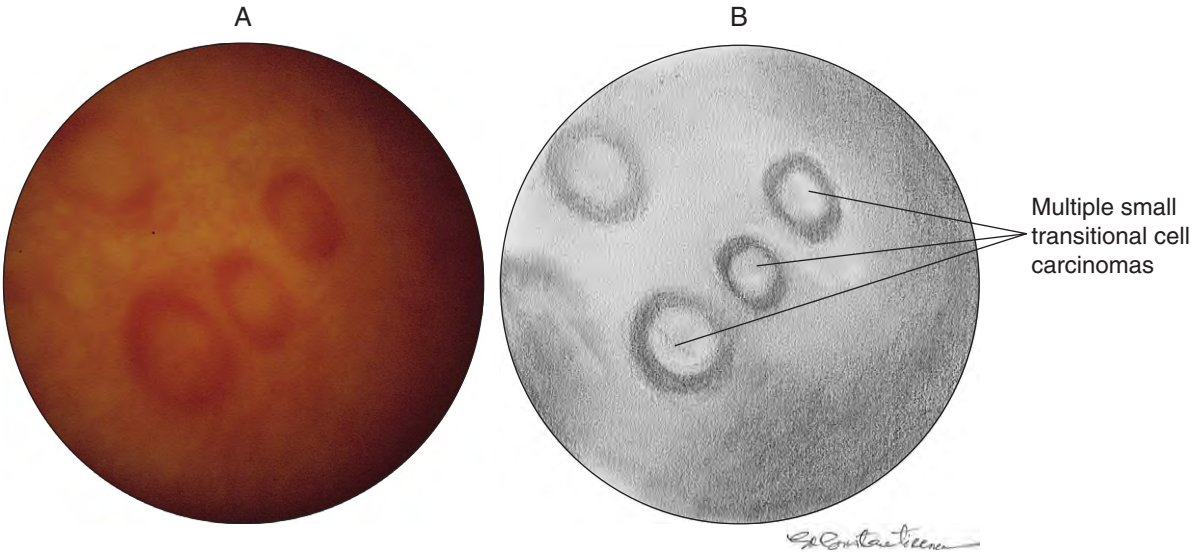



**Fig. 4-65**
The same lesions as in Fig. 4-64 as seen through saline. With the liquid media, the lesions appear as flat or indented areas with peripheral hyperemia. These lesions cannot be differentiated from small inflammatory polyps without histopathologic study.

white, friable—almost cottony—appearance. Small transitional cell carcinomas in the bladder and small inflammatory polyps or lymphoplasmacytic nodules in the bladder look similar. Lymphoplasmacytic nodules or polyps can be seen in multiple locations in the lower urinary tract, in the vagina, and in many other areas of the body. These small, smooth nodules appear different when viewed through air (Fig. 4-64) and when viewed through a liquid (Fig. 4-65). Even with the classic and characteristic appearance of some transitional cell carcinomas, histopathology is still relied on for a final diagnosis.

## Chronic Cystitis and Urethritis

Inflammatory changes are less easily defined grossly than are neoplastic lesions. Inflammation may range from

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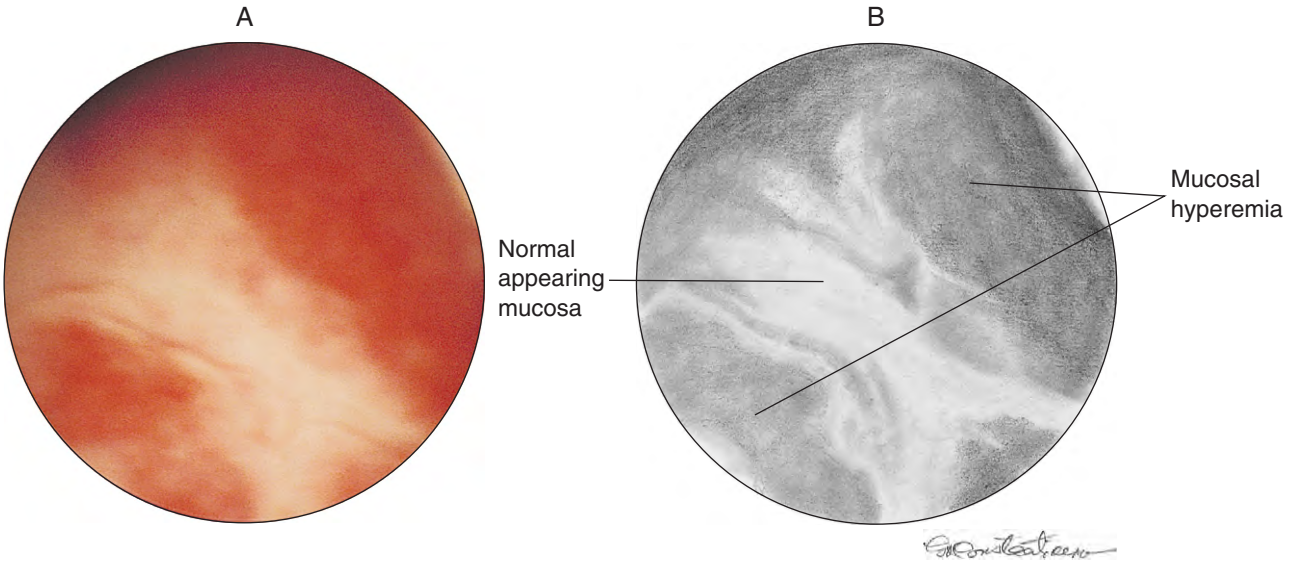



**Fig. 4-66**
Bladder mucosal hyperemia in a female dog with acute severe cystitis as seen with transurethral cystoscopy.

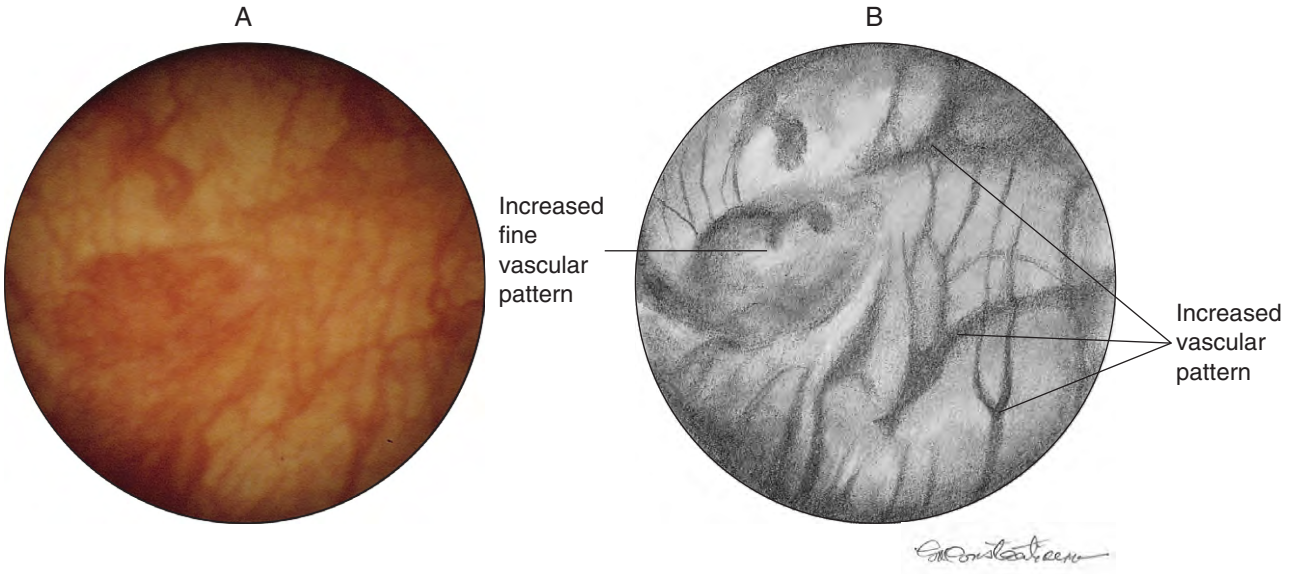



**Fig. 4-67**
Vascular changes of increased numbers of both large and small blood vessels as seen by transurethral cystoscopy performed on a female dog with bladder mucosal inflammation.

acute superficial hyperemia to chronic thickened fibrous scar tissue. Inflammation in the bladder mucosa may appear as hyperemia (Fig. 4-66); increased vascularity (Fig. 4-67); localized mucosal edema, swelling, or thickening (Fig. 4-68); diffuse mucosal edema, swelling, or thickening (Fig. 4-69); increased mucosal opacity (Figs. 4-69 and 4-70); petechiae or "glomerulations" (Fig. 4-71); ecchymoses (Fig. 4-72); or free hemorrhage (Fig. 4-73). With increasing chronicity, mucosal opacity increases and elasticity decreases. These changes result in increased difficulty in distending the bladder for examination, decreased distention as a urine reservoir, and reduced contraction for bladder emptying. When these changes occur, the mucosa may become corrugated with bladder emptying (Fig. 4-74). Fibrous scar tissue can be localized (Fig. 4-75) or extensive and generalized (Fig. 4-76)

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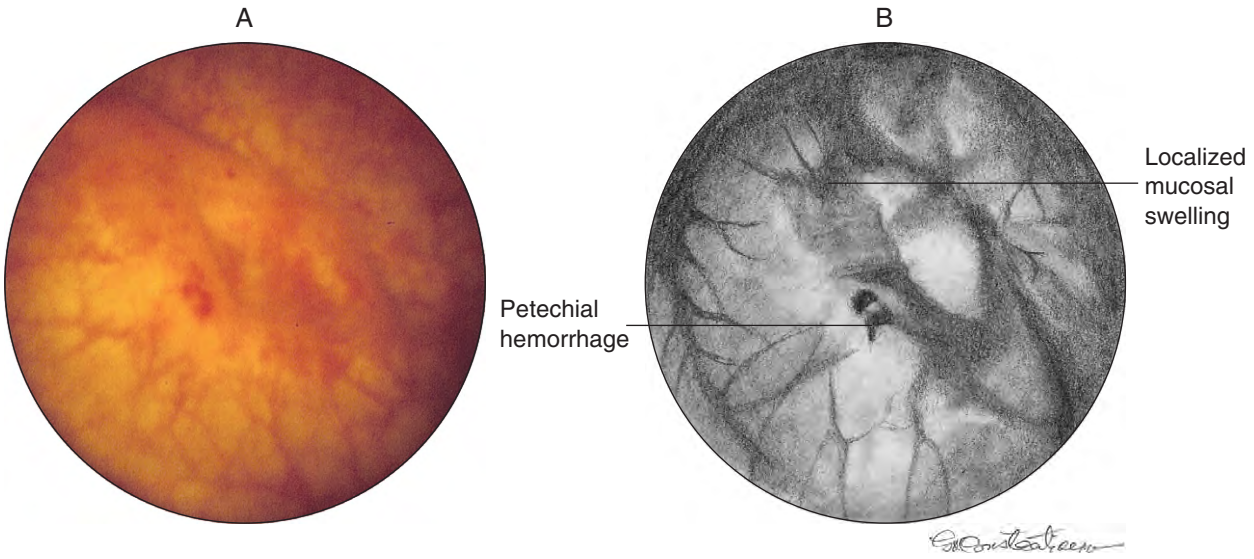



**Fig. 4–68**
Localized mucosal swelling or thickening in a female dog with cystitis seen during transurethral cystoscopy.

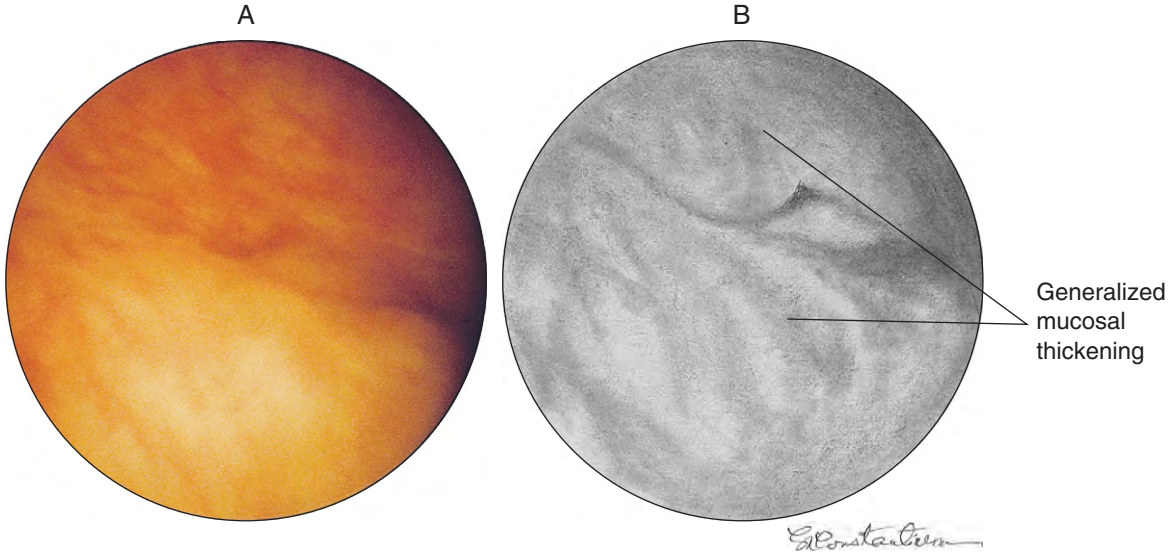



**Fig. 4–69**
Diffuse inflammation of the bladder mucosa showing swelling and thickening in a female dog as visualized with transurethral cystoscopy.

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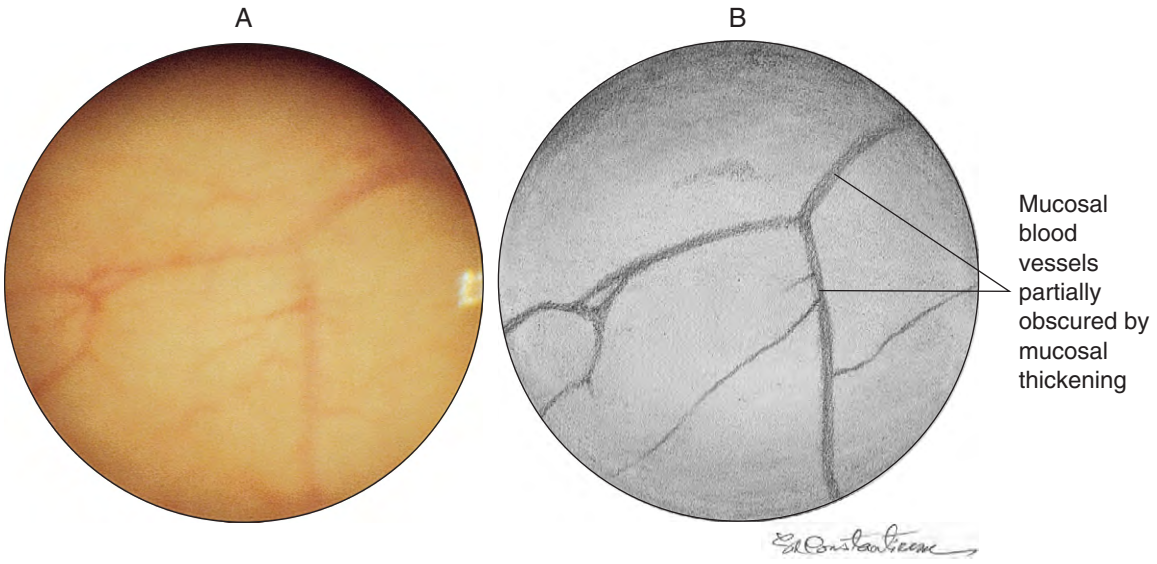



**Fig. 4–70**
Mucosal thickening obscuring visibility of blood vessels in a male cat with chronic lower urinary tract disease. Compare with the normal findings in Figs. 4-36 and 4-37. The examination was performed transurethrally immediately after perineal urethrostomy surgery.

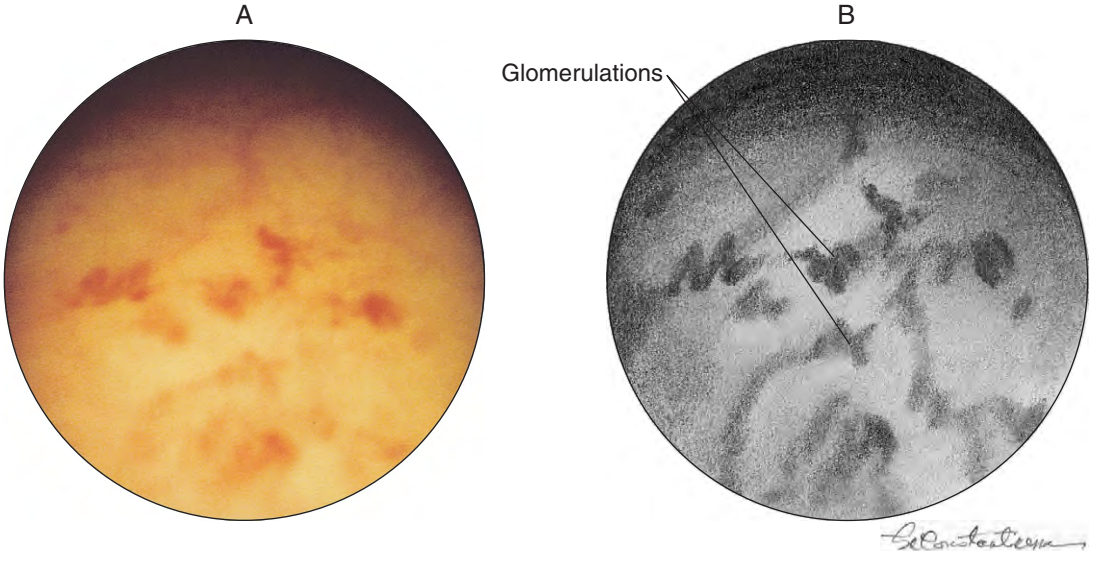



**Fig. 4–71**
Petechiae, or "glomerulations," in the bladder mucosa of a male cat with cystitis observed during prepubic percutaneous cystoscopy.

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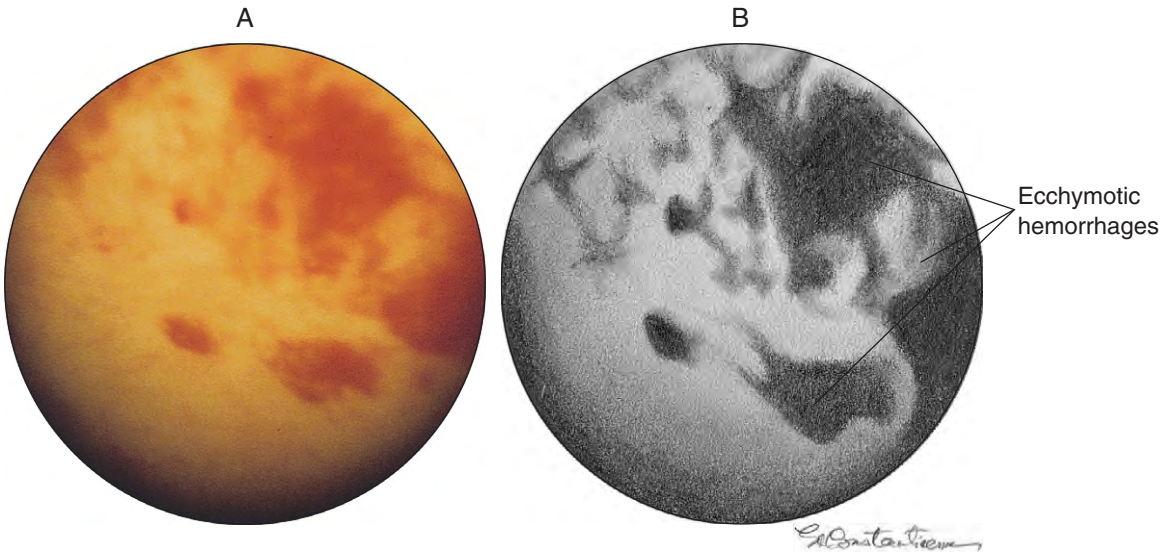



**Fig. 4–72**
Ecchymotic hemorrhages in the bladder of a female dog with acute severe eosinophilic cystitis as seen with transurethral cystoscopy.

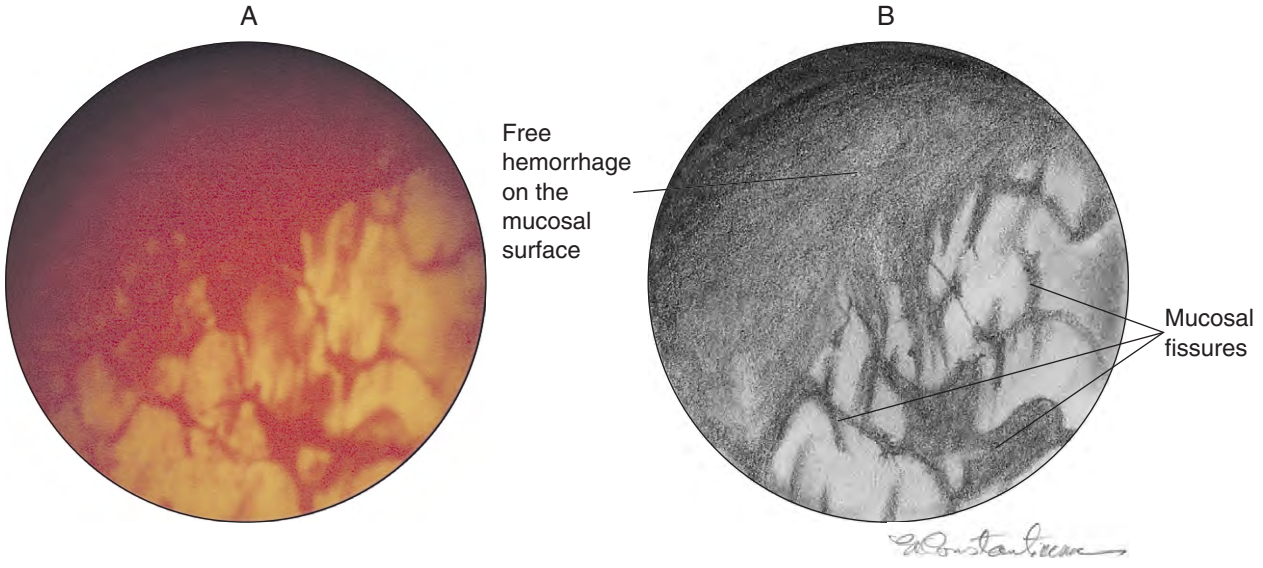



**Fig. 4–73**
Free hemorrhage from the bladder mucosa of a female dog with hemorrhagic cystitis as observed with transurethral cystoscopy.

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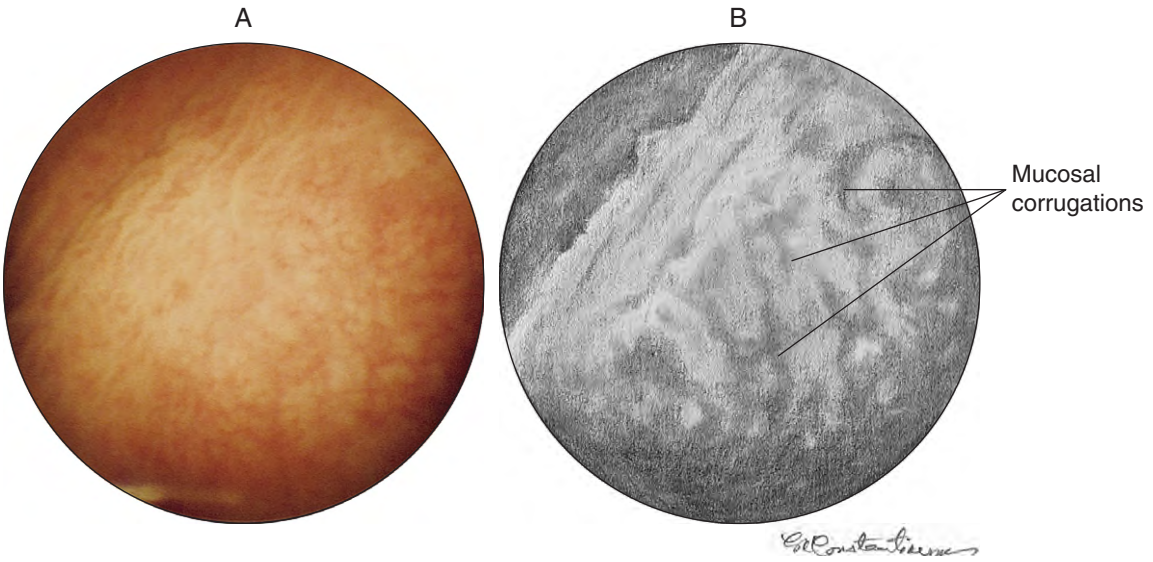



**Fig. 4–74**
Mucosal corrugations in the bladder of a female dog with chronic cystitis as seen with transurethral cystoscopy. Fibrosis in the bladder wall prevents normal distention and flattening or smoothing of the mucosa.

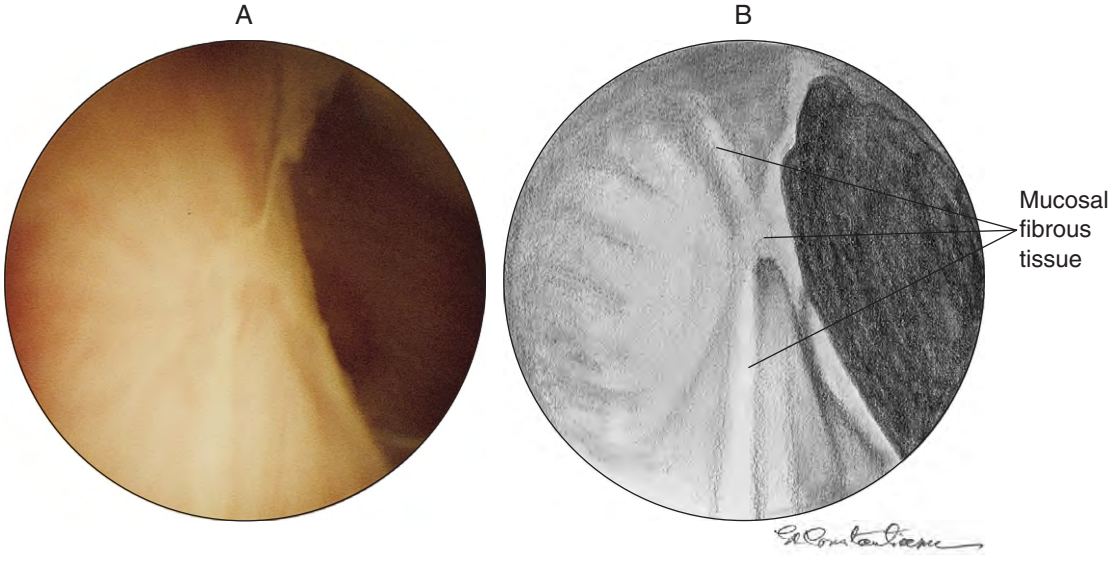



**Fig. 4–75**
Localized scar tissue in the mucosa of a female dog with chronic cystitis. The examination was performed transurethrally.

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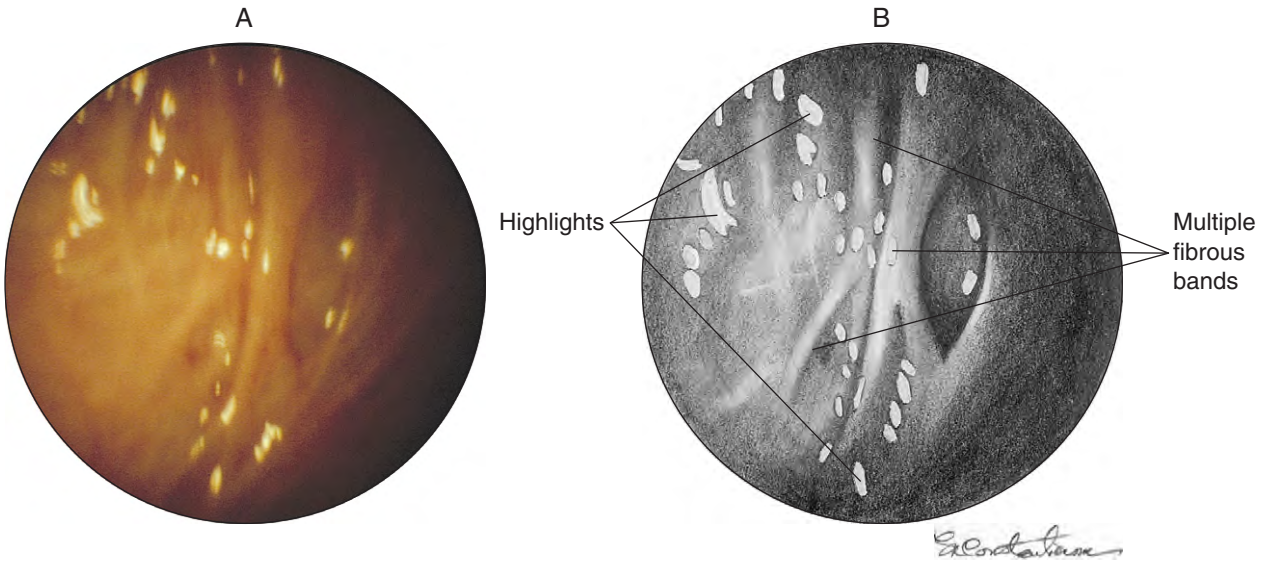



**Fig. 4–76**
Extensive bands of fibrous tissue preventing normal bladder distention in a male dog with chronic nonsuppurative cystitis as observed during prepubic percutaneous cystoscopy.

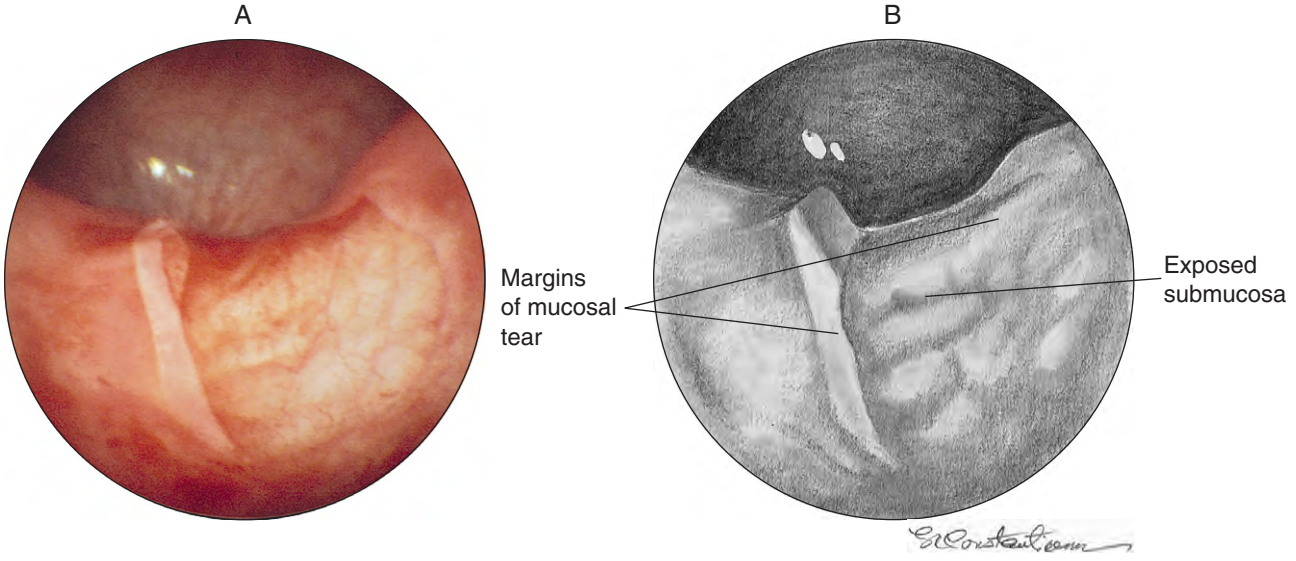



**Fig. 4–77**
Mucosal tearing in the bladder of a female dog with chronic cystitis. The bladder was distended normally and mucosal tearing occurred due to scarring in the mucosa. Bladder wall fibrosis also resulted in interference of bladder distention with formation of a narrowing or band around the middle of the bladder.

preventing local or generalized bladder distention. Mucosal tearing may occur more commonly with normal bladder distention in the presence of increasing chronicity and mucosal fibrosis (Fig. 4-77).

Vascular changes are seen with inflammation. Increased numbers of smaller vessels are visible in acute and some more severe chronic inflammatory conditions (see Fig. 4-67). With chronicity, the number of visible smaller vessels may decrease as a result of mucosal thickening, and the number of visible larger vessels may increase or decrease (see Fig. 4-70). The larger vessels may show increased tortuosity and size, and may protrude into the bladder lumen (Fig. 4-78).

Inflammatory polyps can develop with chronic inflammation (see Figs. 4-61 through 4-63). Multiple small transitional cell carcinomas and the difference in

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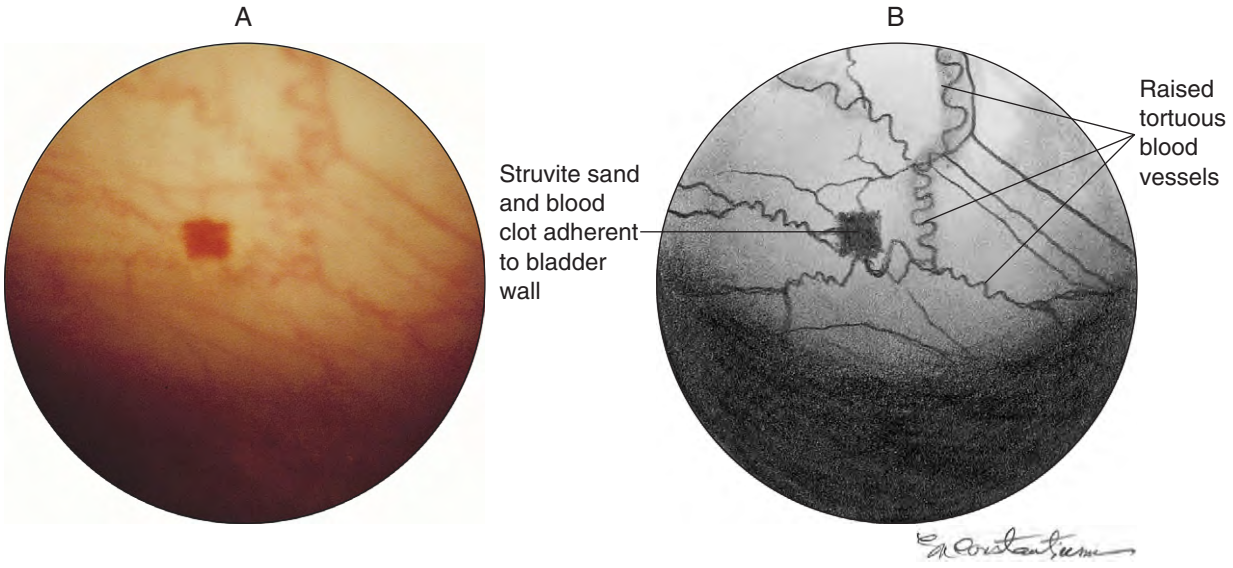



**Fig. 4–78**
Raised tortuous blood vessels in the bladder mucosa of a male cat with chronic cystitis and struvite sand as seen with prepubic percutaneous cystoscopy.

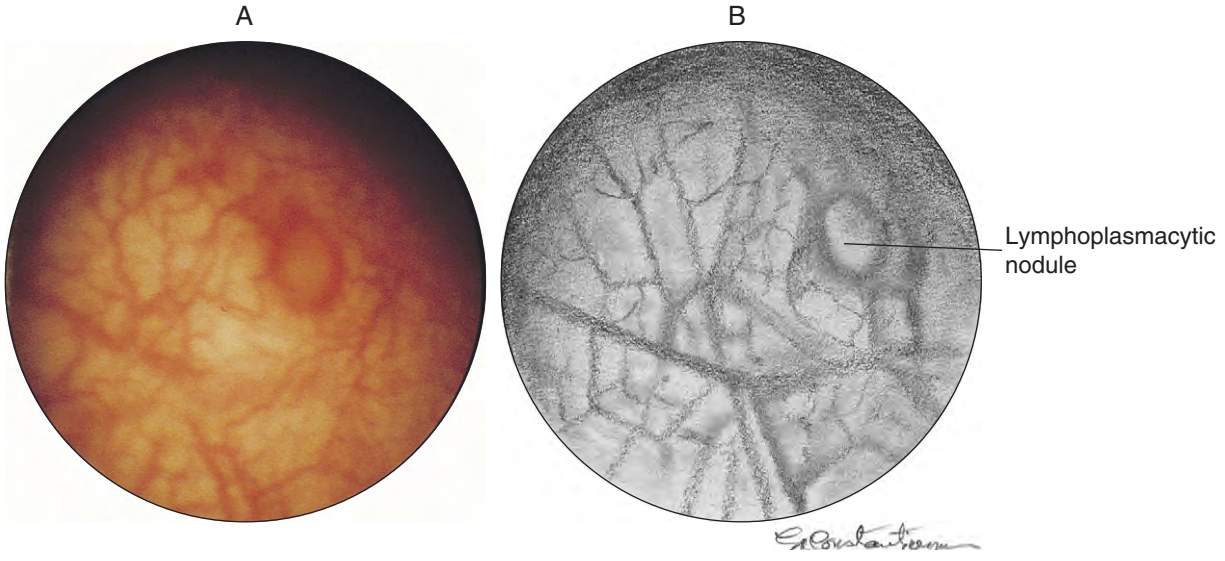



**Fig. 4–79**
A lymphoplasmacytic nodule or polyp in the bladder of a female dog that also had a bladder diverticulum.

their appearance through air and through liquid are shown in Figs. 4-64 and 4-65. Small lymphoplasmacytic nodules or polyps appear identical to small transitional cell carcinomas, and histopathology must be used to differentiate these lesions from transitional cell carcinomas. They may be solitary (Fig. 4-79) or multiple (Fig. 4-80). The progression in polyp formation can be from these lymphoplasmacytic nodules or from accumulation of more vascular tissue (Figs. 4-81 and 4-82). With increasing size, inflammatory polyps seem to maintain two types: those that are highly vascular (Figs. 4-62 and 4-83) and those that develop with limited or minimal vascularity (Figs. 4-63, 4-84, and 4-85).

Changes visible in the bladder mucosa are affected by chronicity of the disease process, by the severity of the inflammation, by the extent of bladder distention, by contact with instrumentation, and by collection of biopsy samples. Inflamed bladder and urethral mucosa is more

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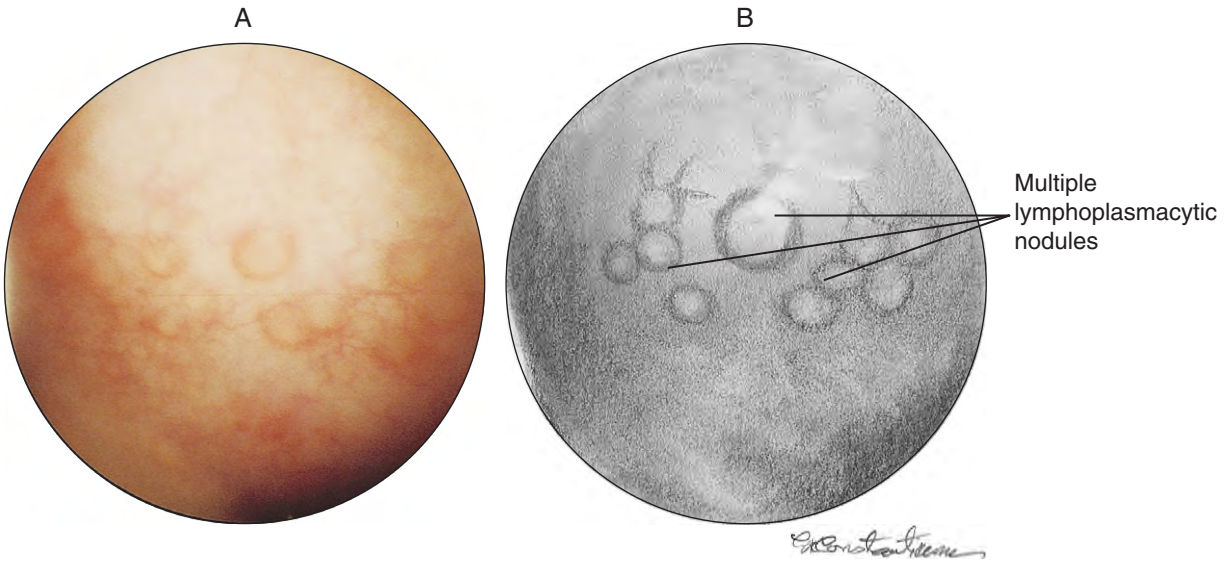



**Fig. 4–80**
Multiple lymphoplasmacytic nodules or polyps in the bladder of a female dog with a chronic cystitis secondary to cystic calculi.

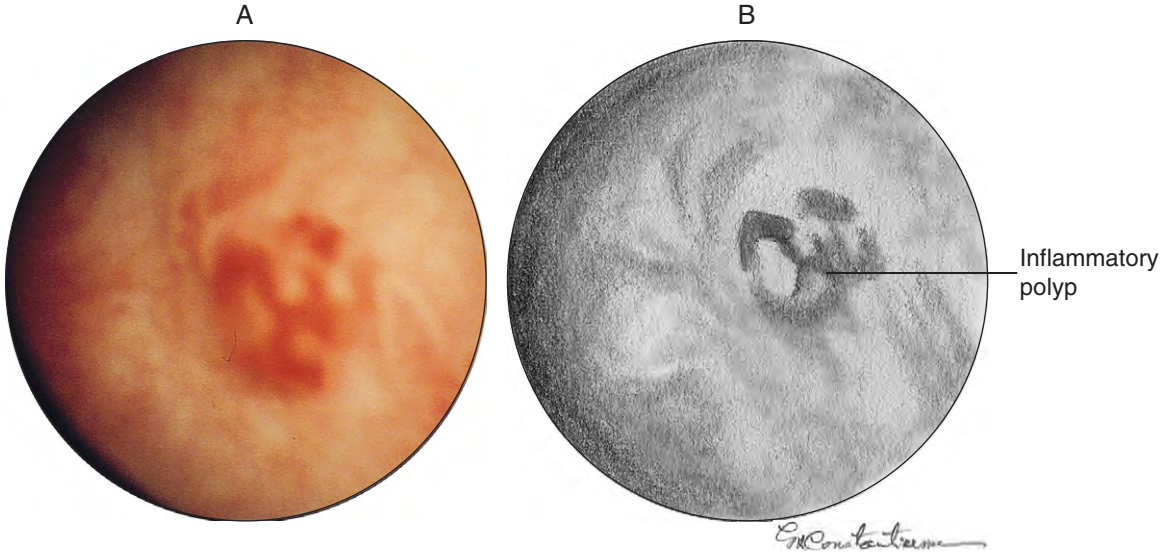



**Fig. 4–81**
An early small inflammatory polyp beginning as a tuft of blood vessels on the mucosal surface in a bladder with chronic cystitis.

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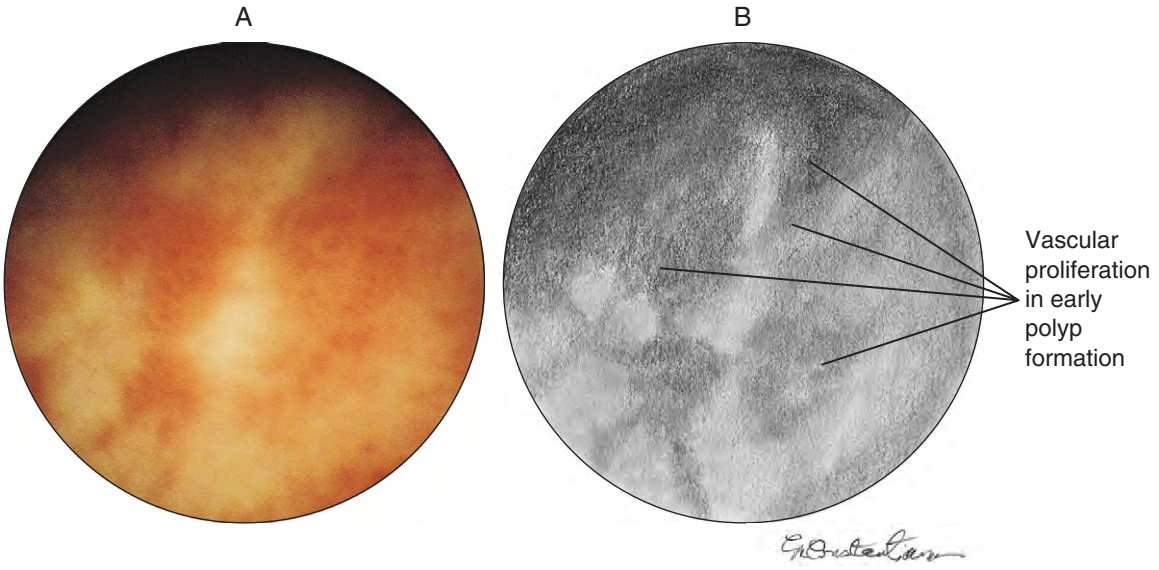



**Fig. 4-82**
A larger area of accumulation of blood vessels in the early stages of inflammatory polyp formation from the same case as in Fig. 4-81.

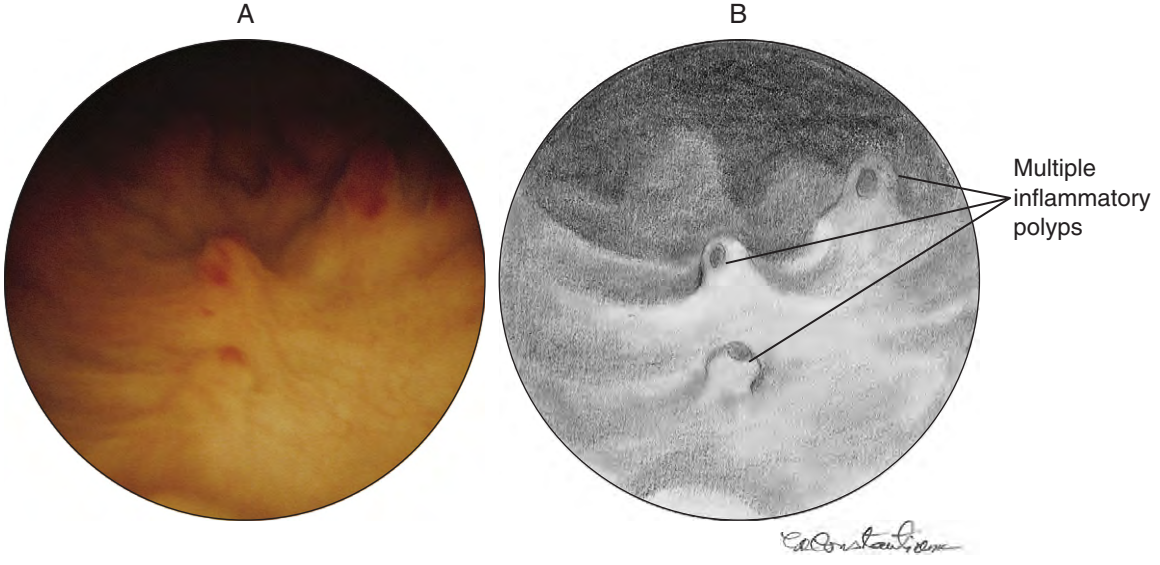



**Fig. 4-83**
Multiple vascular inflammatory polyps in the bladder of a dog with chronic lymphoplasmacytic cystitis.

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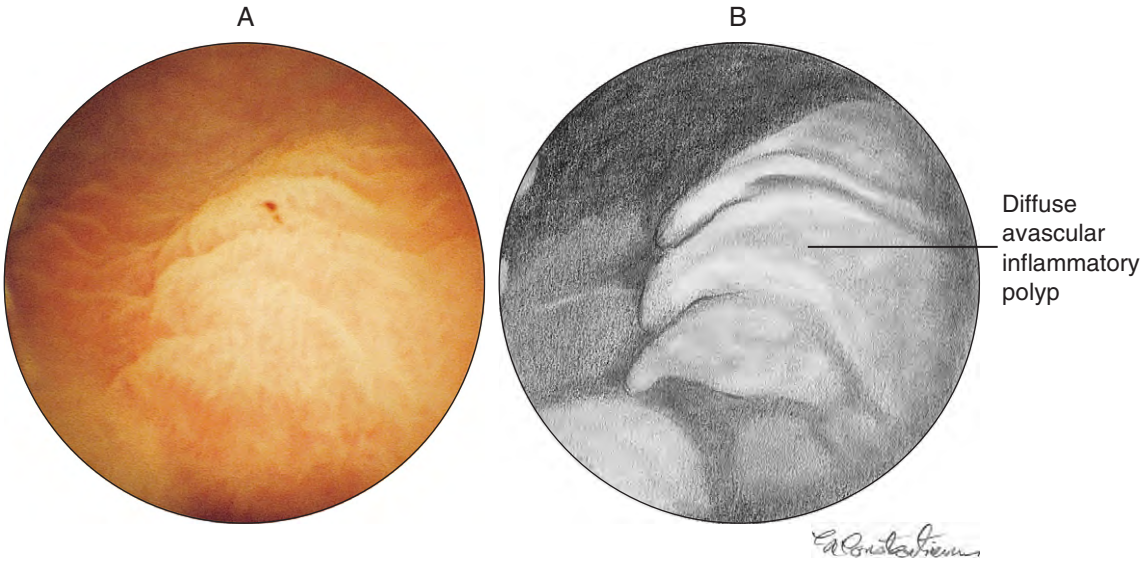



**Fig. 4–84**
A larger and less vascular inflammatory polyp in a dog with cystic calculi.

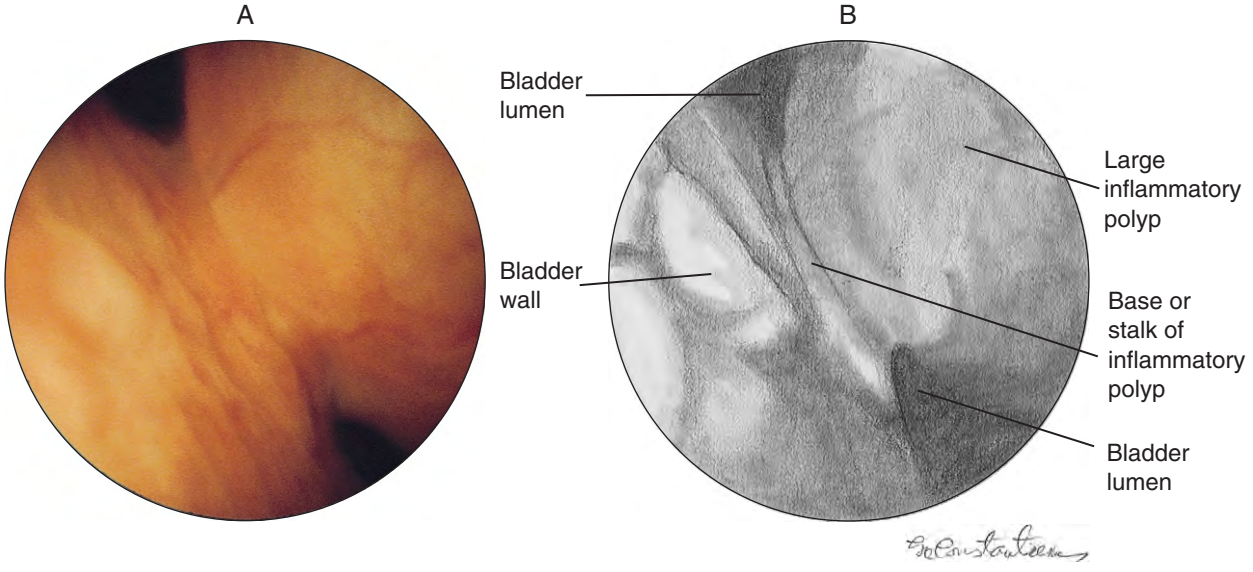



**Fig. 4–85**
The base of a large inflammatory polyp in the bladder of a female dog with chronic cystitis.

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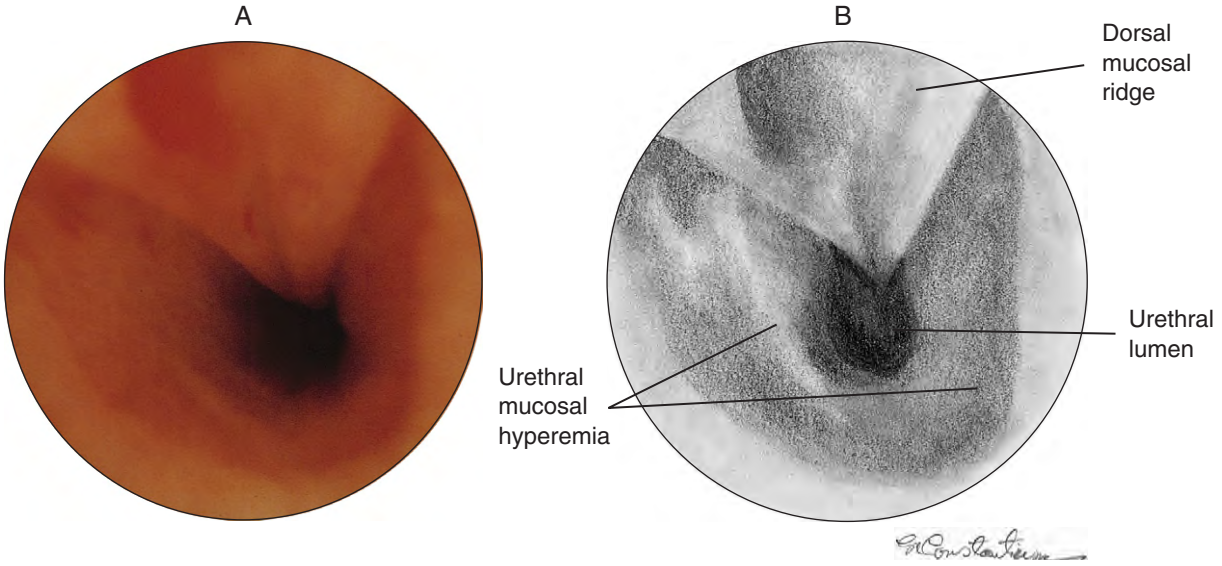



**Fig. 4-86**
Hyperemia of the proximal urethral mucosa of a male cat seen by passing the endoscope from the bladder caudally into the urethra from a prepubic percutaneous puncture of the bladder.

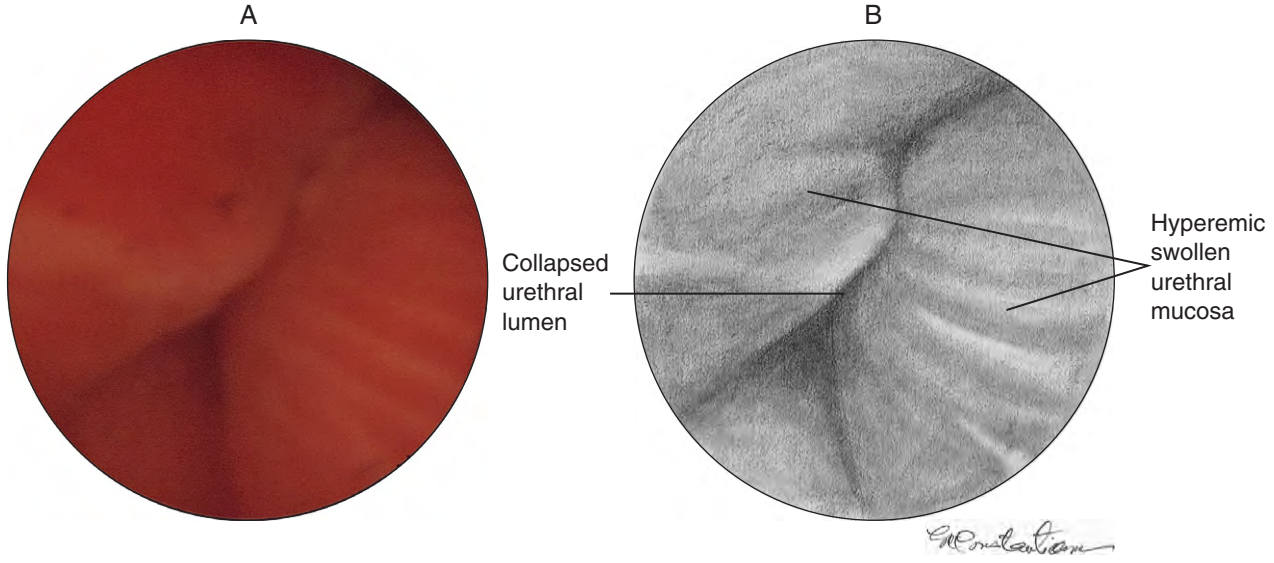



**Fig. 4-87**
Mucosal hyperemia in the urethra of a female dog with acute severe urethritis.

susceptible to iatrogenic changes, and care must be taken to prevent masking true lesions by traumatic change from the examination.

Acute and chronic inflammatory changes may also be found in the urethra but are less commonly recognized than are bladder lesions. Mucosal hyperemia (Figs. 4-86 and 4-87), swelling and roughening (Fig. 4-88), ulceration (Fig. 4-89), increased vascularity (Fig. 4-90), petechial hemorrhages (Fig. 4-91), and ecchymotic hemorrhages (Fig. 4-92) can be seen. An increased number and size of blood vessels are a normal finding in the cranial portion of the female urethra (see Fig. 4-28) and must be recognized and distinguished from inflammatory changes. Chronicity may lead to urethral mucosal corrugation (Fig. 4-93), urethral strictures that occur occasionally in females and more commonly in males (Fig. 4-94), and

*Text continued on p. 105.*

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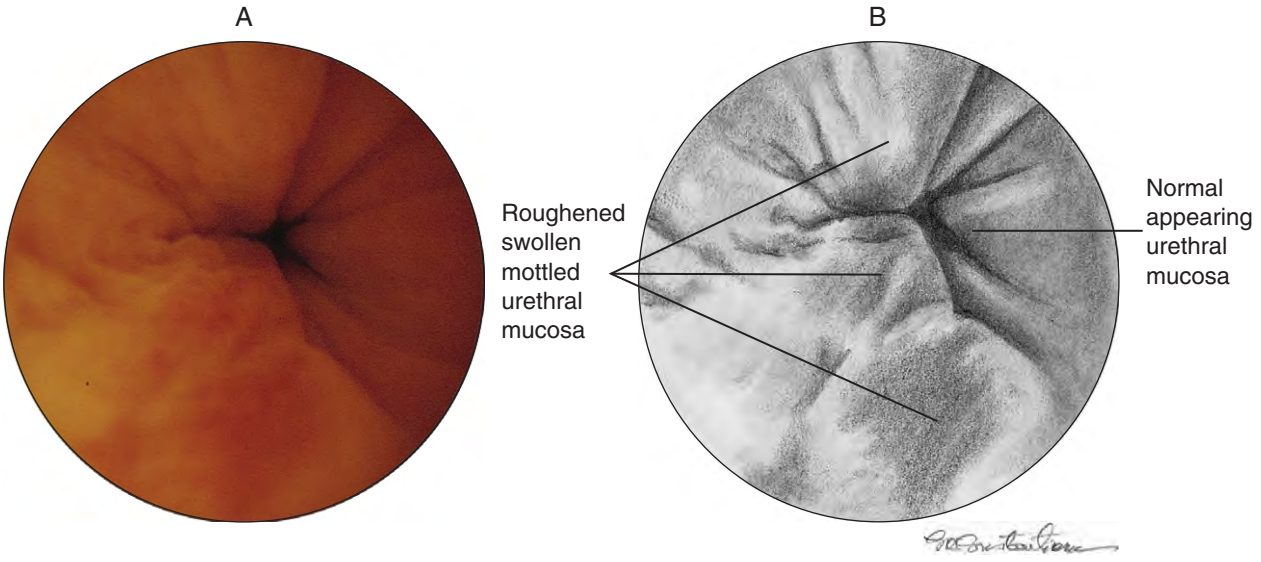



**Fig. 4–88**
Urethral mucosal swelling and roughening in a female dog with cystitis and urethritis as seen with transurethral cystoscopy.

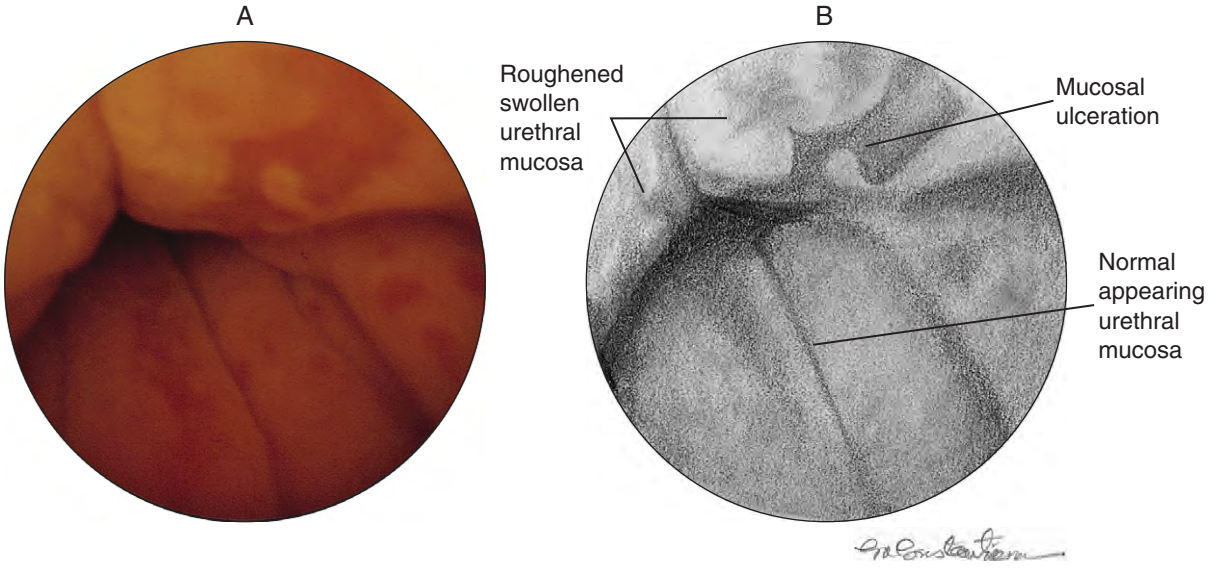



**Fig. 4–89**
Urethral mucosal ulceration in a female dog with lymphoplasmacytic cystitis and urethritis seen by transurethral examination.

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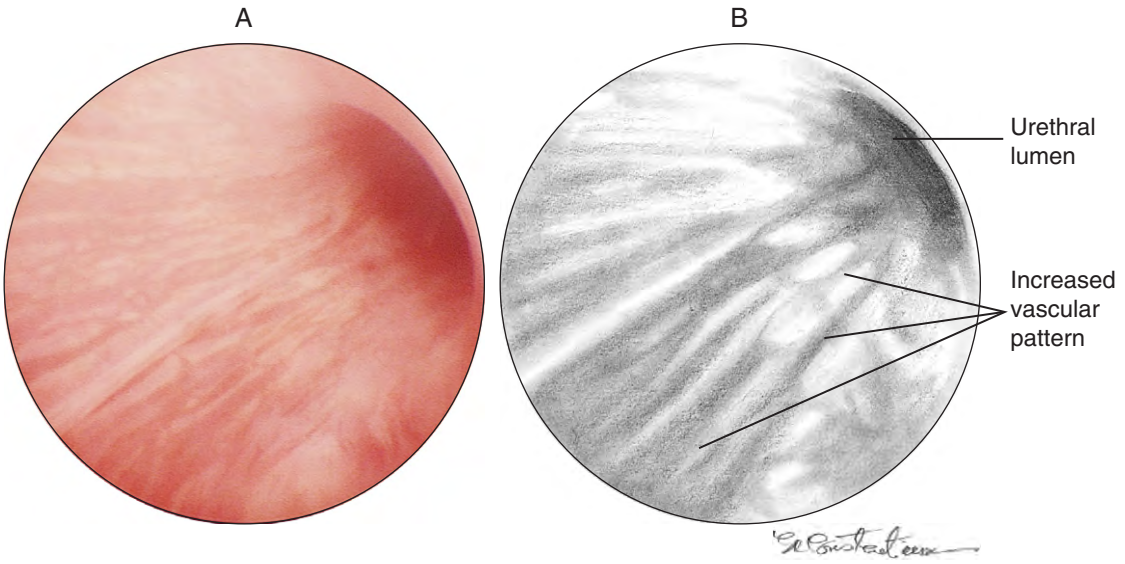



**Fig. 4–90**
Increased urethral vascular pattern in a female dog with urethritis.

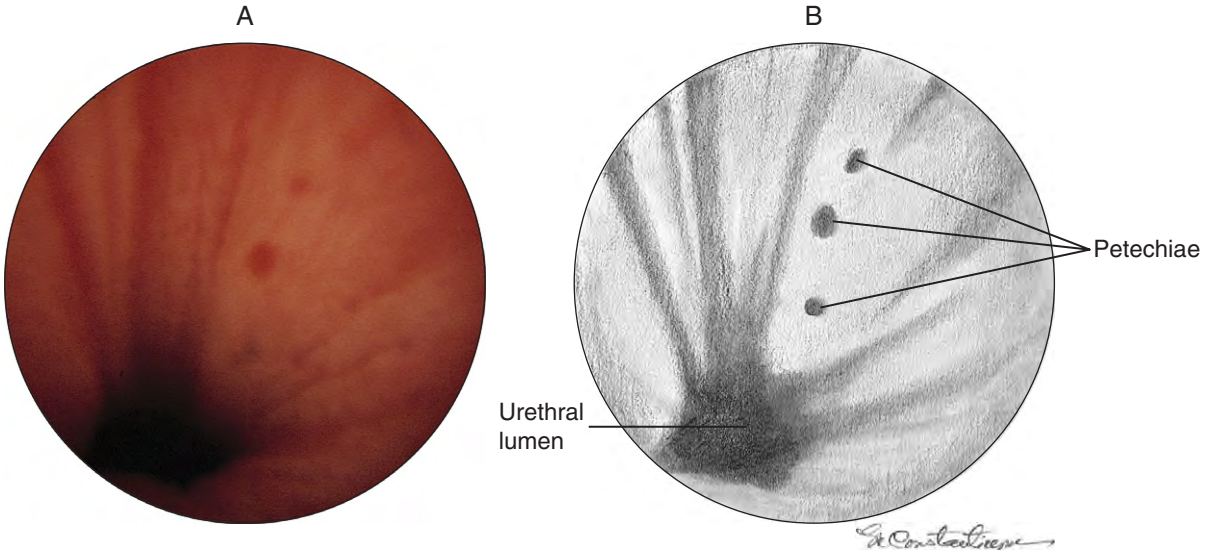



**Fig. 4–91**
Petechial hemorrhages in the urethra of a female dog seen with transurethral cystoscopy in a case with lymphoplasmacytic urethritis and cystitis.

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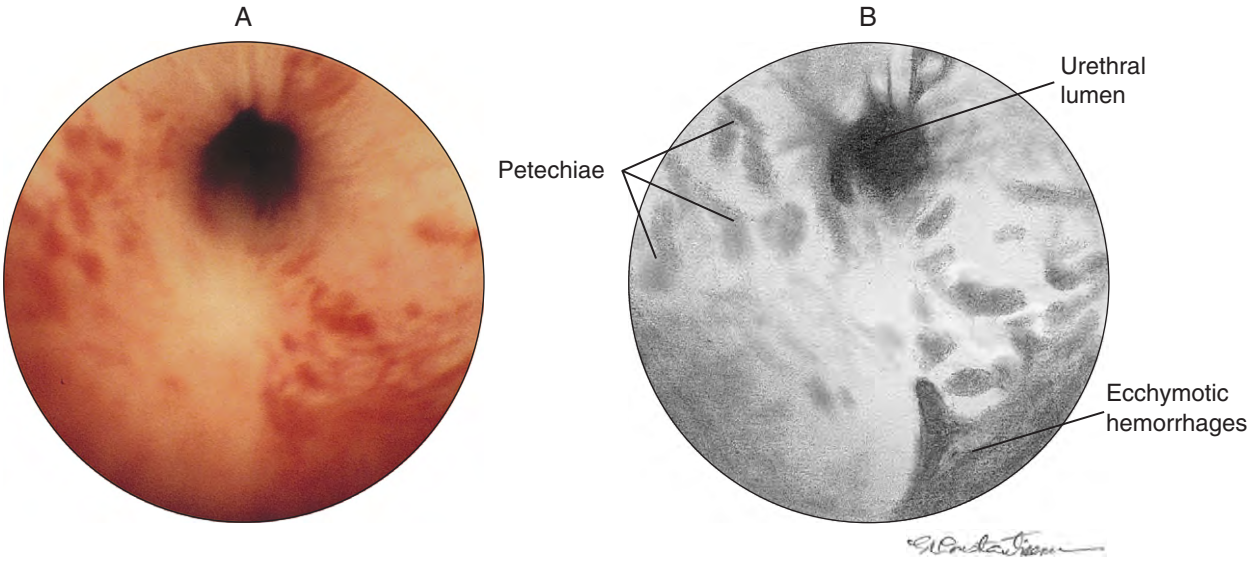



**Fig. 4–92**
Ecchymotic hemorrhages in the proximal urethra of a male cat as seen with transurethral cystoscopy immediately after a perineal urethrostomy had been performed. Urethritis of this severity can produce a functional obstruction of the urethra.

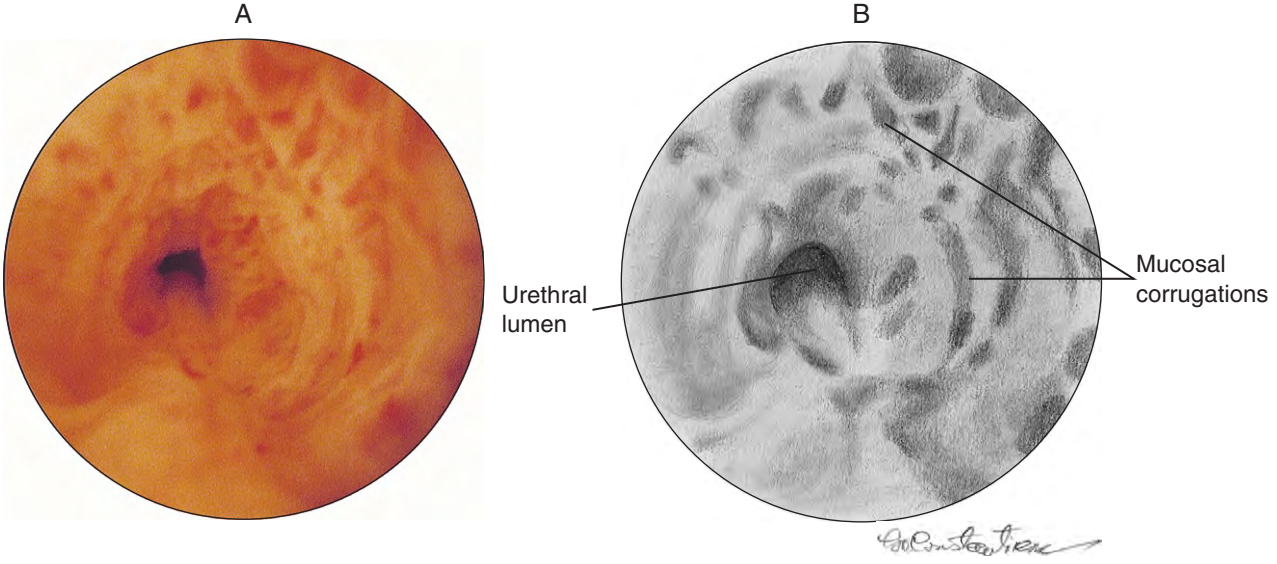



**Fig. 4–93**
Marked urethral mucosal corrugation in an 18-year-old female cat with chronic urethritis.

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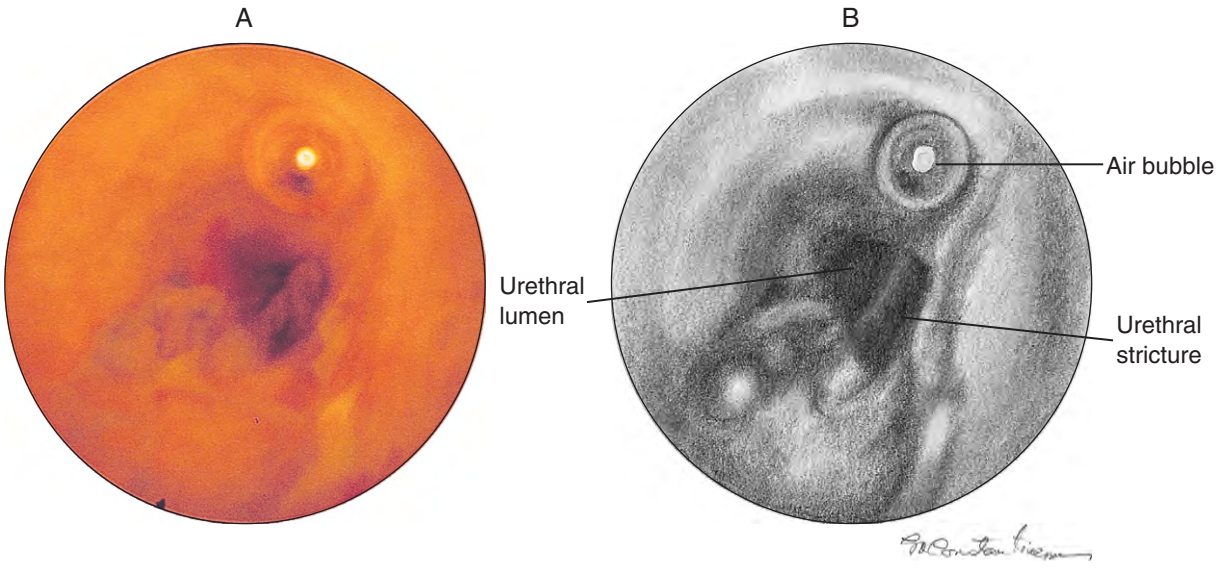



**Fig. 4-94**
Stricture of the penile urethra in a male dog with a previous history of bladder and urethral stones. The examination was done transurethrally using a 2.7-mm diameter arthroscope. Stricture dilation was achieved endoscopically and surgery was not required.

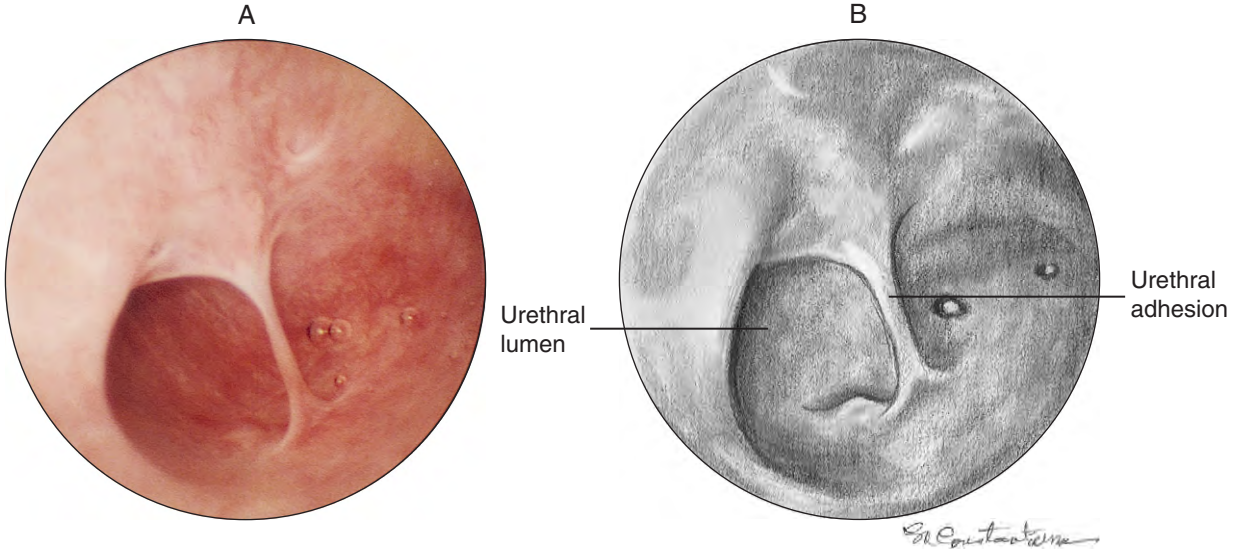



**Fig. 4-95**
A urethral adhesion in a female dog seen with transurethral cystoscopy after treatment for cystitis and urethritis.

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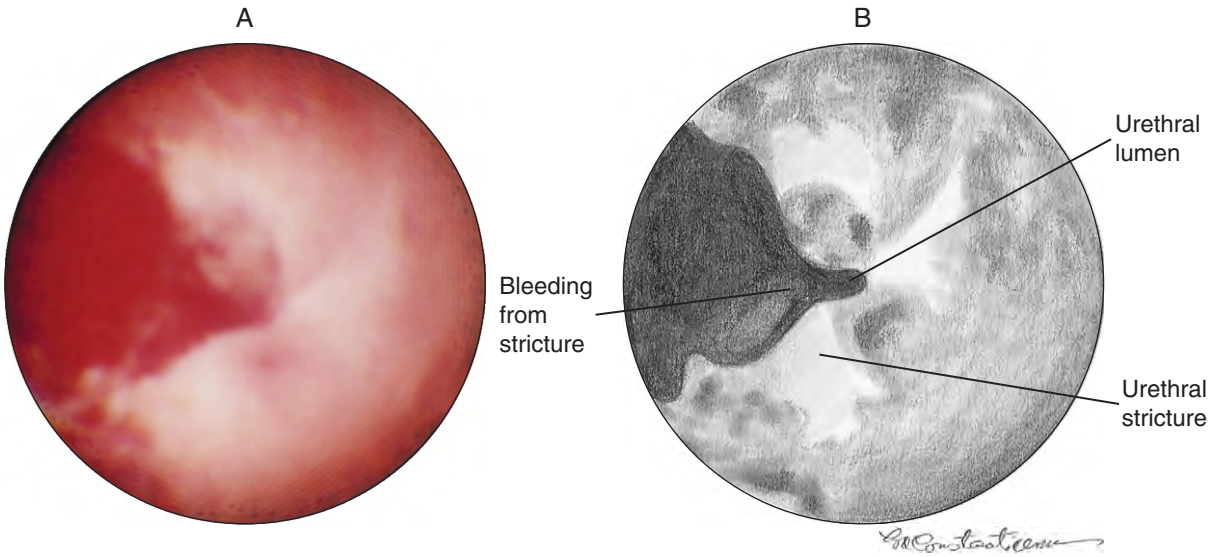



**Fig. 4–96**
An iatrogenic stricture in a male dog following a urethral anastomosis as visualized with transurethral cystoscopy using a flexible cystourethroscope.

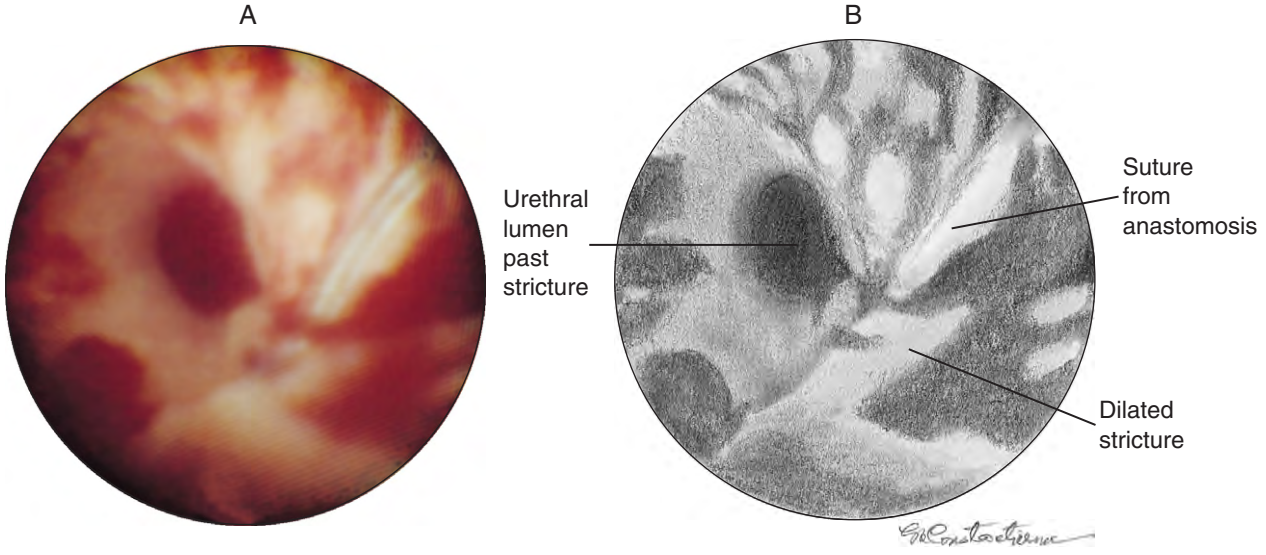



**Fig. 4–97**
Following balloon dilation of the urethral stricture shown in Fig. 4-96. A single balloon dilation was required for resolution of this stricture.

urethral adhesions following severe urethritis (Fig. 4-95). Iatrogenic urethral strictures can be diagnosed (Fig. 4-96) using TUC and dilated (Fig. 4-97) using bougies or balloon dilation catheters.

## Prostatitis

Prostatic inflammation and hyperplasia can produce changes in the prostatic urethral mucosa, including roughening or irregularity of the mucosal surface, patchy discoloration with areas ranging from white to purple, and petechial hemorrhages (Fig. 4-98). Narrowing of the prostatic urethra occurs with progression of inflammatory prostatic disease and can produce complete urethral occlusion (Fig. 4-99). Occlusive disease can prevent distention of the urethra to allow visualization without preventing passage of the endoscope into the bladder.

## Calculi

Cystic and urethral stones can be easily seen with cystoscopy. Their appearance varies widely depending on

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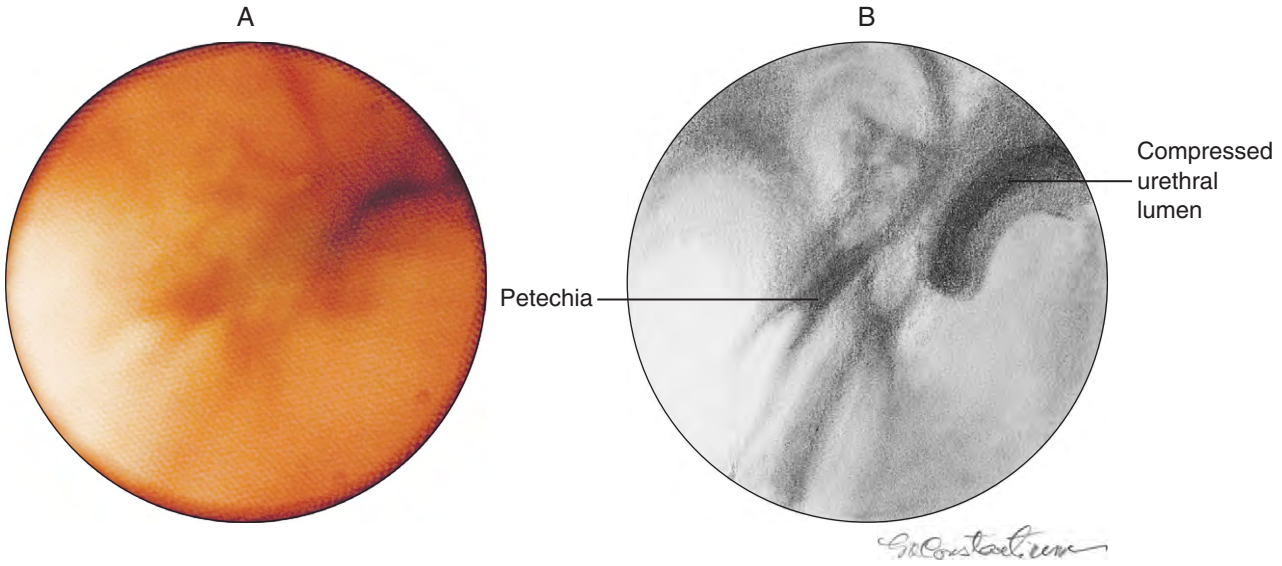



**Fig. 4–98**
Prostatic urethral petechia in a male dog with prostatitis as seen by transurethral examination using a flexible cystourethroscope.

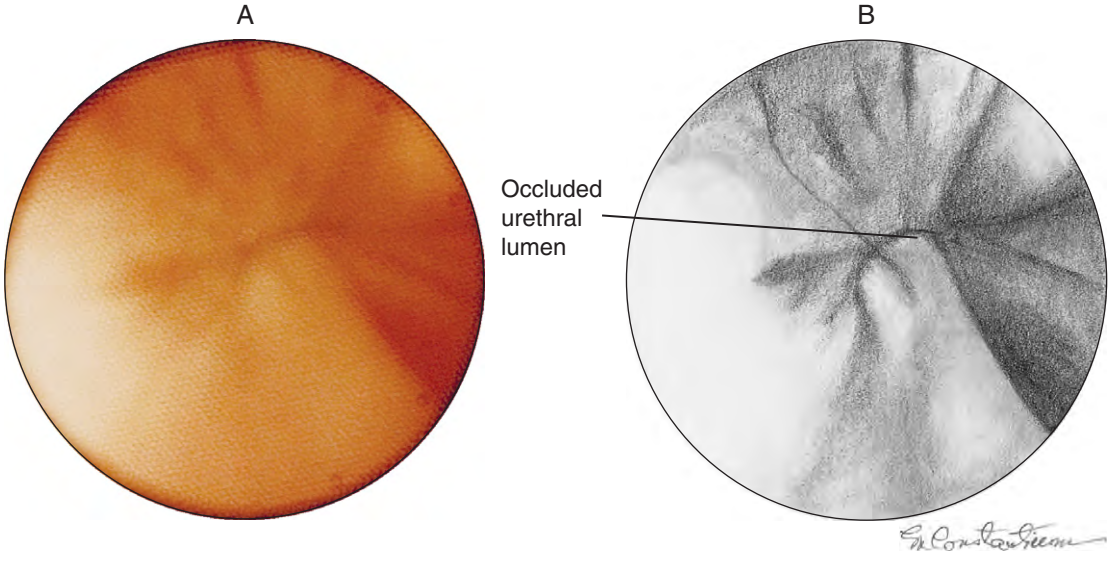



**Fig. 4–99**
Urethral occlusion due to prostatic disease in a male dog as seen with a flexible cystourethroscope.

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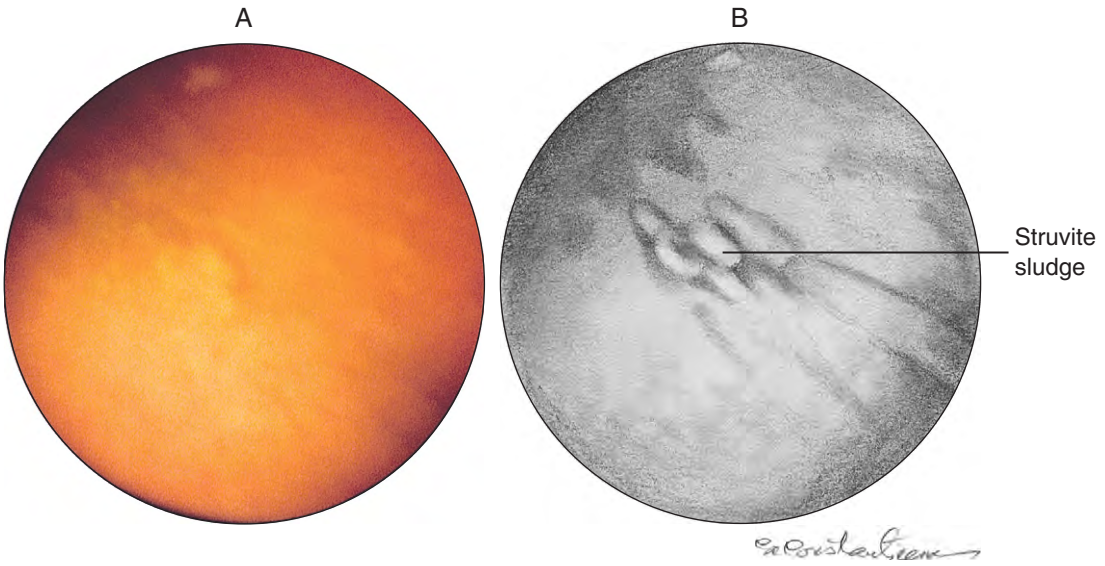



**Fig. 4–100**
Amorphous debris or sludge containing struvite in the bladder of a female dog with lymphoplasmacytic cystitis. This debris can be easily removed with irrigation and suction through the cystoscope.

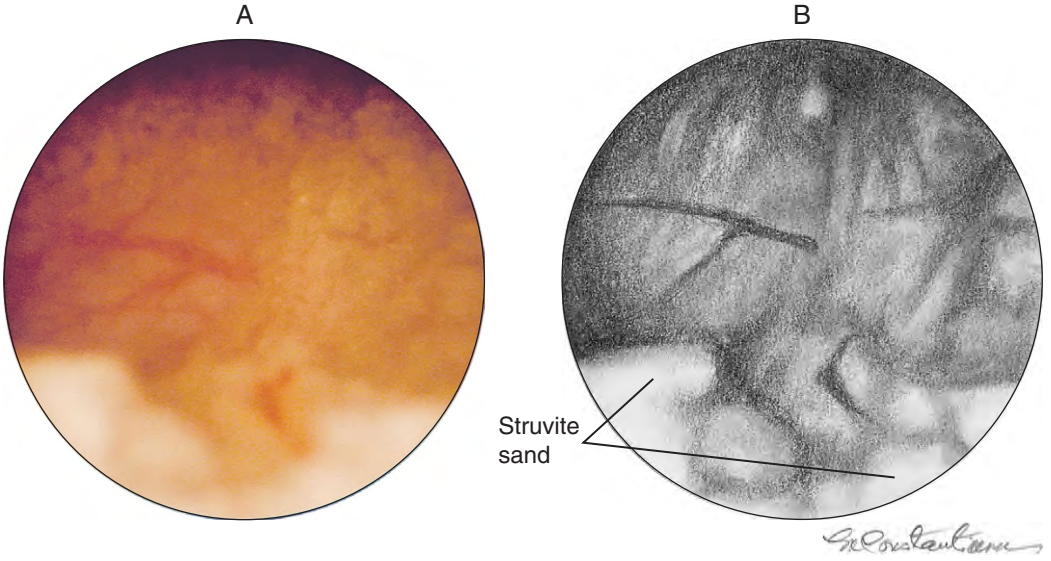



**Fig. 4–101**
Fine struvite sand in the bladder of a male cat with chronic recurrent cystitis examined by prepubic percutaneous cystoscopy. This sand was removed with irrigation through the cystoscope and aspiration through the second puncture cannula.

their composition. Size also varies from amorphous debris or sludge (Fig. 4-100) and fine sand (Fig. 4-101), coarse sand (Fig. 4-102), single or multiple small stones (Figs. 4-103 and 4-104), to single or multiple large stones (Figs. 4-105 and 4-106). Fine calculi, sand, or sludge (see Figs. 4-100 through 4-102) can be removed by aspiration through the endoscope or through percutaneously placed cannulae. Smaller stones (see Figs. 4-103 and 4-104) can be picked up with forceps or stone baskets and removed therapeutically or for stone analysis. Admixture of sand or stones with blood may increase the difficulty of stone removal in some cases (Fig. 4-107) and may make stone removal impossible in others (Fig. 4-108). Larger stones (see Figs. 4-105 and 4-106) can be crushed with forceps or fractured with laser or electrohydraulic lithotripsy and the fragments removed by aspiration through the endoscope cannula or with forceps or baskets. Application of cystoscopy for therapeutic bladder stone removal has

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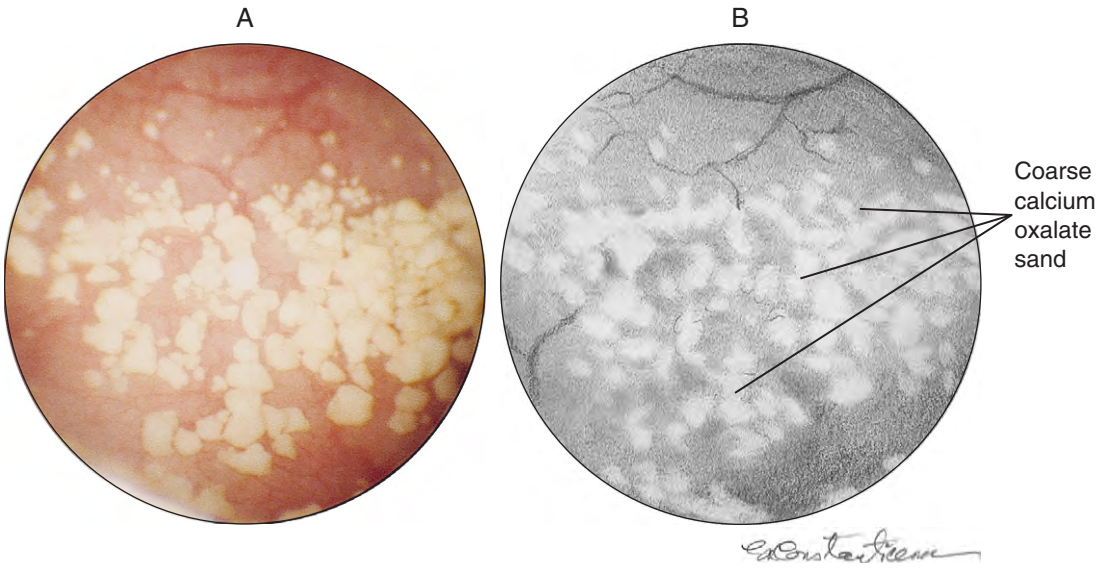



**Fig. 4–102**
Coarse calcium oxalate sand in the bladder of a female dog with chronic cystitis. This sand was removed with irrigation and aspiration through the transurethrally placed cystoscope.

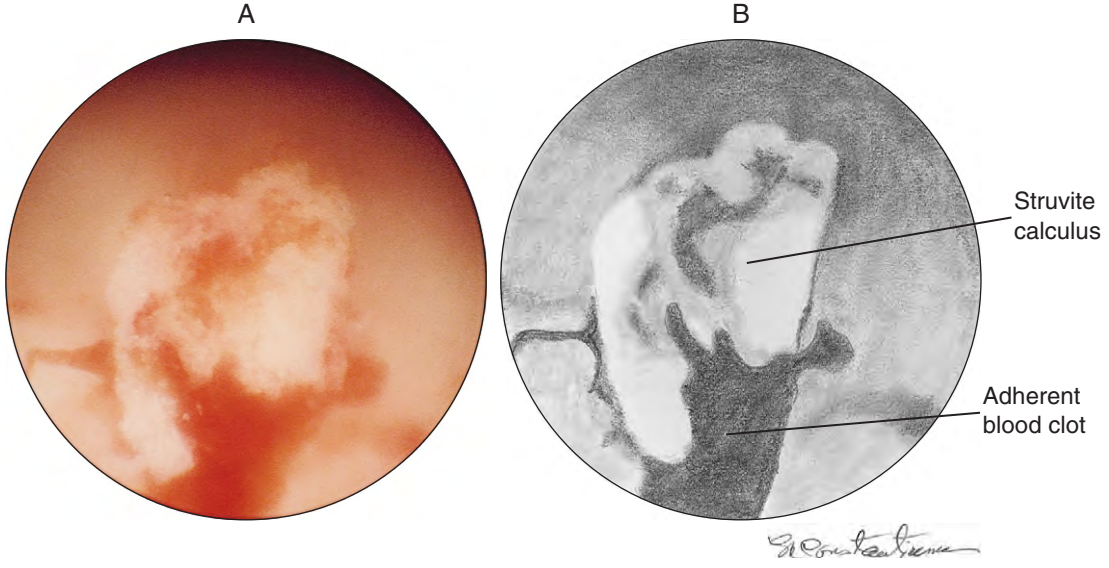



**Fig. 4–103**
A single small struvite calculus in the bladder of a female cat with chronic cystitis seen and removed with transurethral cystoscopy.

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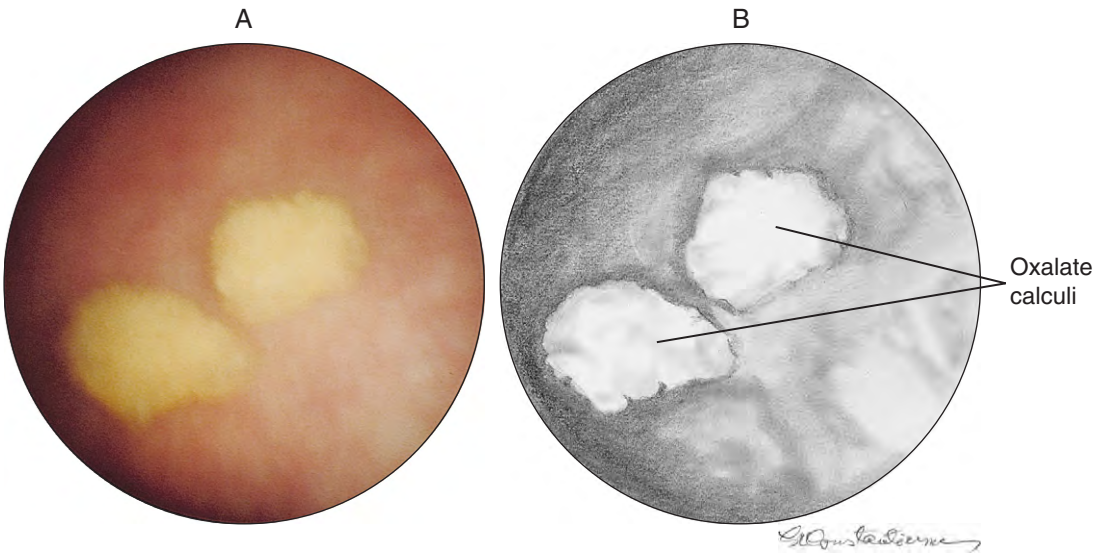



**Fig. 4–104**
Two small oxalate calculi in the bladder of a female dog with chronic unresolved lower urinary tract disease. These calculi were removed transurethrally with a transurethrally placed cystoscope and a stone basket.

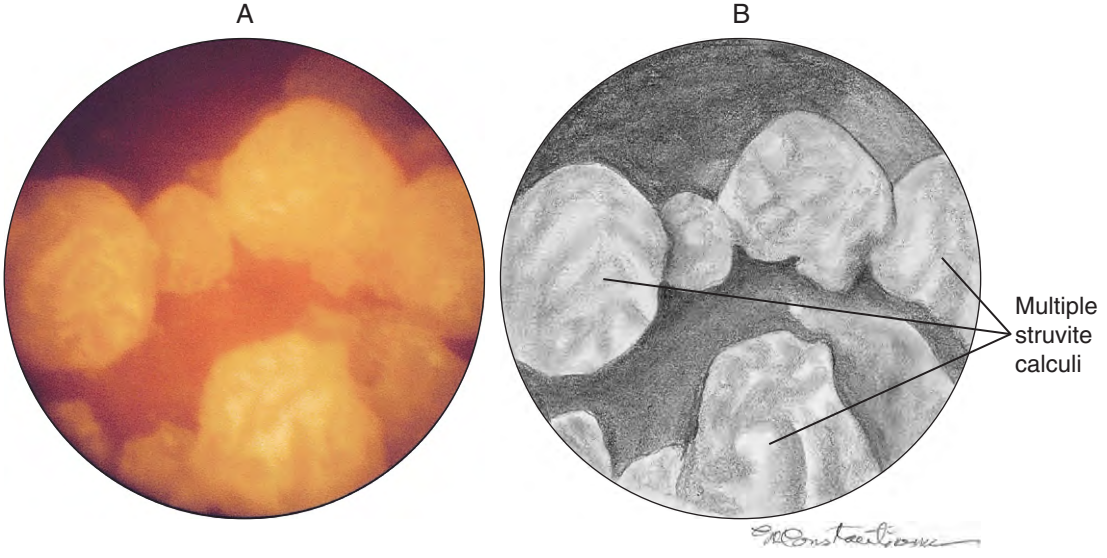



**Fig. 4–105**
Multiple larger struvite calculi in the bladder of a female dog as seen with transurethral cystoscopy. These stones were removed surgically.

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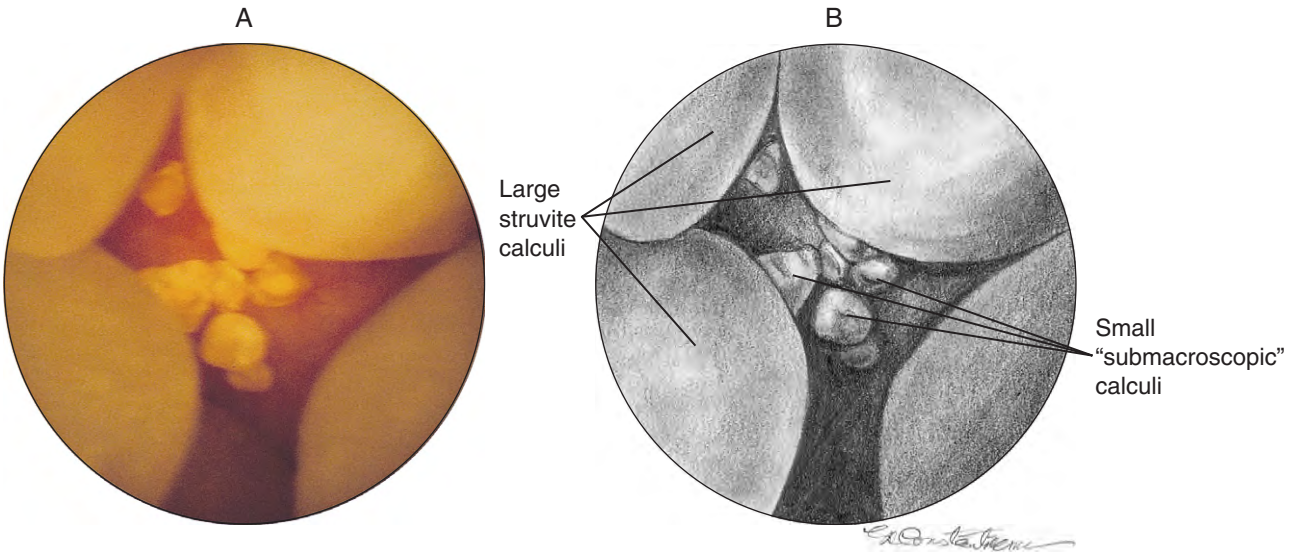



**Fig. 4–106**
Multiple large and small struvite stones in the bladder of a female dog examined with prepubic percutaneous cystoscopy. These stones were removed surgically. The smaller stones or sand-sized calculi seen here with cystoscopy could not be seen at surgery.

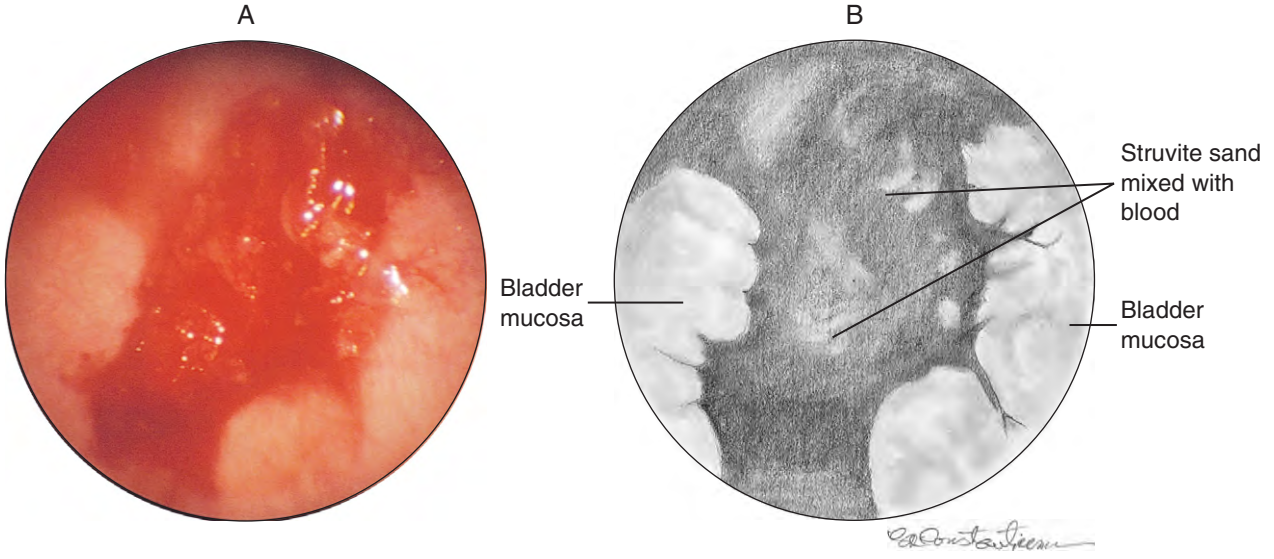



**Fig. 4–107**
Struvite sand mixed with blood in the bladder of a female cat that was examined with transurethral cystoscopy. The presence of blood increased the difficulty of endoscopic removal of the sand and calculus.

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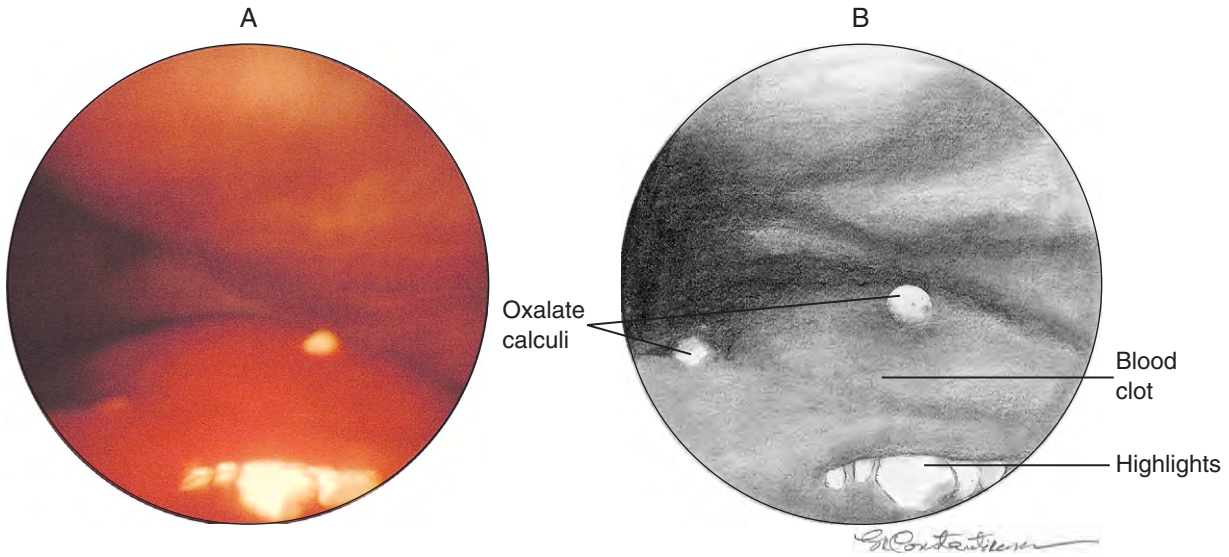



**Fig. 4-108**
Oxalate sand-sized calculi in a large blood clot in the bladder of a male cat seen with transurethral cystoscopy immediately after a perineal urethrostomy had been performed. The size of the blood clot in this bladder made removal of any of the sand endoscopically not possible.

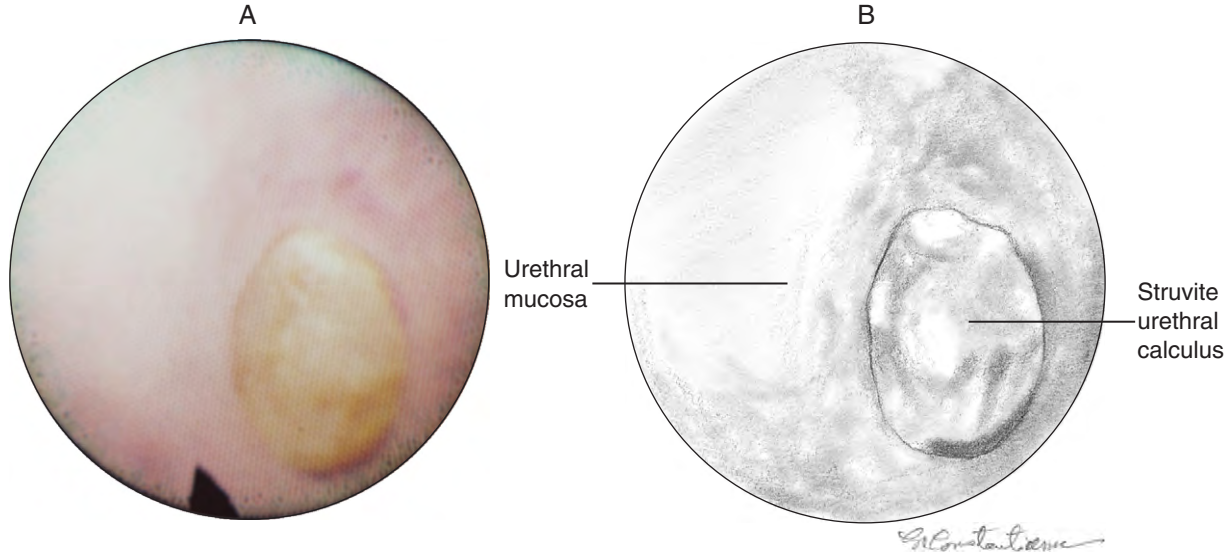



**Fig. 4-109**
A struvite calculus lodged in the urethra of a male dog. This calculus was hydropropulsed back into the bladder where it was removed surgically.

become more rewarding with increased experience and improved instrumentation. Recent experience with sand and with small stones has been consistent endoscopic removal. Magnification produced with the endoscope greatly facilitates stone identification and makes it possible to remove stones and sand that are smaller than can be seen at surgery. The greatest number of stones removed from a case endoscopically has been 26 from a male dog. Surgical removal is still used for multiple large stones and in many cases of multiple small stones. If all calculi cannot be removed, diagnostic samples are obtained for stone analysis and culture. Appropriate dietary or medical therapy may then be used, if indicated, eliminating the need for surgical removal of stones that cannot be removed endoscopically.

Urethral calculi in male (Figs. 4-109 through 4-111) and female (Fig. 4-112) dogs, and in cats (Figs. 4-113 and 4-114) can be located easily with TUC. The approach for

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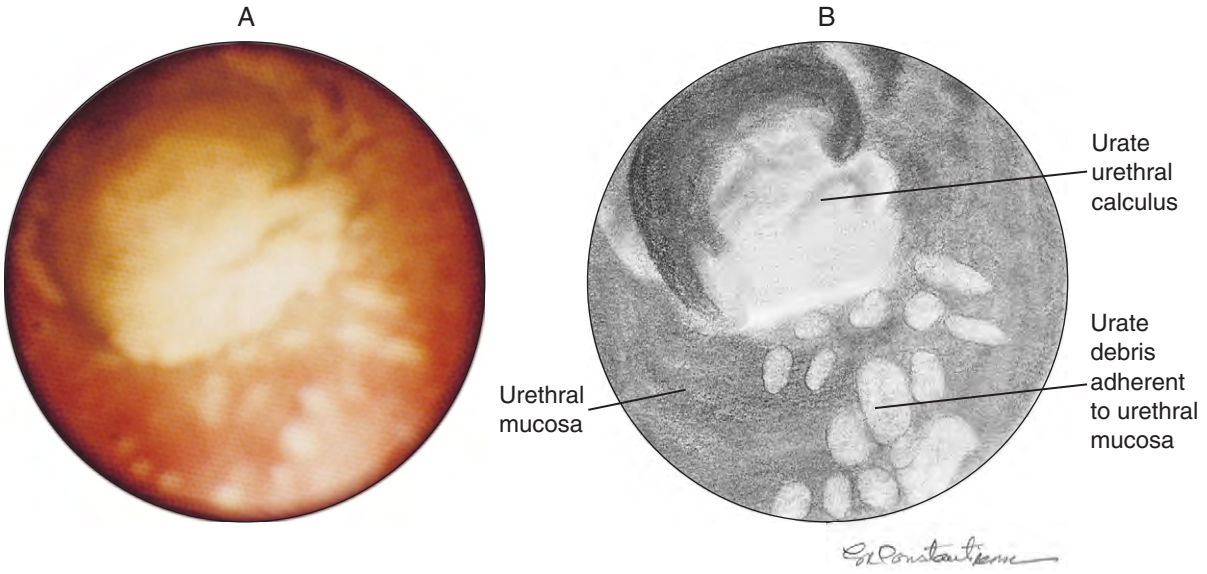



**Fig. 4–110**
A urate calculus and urate sludge in the urethra of a male dog. Removal of this calculus was by hydropropulsion into the bladder followed by a cystotomy.

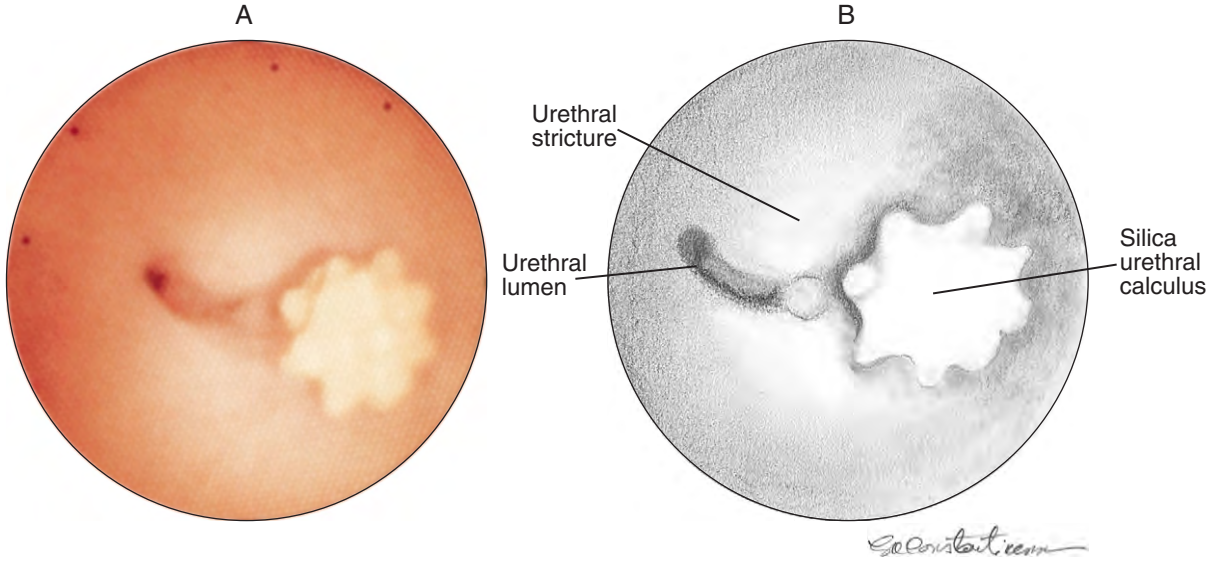



**Fig. 4–111**
This silica calculus was trapped between two urethral strictures from previous urethrotomies for stone removal. The strictures were dilated and the stone removed transurethrally with a stone basket.

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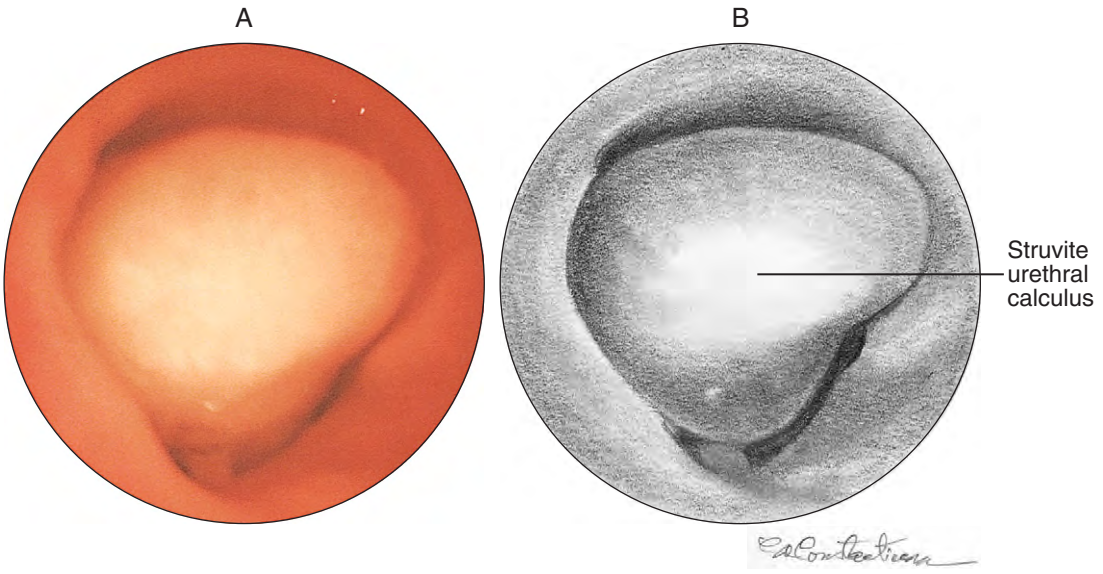



**Fig. 4–112**
A urethral struvite calculus-producing obstruction in a female dog seen with transurethral cystoscopy. The stone was crushed transurethrally and removed in pieces with graspers and irrigation.

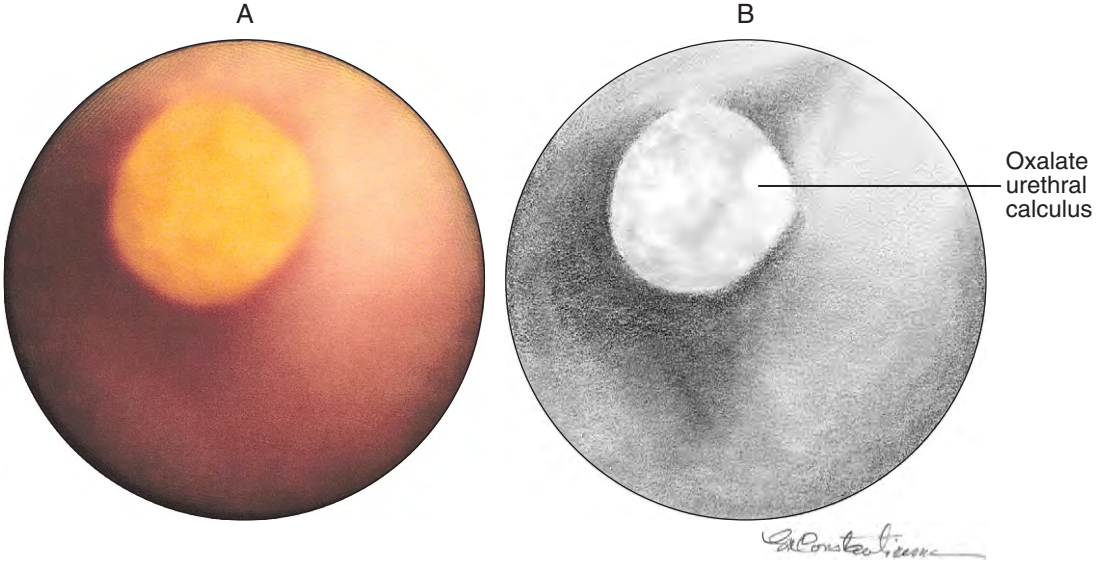



**Fig. 4–113**
A single oxalate calculus in the urethra of a male cat that was producing intermittent obstruction as seen with transurethral cystoscopy using the 1.2-mm diameter cystourethroscope.

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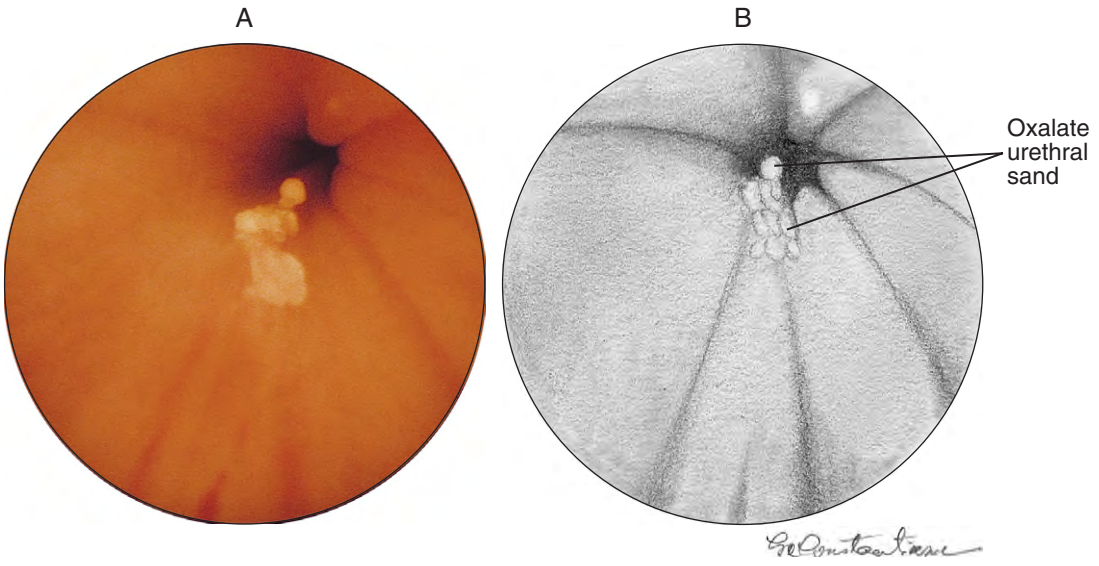



**Fig. 4–114**
Oxalate sand in the urethra of a male cat seen with transurethral cystoscopy performed immediately after a perineal urethrostomy. This sand was removed with irrigation through the endoscope.

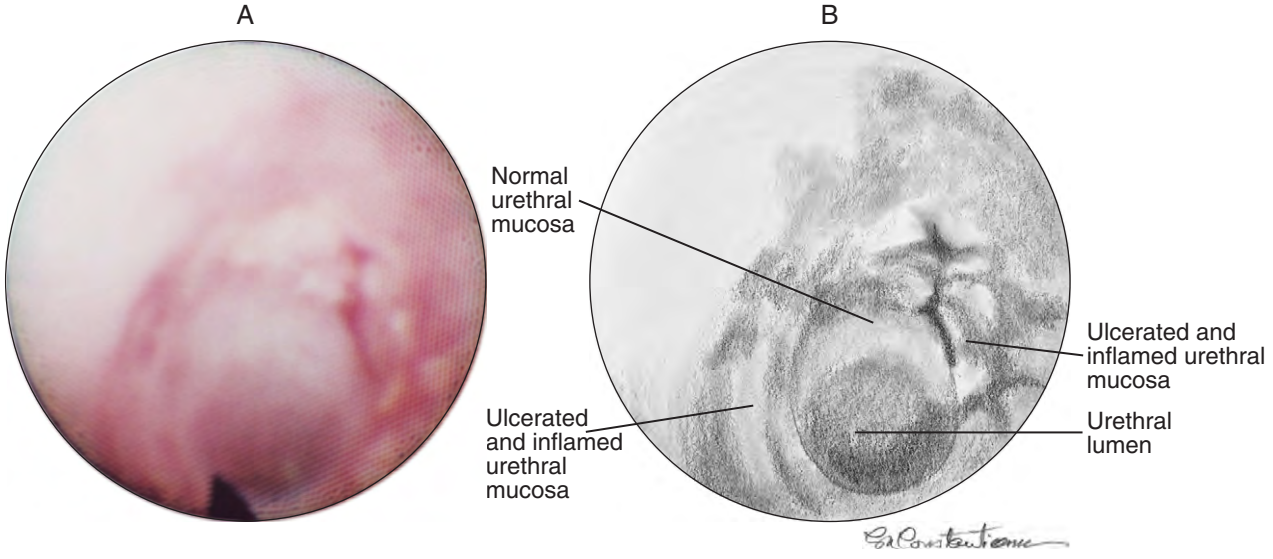



**Fig. 4–115**
An area of urethritis visible after displacement of the stone in Fig. 4-109 with hydropropulsion. There is significant inflammation and ulceration involving the lateral walls of the urethra but only minimal inflammation dorsally and ventrally. The absence of 360-degree inflammation greatly decreases the potential for stricture in this case.

removal is then selected based on endoscopic findings, the success of hydropropulsion for flushing stones back into the bladder can be evaluated easily with TUC, and the thoroughness of surgical removal of cystic and urethral calculi can be checked cystoscopically. Urethral mucosa condition is routinely examined after urethral stones have been removed or flushed back into the bladder (Figs. 4-115 and 4-116). Urethral damage is assessed to prognose urethral stricture formation and for determining the need for treatment to prevent urethral stricture formation. Management of urethral calculi has been greatly facilitated based on endoscopic findings. Urethrotomy for removal of urethral calculi has not been required since TUC and hydropropulsion have been combined for management of urethral calculi cases.

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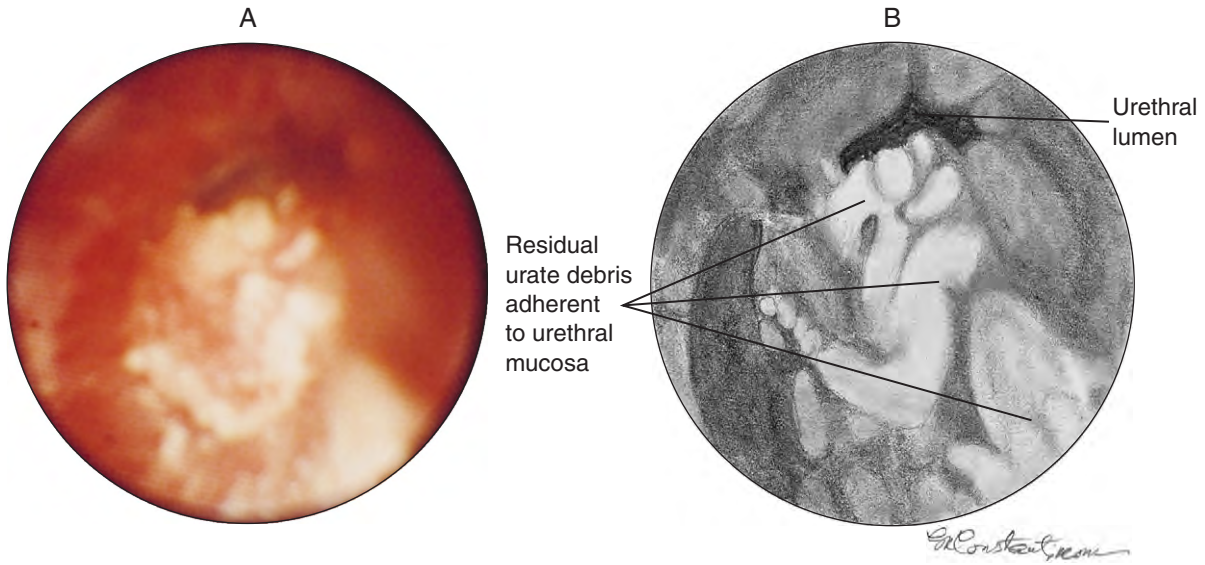



**Fig. 4–116**
Urethritis and urate sludge remaining after removal of the calculus in Fig. 4-110. The remaining sludge is adherent to the inflamed urethral mucosa and increases the possibility of stone reformation. Removal by irrigation is indicated.

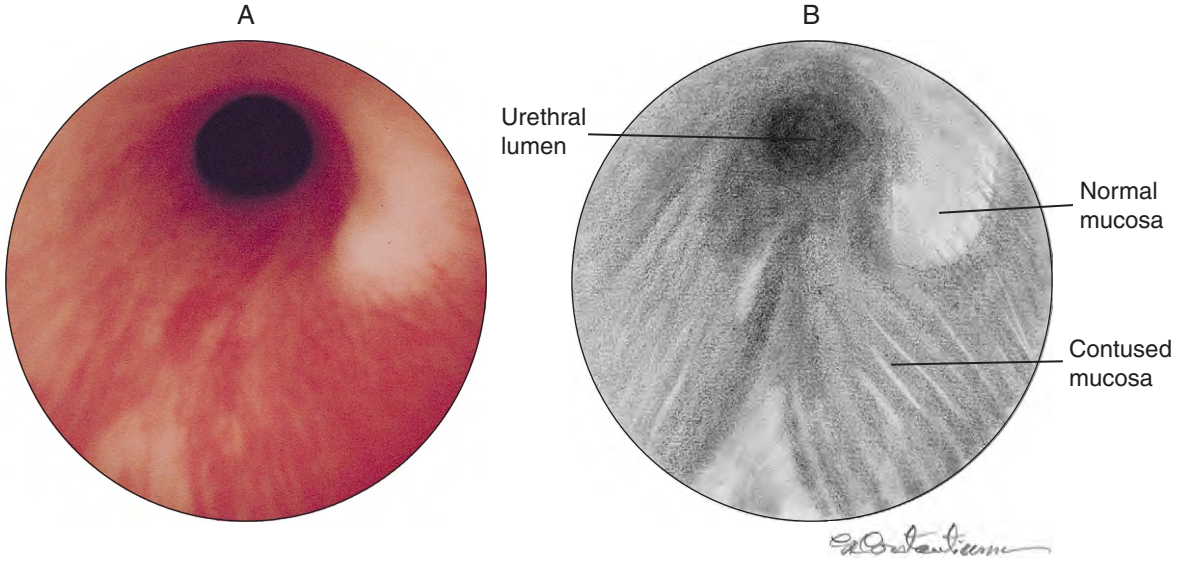



**Fig. 4–117**
Contusions in the urethra of a female dog with a pelvic fracture seen with transurethral cystoscopy.

## Trauma

The presence of urinary tract trauma is easily assessed with TUC in female dogs and female cats. With small flexible endoscopes, transurethral evaluation can be done in male dogs but is technically more difficult. Transurethral examination of urinary tract trauma in male cats is less effective as a result of absence of distal tip deflection control in the 1.2-mm diameter cystourethroscope. Cystoscopy is more sensitive than contrast radiography in finding urinary tract trauma in cases with pelvic fractures. A study of 42 consecutive pelvic fracture cases evaluated with cystoscopy found 38 cases (90%) with some form of urinary tract trauma[18] compared with contrast radiography, which found urinary tract trauma in only 39% of dogs with pelvic fractures.[19]

Contusions of the urethra and bladder are seen as areas of hyperemia (Fig. 4-117), mucosal petechia (Figs. 4-118 and 4-119), and mucosal ecchymosis (Figs. 4-120 and

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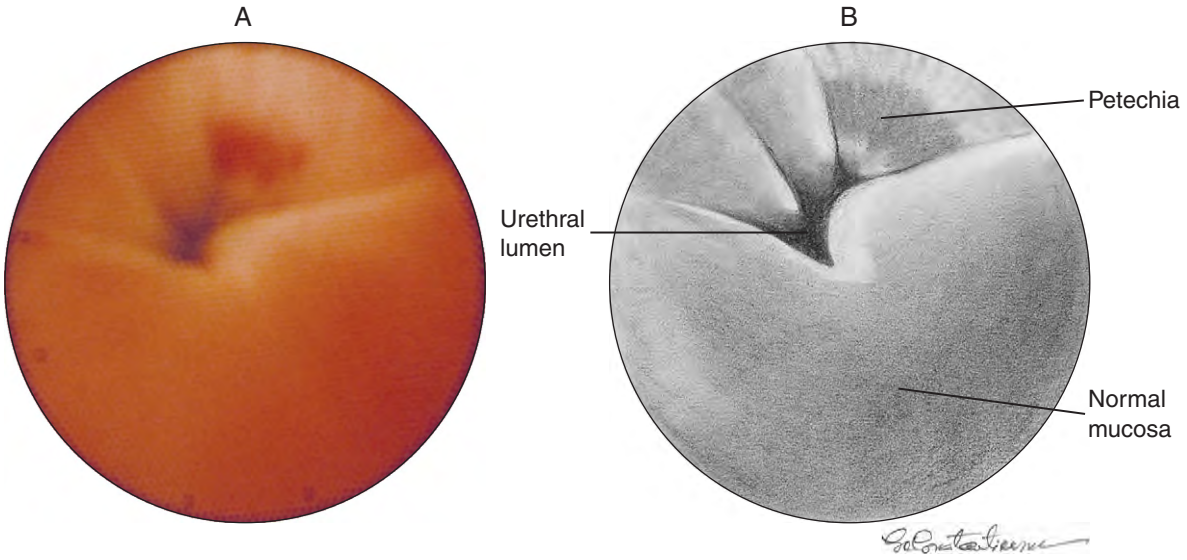



**Fig. 4–118**
Petechia in the pelvic urethra of a male dog with a pelvic fracture as seen with transurethral cystoscopy using a flexible cystourethroscope.

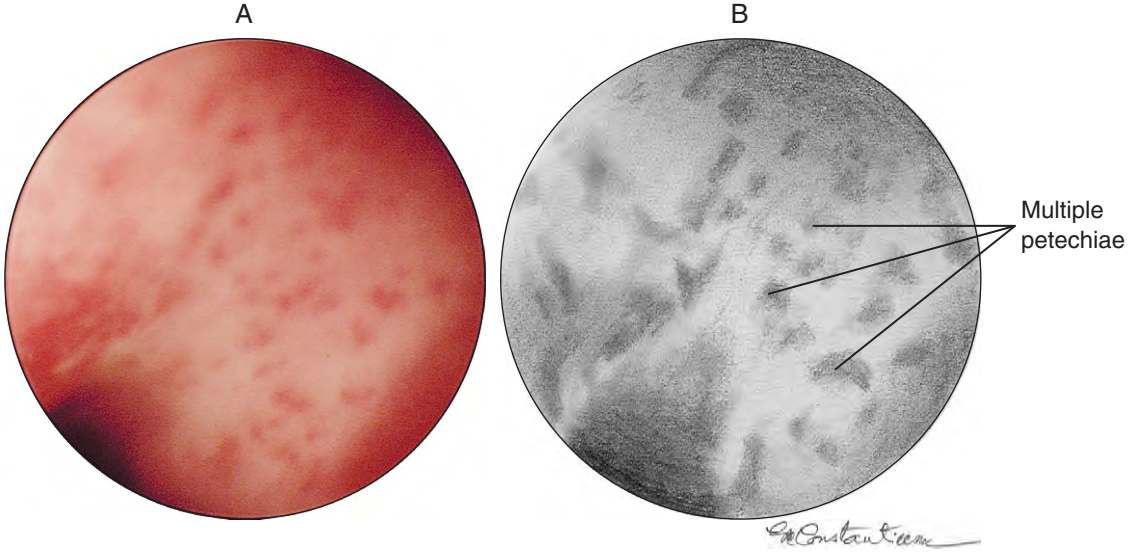



**Fig. 4–119**
Petechiae in the bladder of a female dog with pelvic fractures as seen with transurethral cystoscopy.

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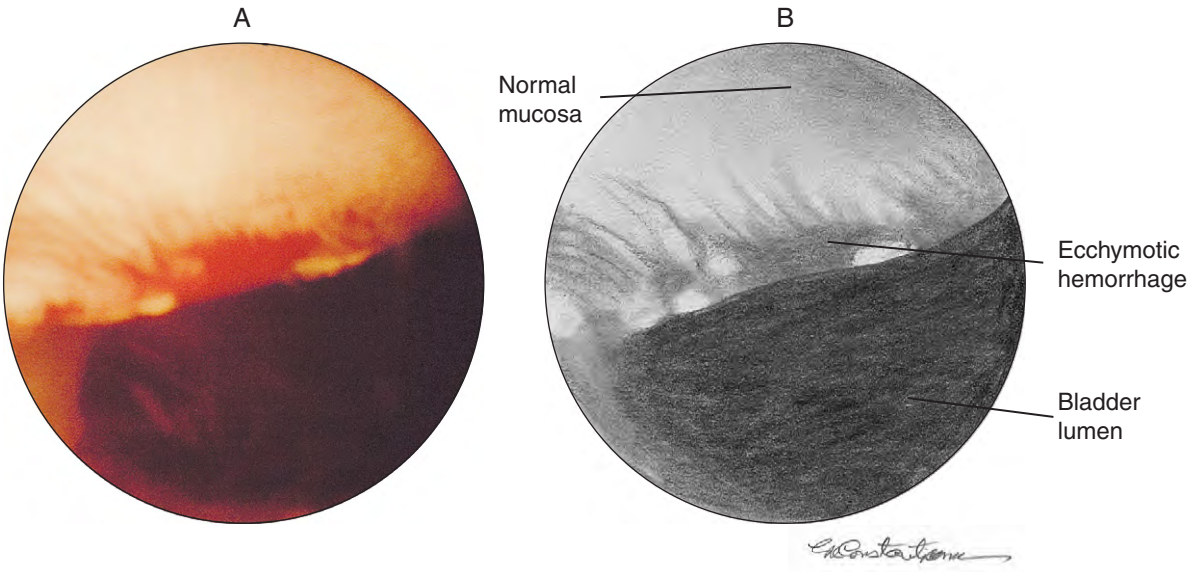



**Fig. 4–120**
An ecchymotic hemorrhage in the trigone area of a female cat with pelvic fractures as seen with transurethral cystoscopy.

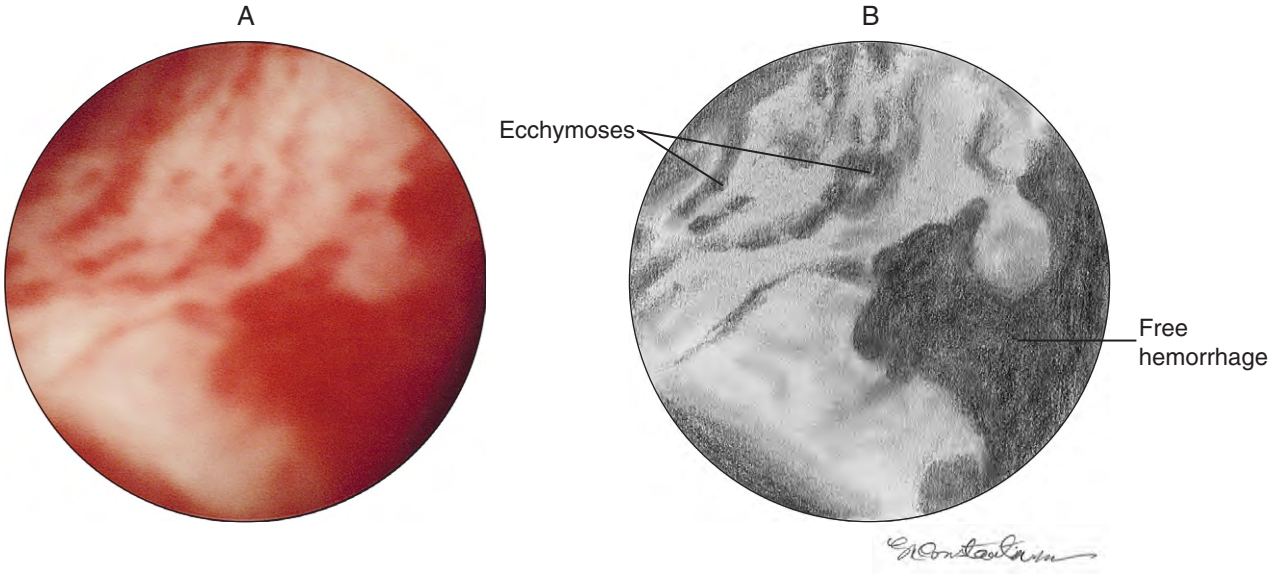



**Fig. 4–121**
Ecchymotic hemorrhages and free blood in the bladder of a female dog with pelvic fractures as seen with transurethral cystoscopy.

4-121). These lesions, if severe enough, can progress to small (Fig. 4-122) or large (Fig. 4-123) areas of mucosal necrosis. Mucosal lacerations that do not penetrate the muscular wall can be found in the urethra and are commonly seen within the bladder (Figs. 4-124 and 4-125). A circumferential 360-degree mucosal tear at the level of the trigone was found in a 2.3-kg Yorkshire Terrier that was hit by a car and sustained multiple pelvic fractures (see Fig. 4-124). Penetrating lacerations of the urethra and bladder can be identified by the presence of exposed mucosal and muscular wall edges and by tissue margin necrosis. Small perforations or penetrating lacerations may be more difficult to identify and may appear only as small areas of necrosis with or without adherent fibrin (Fig. 4-126).

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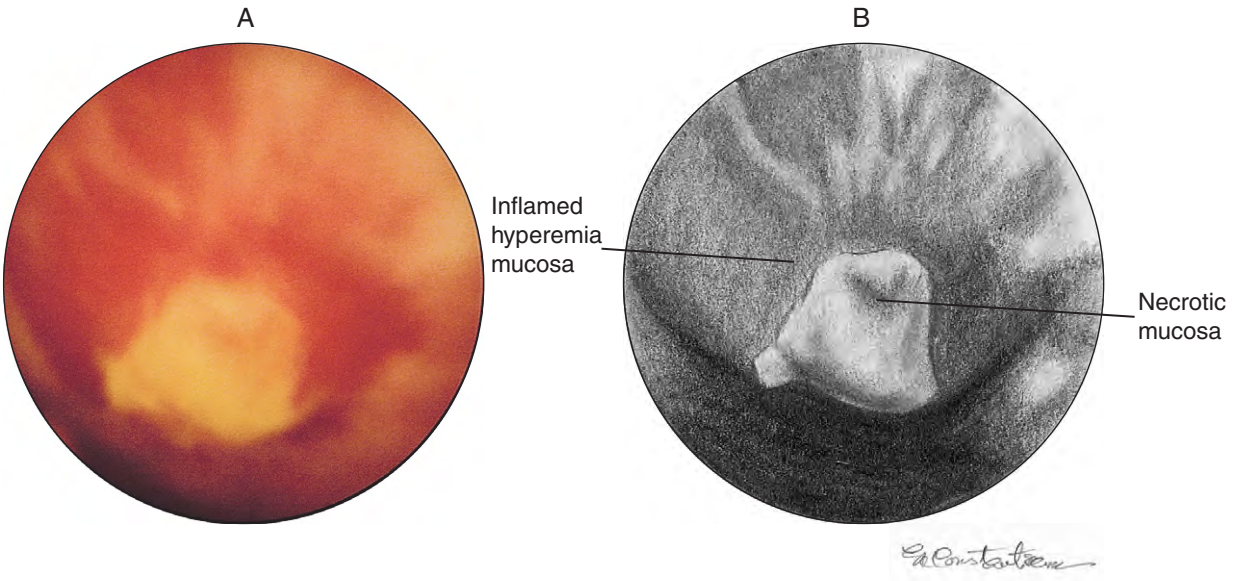



**Fig. 4–122**
A small area of mucosal necrosis surrounded by an area of hyperemia in the bladder of a female dog with a pelvic fracture examined with transurethral cystoscopy.

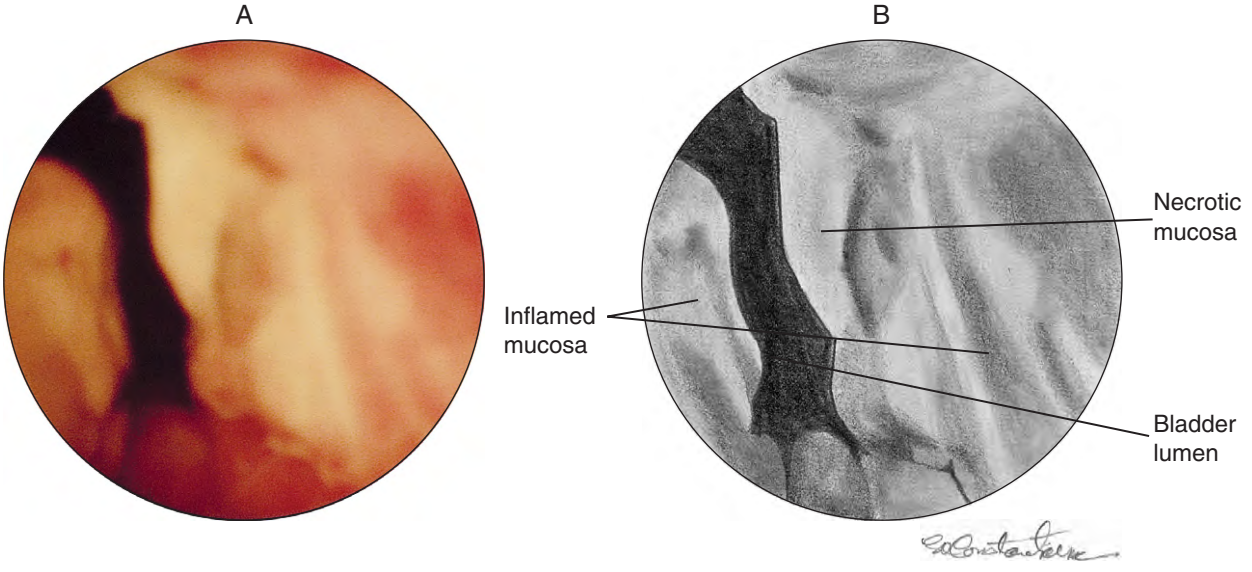



**Fig. 4–123**
An extensive area of mucosal necrosis in the bladder of a female dog with pelvic fractures as seen with transurethral cystoscopy.

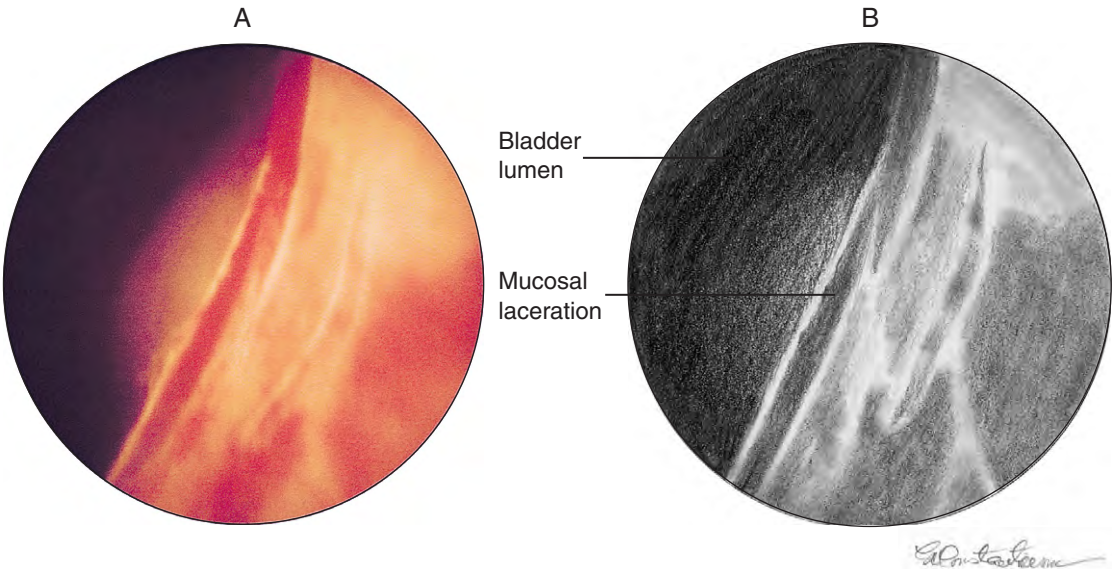



**Fig. 4-124**
A mucosal laceration seen with transurethral cystoscopy in a 2.3-kg female dog that had been hit by a car and had sustained multiple fractures. This laceration extended 360 degrees around the trigone area of the bladder and penetrated the mucosa but not the muscularis. The urinary tract trauma in this case was managed with an indwelling urinary catheter to maintain bladder decompression.

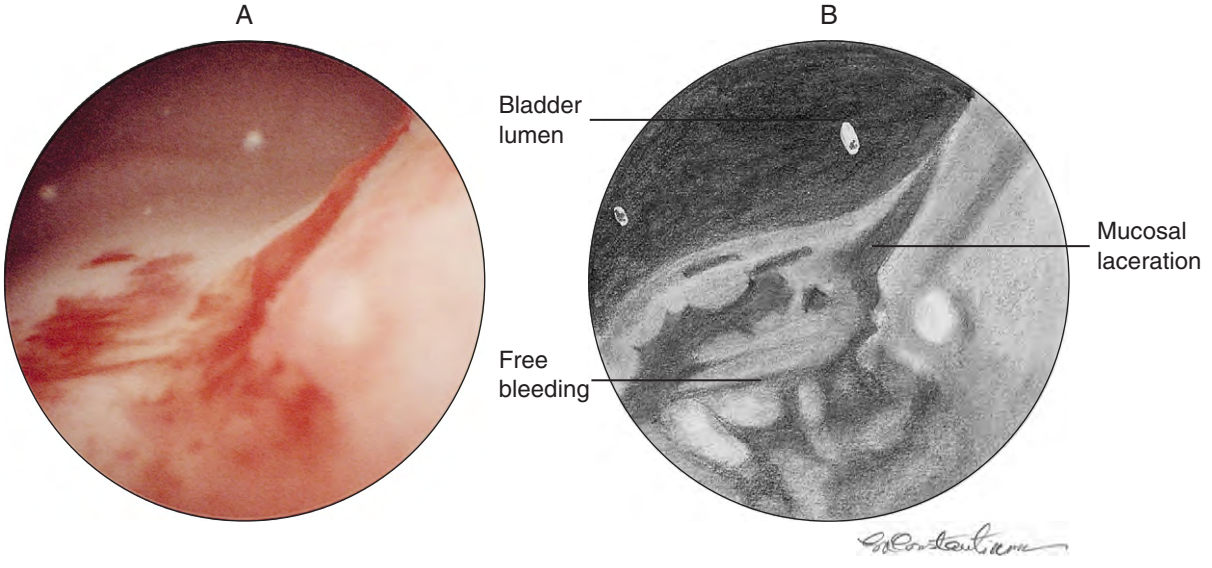



**Fig. 4-125**
Mucosal tearing in the bladder of a female cat with pelvic fractures seen with transurethral cystoscopy.

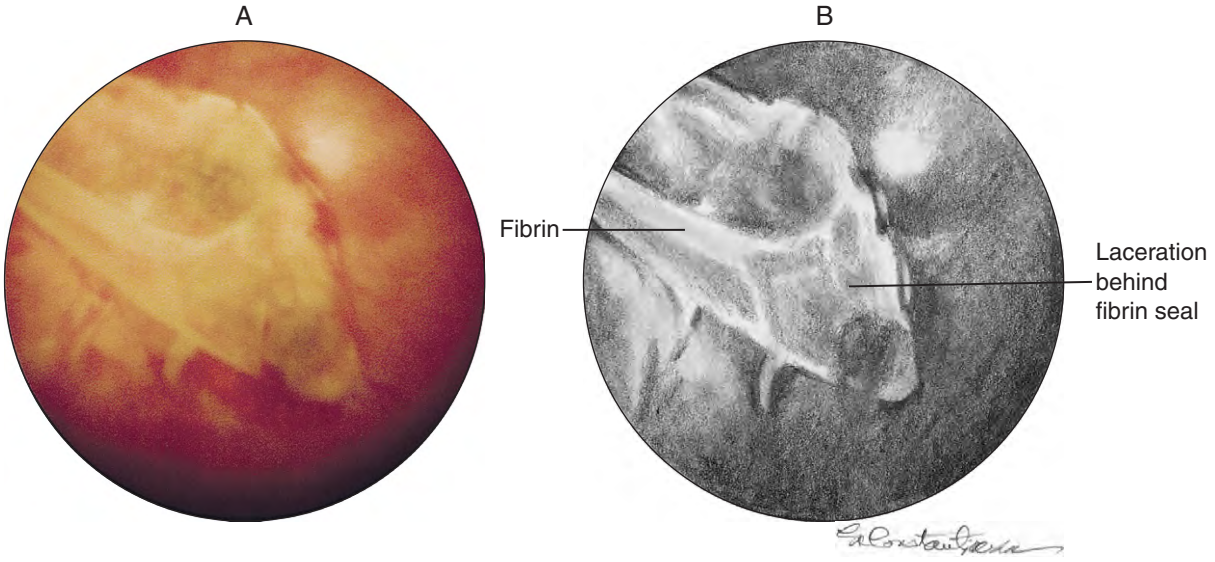



**Fig. 4–126**
A penetrating bladder wall laceration covered with adherent fibrin in a female dog viewed with transurethral cystoscopy.

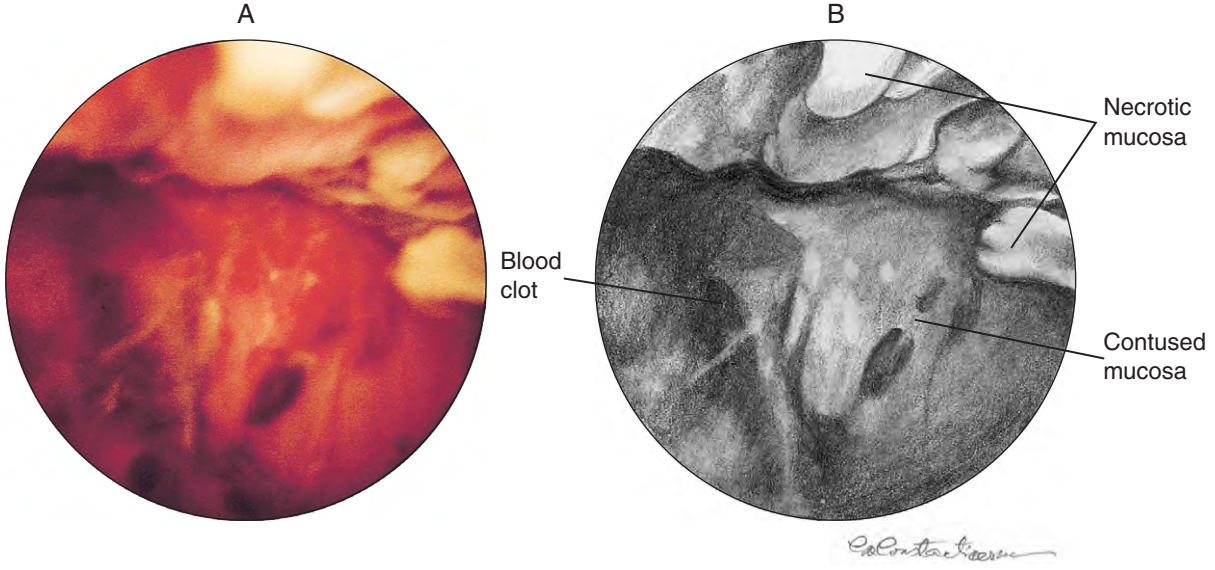



**Fig. 4–127**
Rupture of the bladder with severe bladder wall damage in a female dog examined with transurethral cystoscopy. The cranial wall of the bladder was not visible and it was not possible to distend the bladder sufficiently to allow adequate examination.

Medium-sized lesions can allow bladder distention for examination and then can be easily identified as perforations. In some cases, the endoscope can be passed through the lesion. Large lacerations or complete rupture of the bladder causes sufficient leakage to prevent bladder distention, making examination difficult or impossible (Fig. 4-127). Diagnosis in these cases is made based on inability to distend the bladder and on the presence of severe bladder wall changes. Urethral strictures due to trauma have also been found by TUC (Fig. 4-128).

Assessment of kidney and ureteral trauma has also been done with TUC. Observation of clear urine coming from both ureteral openings confirms that the ureters are intact and that the kidneys are functional, not having sustained significant trauma. Failure of a ureter to produce urine indicates possible ureteral rupture, ureteral

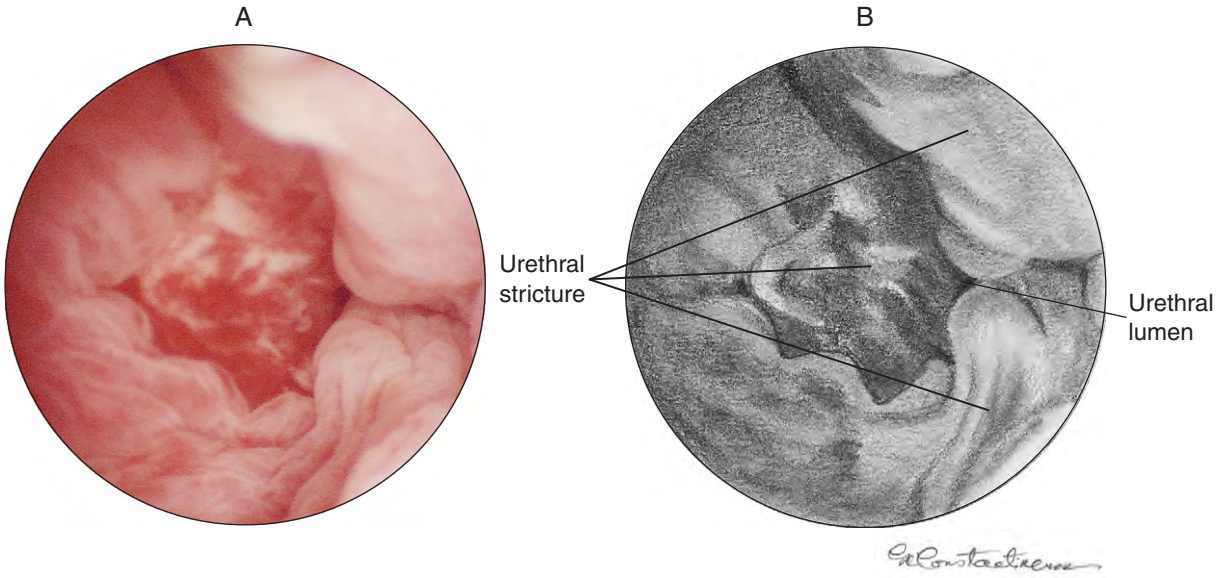



**Fig. 4–128**
A urethral stricture in a female dog examined with transurethral cystoscopy three weeks after trauma and pelvic fracture repair.

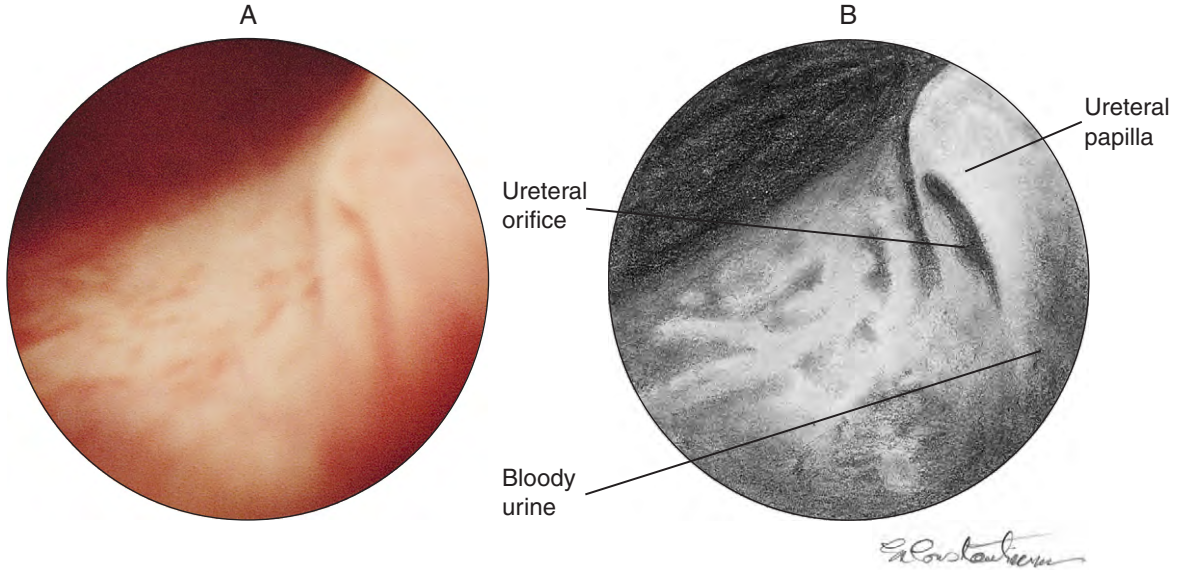



**Fig. 4–129**
Bloody urine coming from the ureter of a female dog with pelvic fractures as seen with transurethral cystoscopy.

transection, or sufficient kidney trauma to cause renal shutdown. Hematuria originating from a ureter indicates renal trauma with sufficient damage for hemorrhage but with a functional kidney and ureter (Fig. 4-129). Evaluation of ureteral urine production in male dogs transurethrally with flexible instruments is more difficult than with rigid instruments in females and is not effective in male cats with currently available instrumentation.

When endoscopic evaluation has inadequately assessed the urinary tract or when renal or ureteral pathology is suspected, further urinary tract evaluation is indicated with contrast cystourethrography, excretory urography, ultrasound, or with exploratory surgery. In cases with pelvic fractures, or with other orthopedic or soft tissue injuries requiring surgery, cystoscopic evaluation of the urinary tract is conducted when the patient is anesthetized for surgery. If urinary tract injuries requiring surgical intervention are ruled out, the orthopedic, or soft tissue, reconstruction is performed. If urinary tract injury requiring surgical intervention is found, then urinary tract reconstruction is

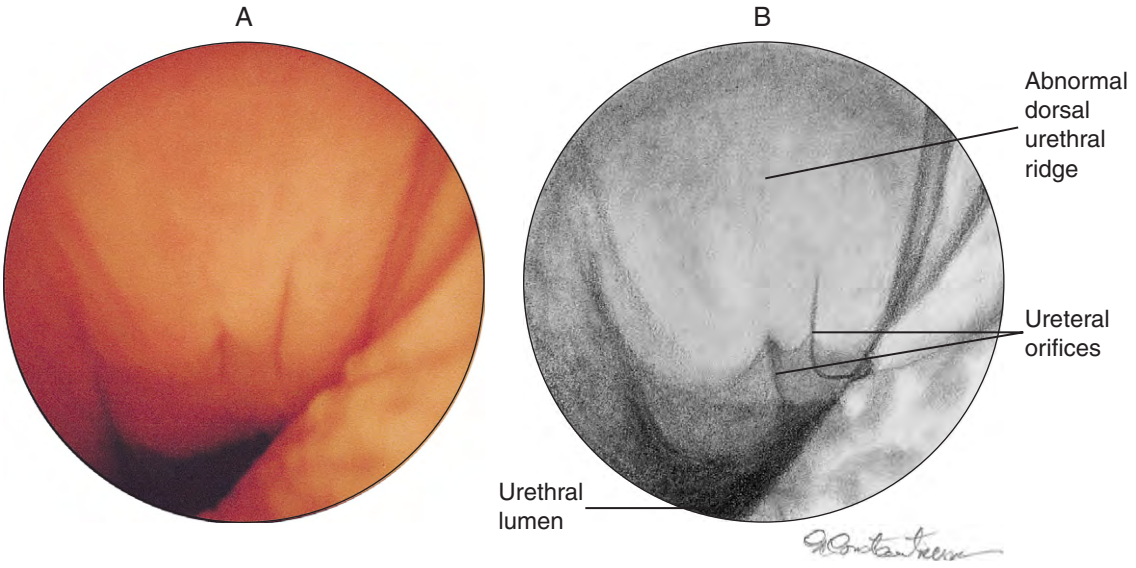



**Fig. 4–130**
Ectopic ureteral openings that are normal in configuration but are displaced medially and caudally into the proximal urethra in a female dog as seen by transurethral cystoscopy.

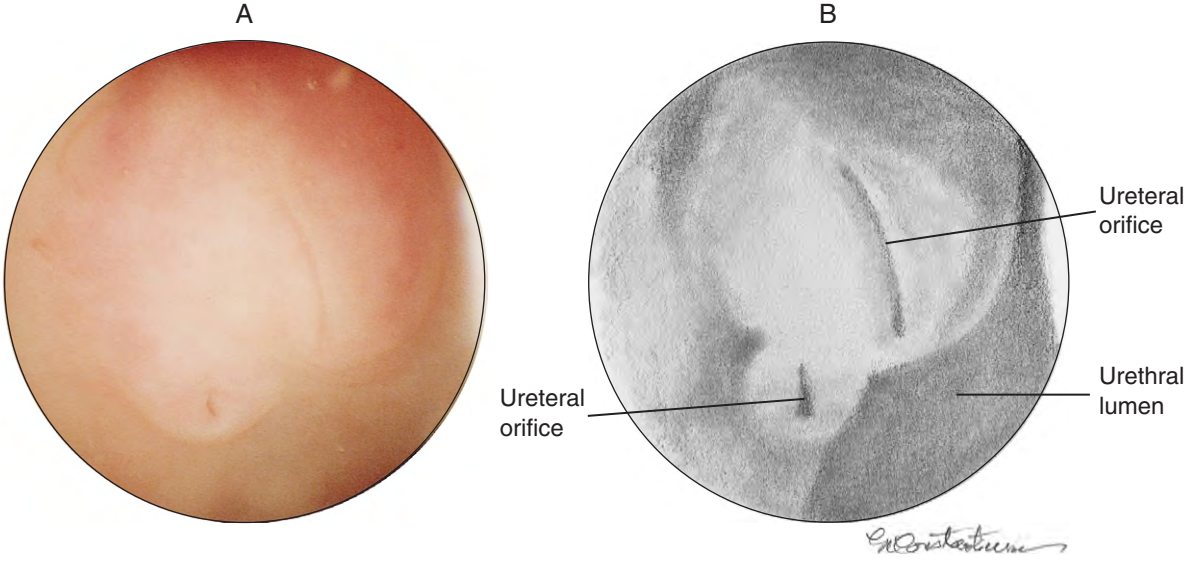



**Fig. 4–131**
Ectopic ureters that are displaced medially and caudally into the proximal urethra with one ureter having a normal slit configuration and one that is deformed into a round opening.

performed and orthopedic reconstructive procedures are delayed and performed during subsequent anesthesia.

## Ectopic Ureters

Pathology associated with ectopic ureters is found more easily and defined more accurately with TUC than with any other diagnostic modality including exploratory surgery. Abnormalities are commonly more than just misplacement of the ureteral openings and may involve abnormal development of the entire urethra, ureters, trigone, and vagina. Openings of the ureters may be found anywhere in the lower urogenital tract caudal to their normal openings in the bladder. Ureteral pathology can be unilateral or bilateral.

Ectopic ureters are more commonly found opening into the urethra than into the vagina. Changes in ureteral stoma location and configuration may be relatively minor with displacement medially and caudally into the cranial portion of the urethra and normal (Fig. 4-130) or slightly abnormal stomal shape (Fig. 4-131). Ureters may

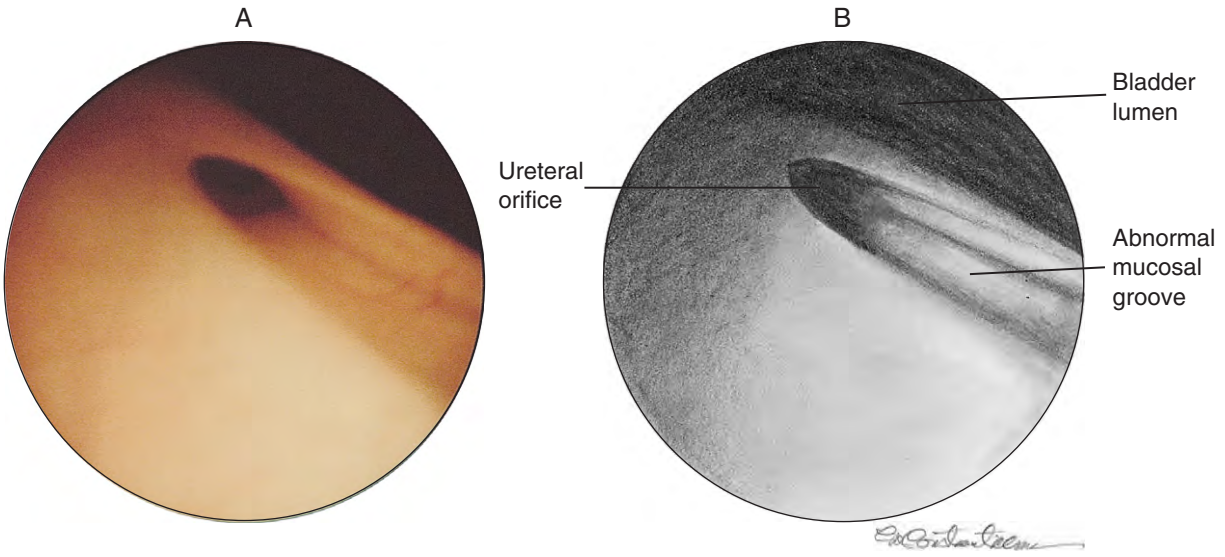



**Fig. 4–132**
Abnormal configuration of a normally placed ureteral opening with a mucosal groove running caudally through the bladder sphincter and into the urethra. This lesion was found in a female dog by transurethral cystoscopy.

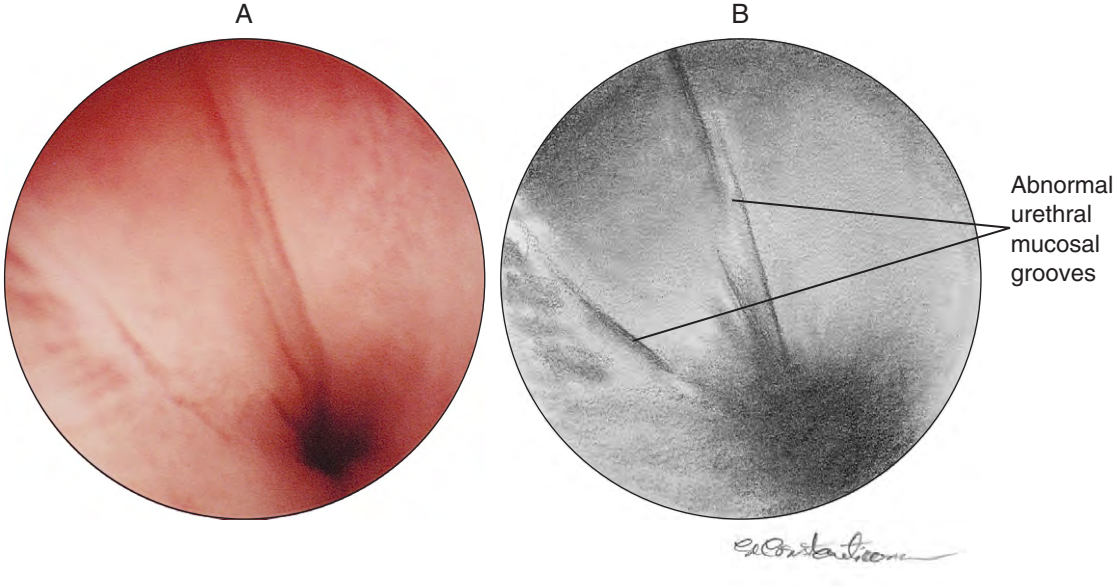



**Fig. 4–133**
Bilateral urethral grooves extending caudally from ureteral openings that are normal in location and configuration as seen with transurethral cystoscopy in a female dog presented for urinary incontinence.

open in a relatively normal location in the bladder but be abnormal in configuration (Fig. 4-132) and may have unilateral or bilateral grooves running through the bladder sphincter and along the urethra (Figs. 4-132 and 4-133). Significant displacement of ureteral openings caudally into the urethra is commonly associated with marked deformity of the ureteral openings and with urethral abnormalities (Fig. 4-134). The most commonly seen urethral deformities include enlargement, increased dispensability, and poor contractile capabilities (see Fig. 4-134). Urethral septa, either partial or complete, are a more severe example of ureteral and urethral pathology. Complete urethral septa have been found where the ureter extends to the caudal end of the urethra and is equal in size to the urethra (Fig. 4-135). Incomplete urethral septa may have fenestrations (Fig. 4-136), may extend only part of the way down the urethra (Fig. 4-137), or both. In some cases, the ureters can only be distinguished from the

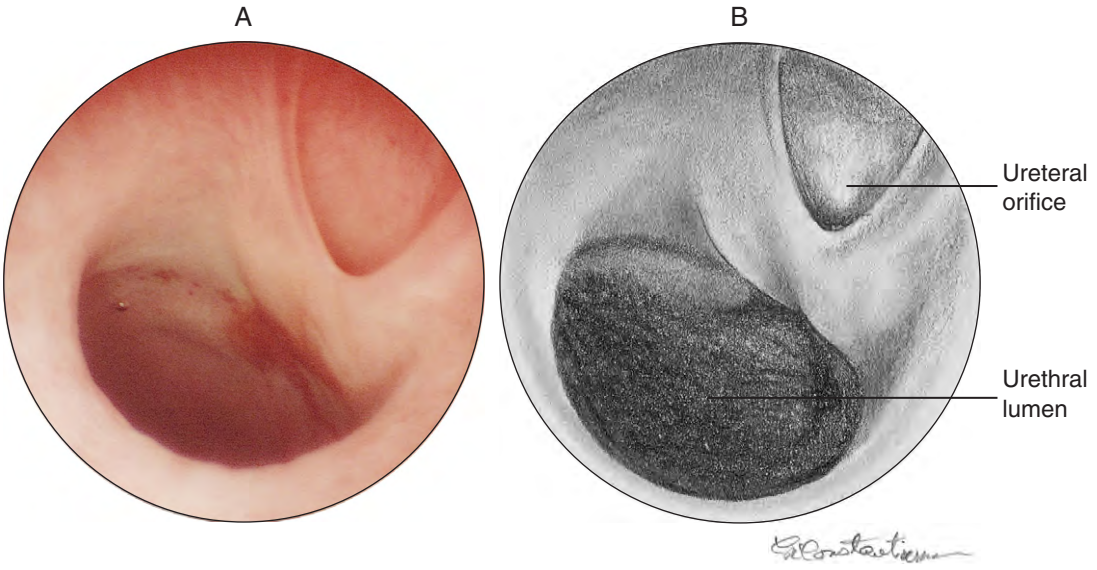



**Fig. 4–134**
An abnormally placed and abnormal-in-configuration ectopic ureteral opening in the urethra viewed with transurethral cystoscopy. The ureteral opening and ureter were markedly dilated. The urethra in this female dog was also abnormal with increased diameter and limited contractile ability.

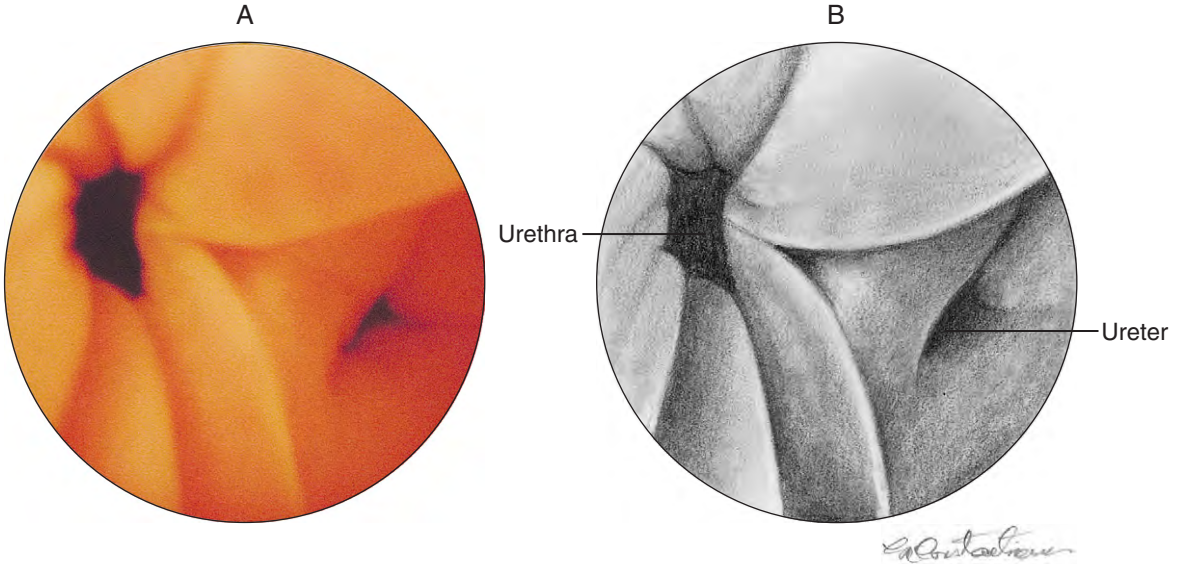



**Fig. 4–135**
The opening of the urethra and a urethral ectopic ureter at the caudal end of a urethral septum. It was not possible to determine by their size and shape which was the urethral orifice and which was the opening of the ectopic ureter. To distinguish between the two, it was necessary to determine which one entered the bladder.

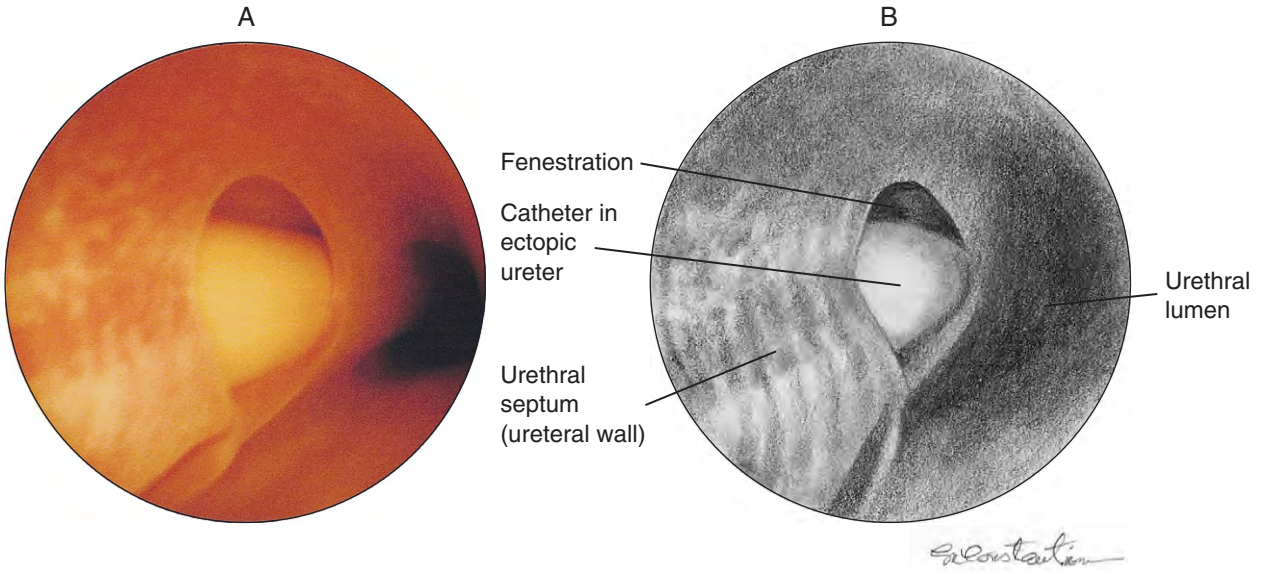



**Fig. 4–136**
A fenestration in the caudal urethral portion of an incomplete urethral septum formed by an ectopic ureter extending almost the full length of the urethra in a female dog with bilateral ectopic ureters. A catheter is present in the ureter and can be seen through the fenestration.

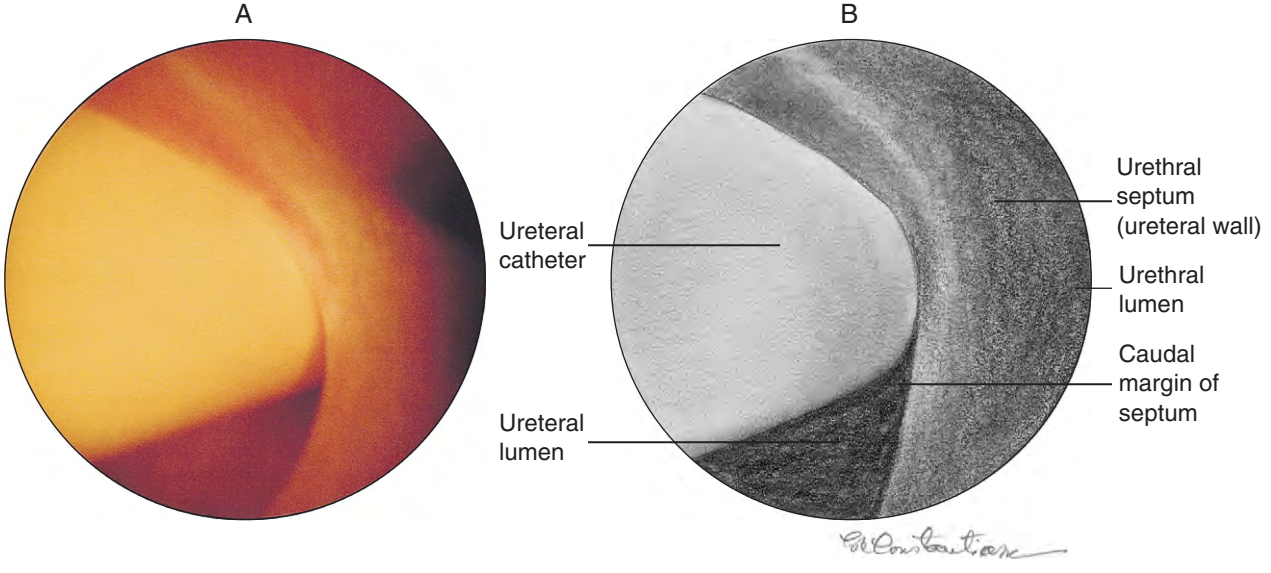



**Fig. 4–137**
The caudal margin of an incomplete urethral septum formed by an ectopic ureter in a female dog seen with transurethral cystoscopy. A urinary catheter is visible entering the ureter.

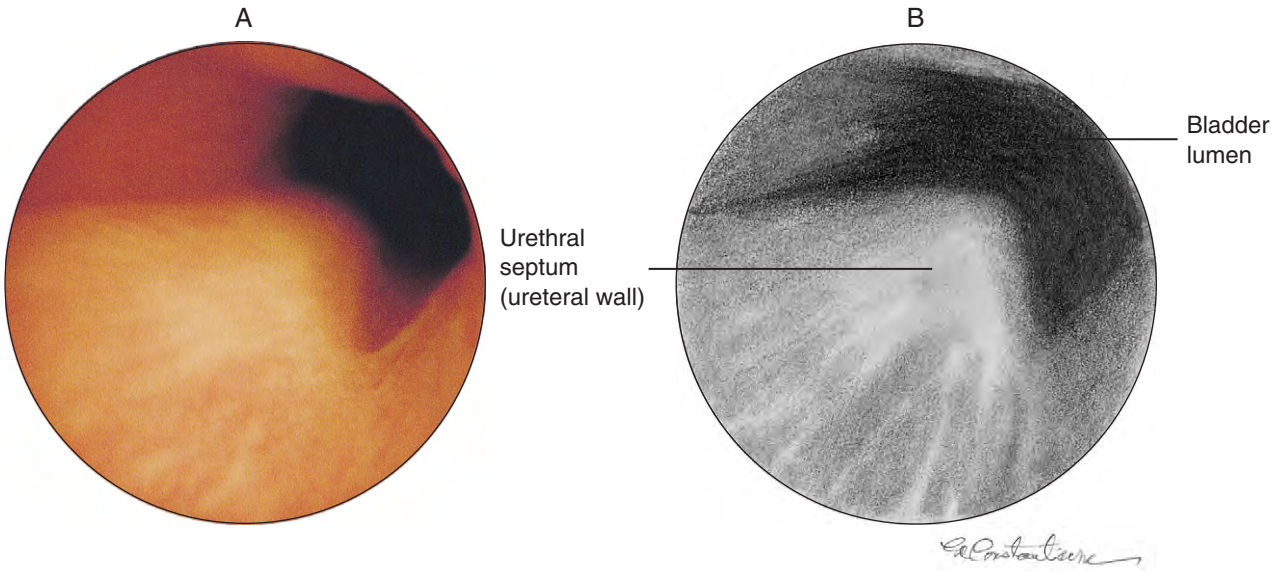



**Fig. 4–138**
The cranial portion of the urethral septum as it enters the bladder in the same case as shown in Fig. 4-136.

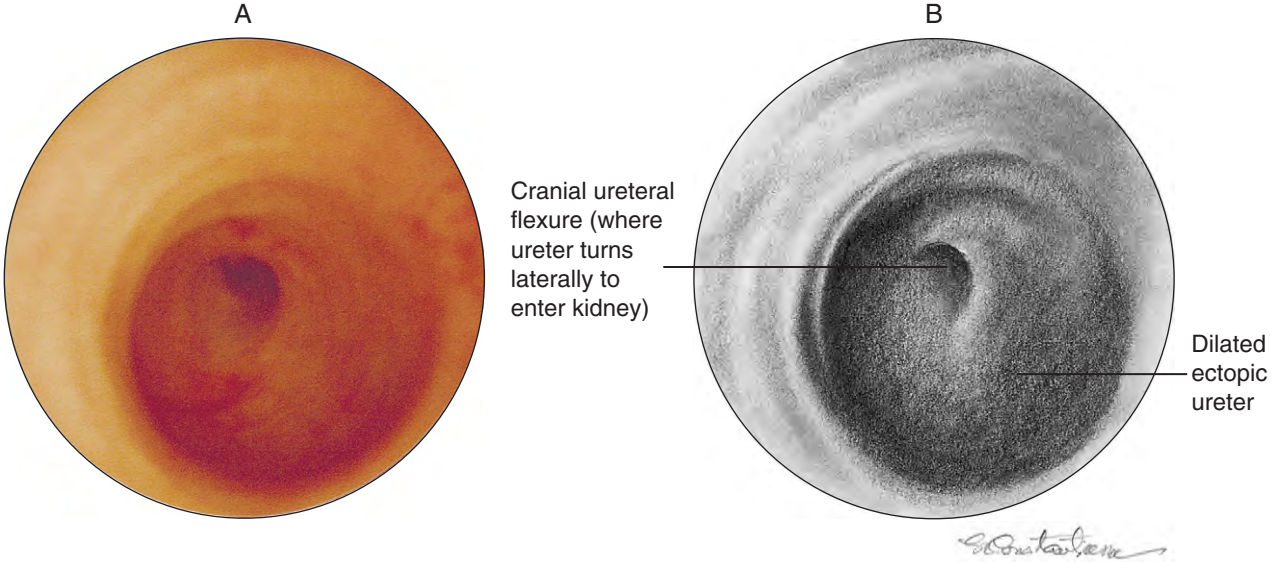



**Fig. 4–139**
Transurethral ureteroscopy of a dilated ectopic ureter in a female dog with bilateral ectopic ureters. The ureter was accessed transurethrally.

urethra by determining which allows passage into the bladder (Fig. 4-138). Ureters in these cases may be sufficiently dilated to allow easy passage of the endoscope into the ureter (Fig. 4-139). With ectopic ureters, the ipsilateral normal ureteral stoma site in the bladder may show a mucosal depression (Fig. 4-140) or a raised mucosal ridge (Fig. 4-141) but with no opening into the bladder. Ectopic ureters can be unilateral with a normally located and configured contralateral ureter, bilateral with symmetry (see Figs. 4-130 and 4-131), or bilateral with asymmetry (Figs. 4-142 and 4-143). Urethral diverticula occur that must be differentiated from ectopic ureters by determining that they do not have a lumen (Fig. 4-144).

Vaginal ectopic ureters are less common than urethral locations. Their openings must be distinguished from the urethral orifice (see Fig. 4-135), from periurethral mucosal pockets (Figs. 4-145 and 4-146), and from the opening into the cranial vagina (Fig. 4-147). In some cases there is difficulty differentiating various structures and in some cases they are easily found (Fig. 4-148).

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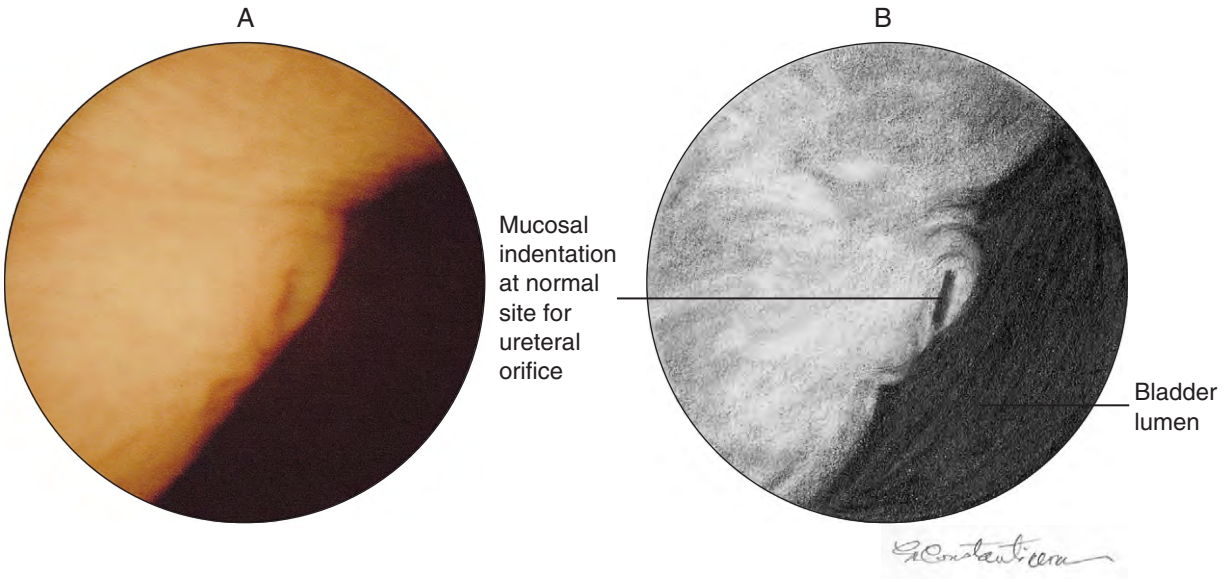



**Fig. 4–140**
A mucosal depression at the normal location for a ureteral opening in a female dog with bilateral ectopic ureters that opened in the cranial urethra as seen by transurethral cystoscopy.

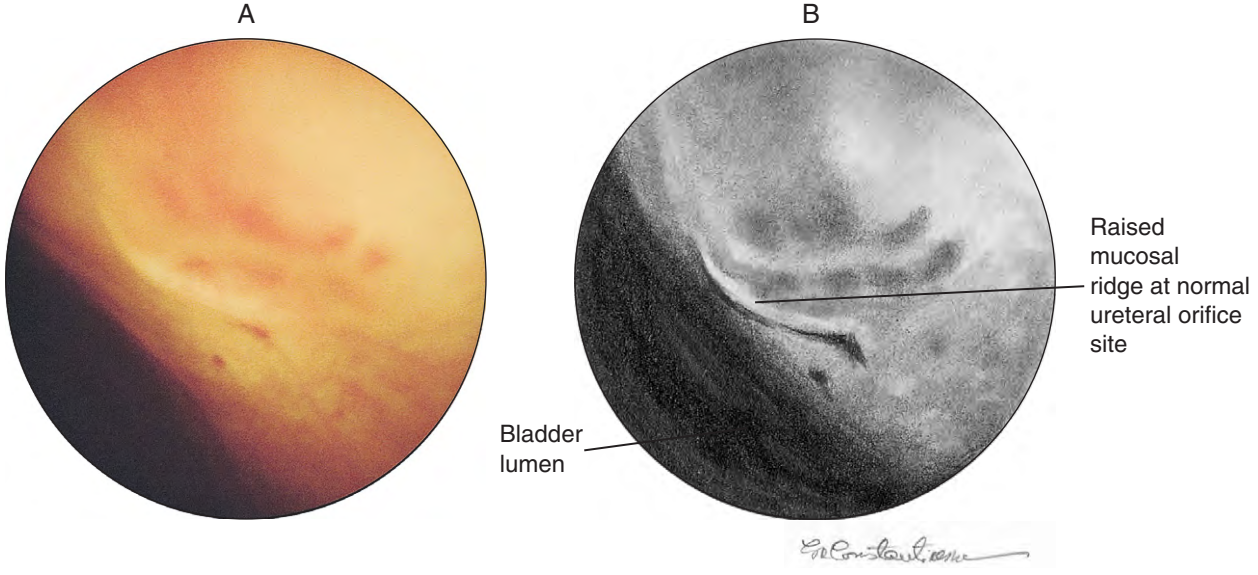



**Fig. 4–141**
A raised mucosal ridge at the normal ureteral orifice site seen with transurethral cystoscopy in a female dog with bilateral ectopic ureters that opened in the caudal urethra.

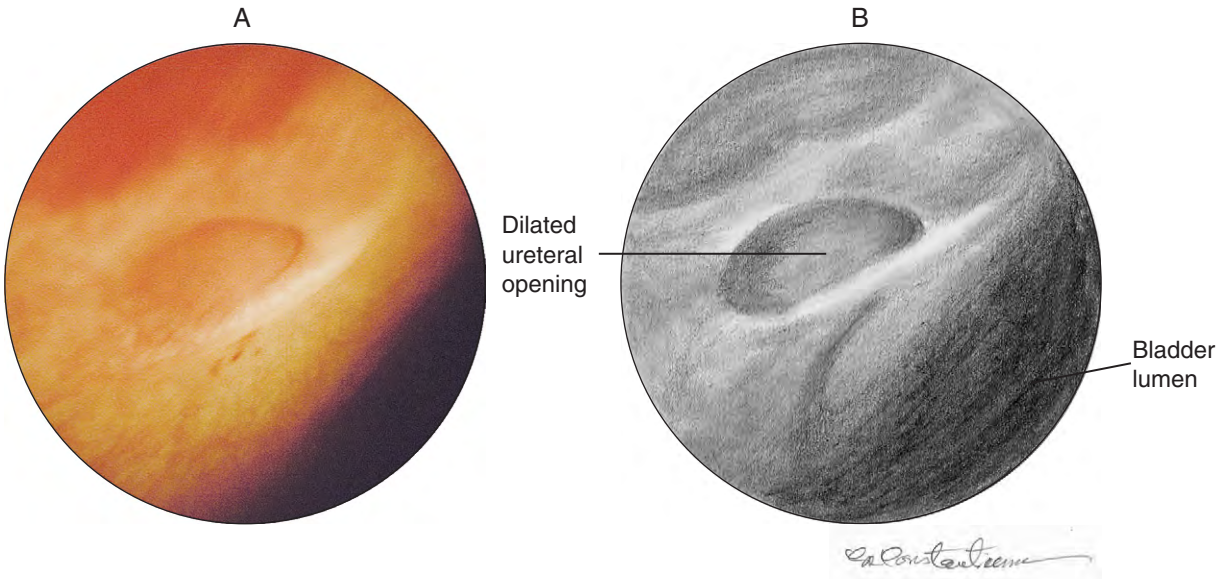



**Fig. 4–142**
The contralateral ureteral opening in the dog with the ectopic ureter forming a partial urethral septum as seen in Figs. 4-137 and 4-138. This ureteral opening was in a normal location but was enlarged and opened into a dilated ureter.

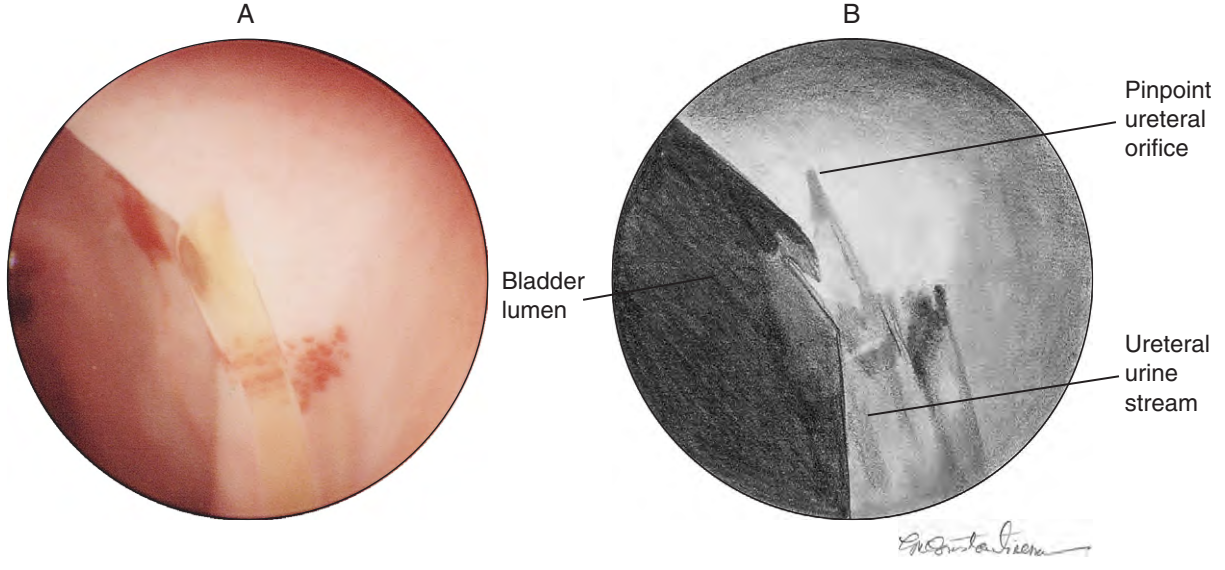



**Fig. 4–143**
The contralateral ureteral opening in the dog with the dilated and displaced ectopic ureter and dilated urethra seen in Fig. 4-134. The opening of this ureter was a very small round pinpoint hole in the trigone of the bladder located on the free wall of the urethral ectopic ureter. There is a stream of urine visible coming from the ureteral orifice.

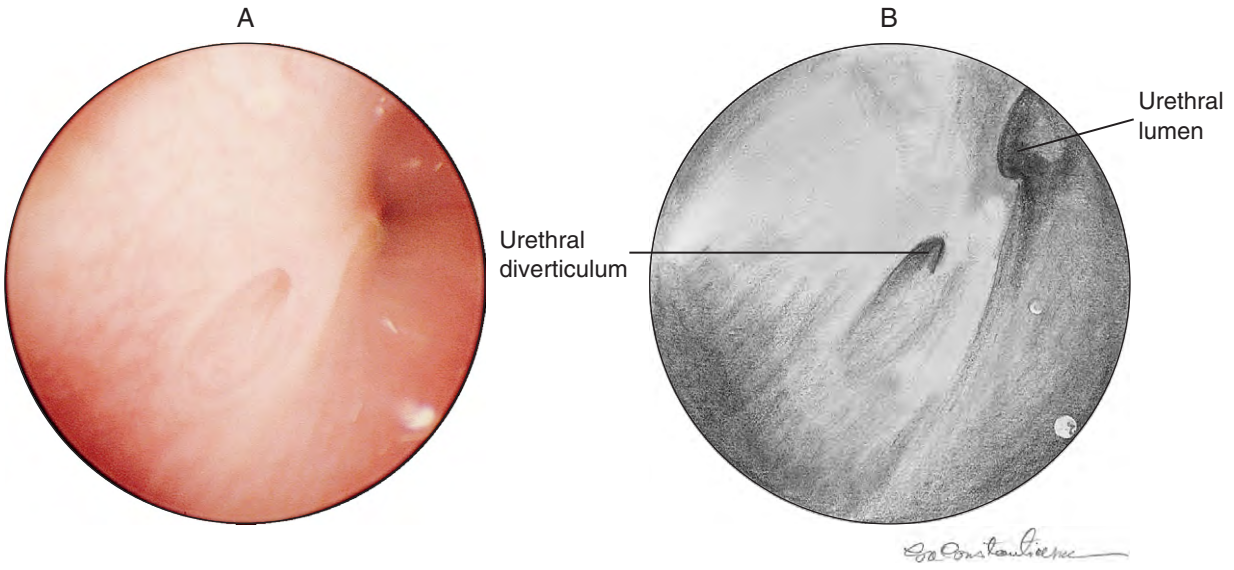



**Fig. 4–144**
A urethral diverticulum in a female dog as seen with transurethral cystoscopy.

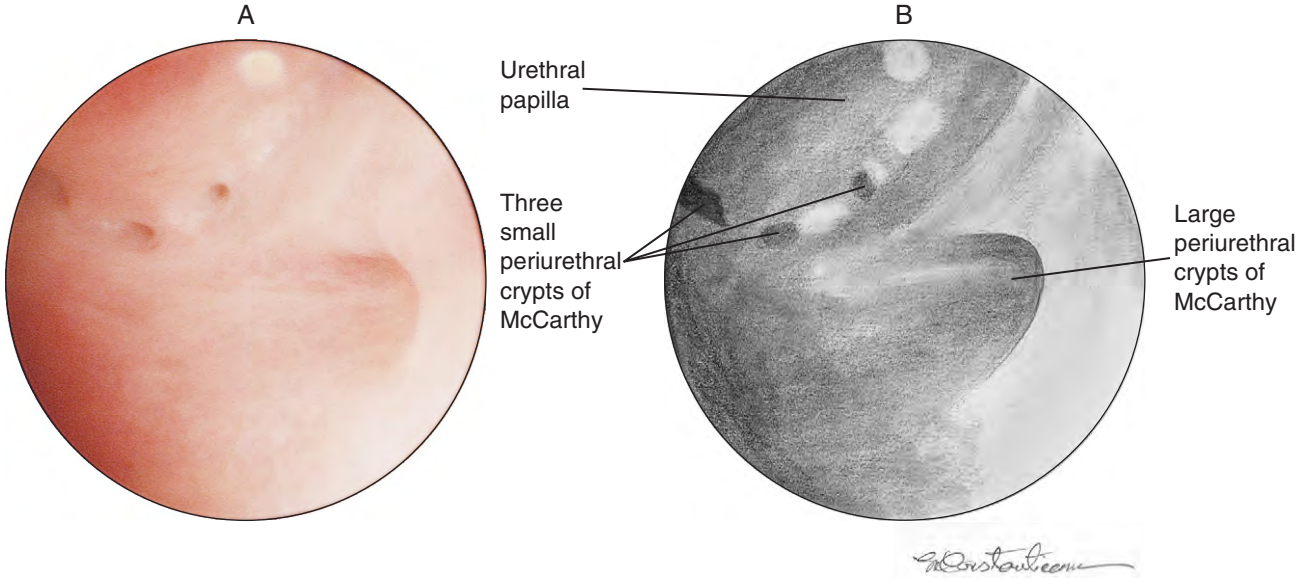



**Fig. 4–145**
Multiple periurethral crypts of McCarthy in a female dog. These indentations are normal but may be large enough, as pictured here, to be confused with openings of ectopic ureters. Each opening must be probed with the endoscope or with a catheter to confirm that it is an indentation and not a ureter.

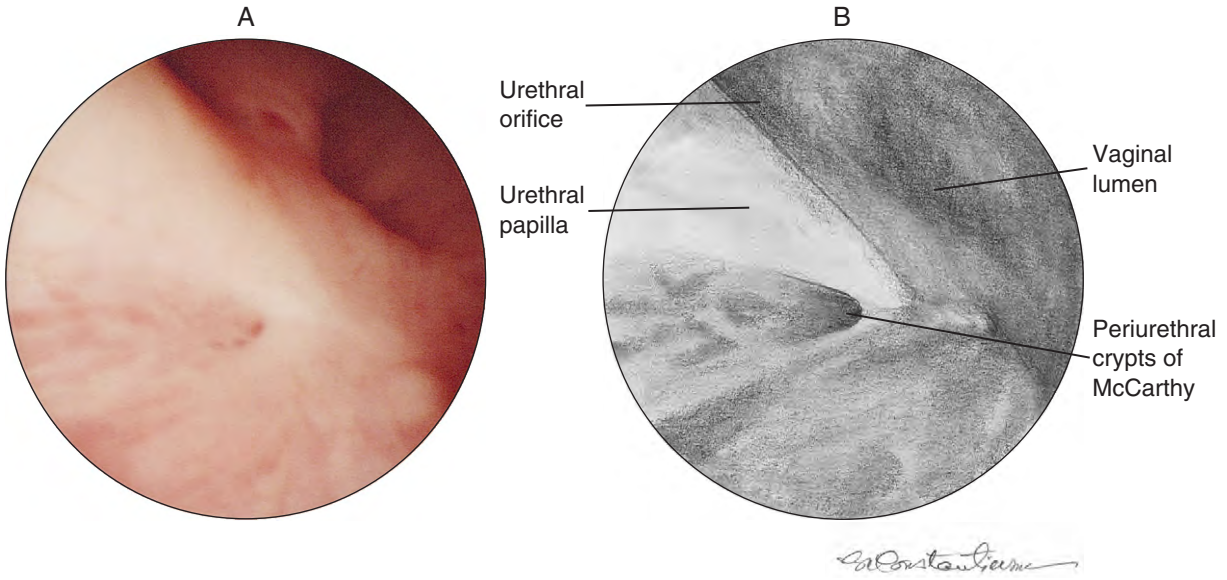



**Fig. 4–146**
A periurethral crypt of McCarthy in a female cat. These indentations are much less common in cats than in dogs but do occur and must undergo the same scrutiny as in a dog.

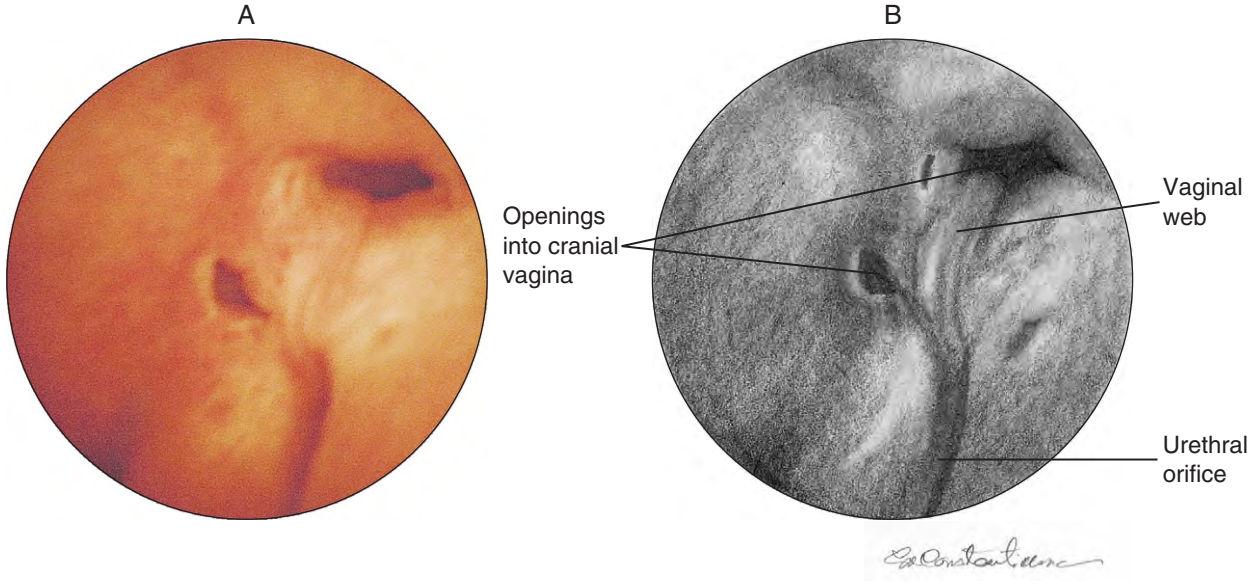



**Fig. 4–147**
A short thick vaginal web, seen with vaginoscopy in a female dog presented for incontinence, producing two small openings that could be confused with ectopic ureteral openings. The endoscope was passed through each of the openings to confirm that they both entered the cranial vagina. Bilateral ectopic ureteral openings were found in the urethra.

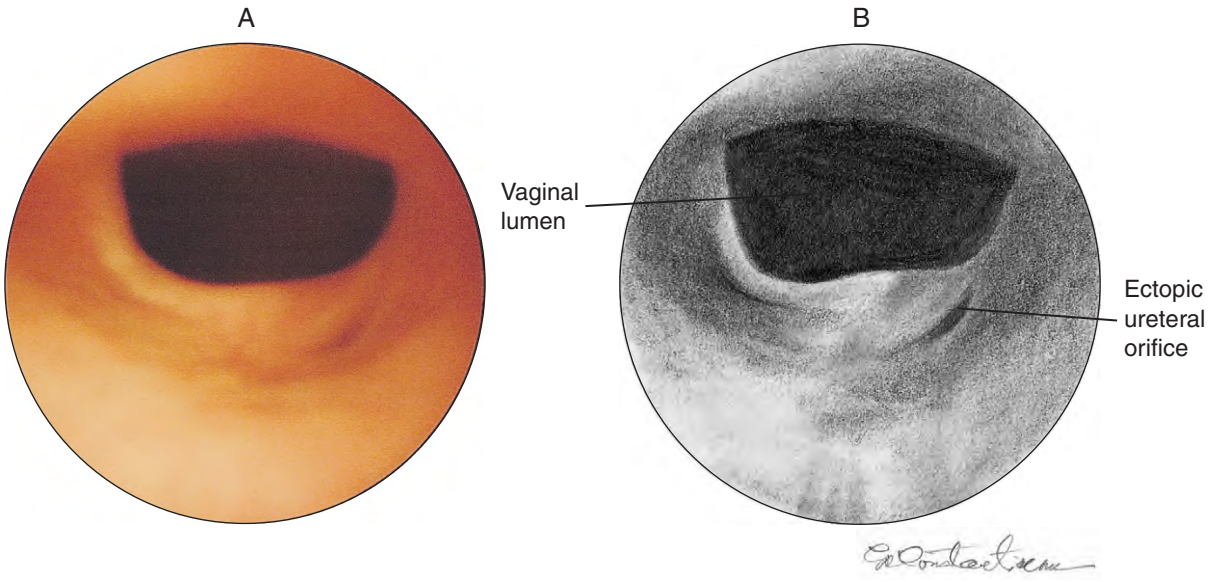



**Fig. 4–148**
Vaginoscopy of a female dog with an ectopic ureteral opening in the vagina cranial to the urethral opening. The other ureter was also ectopic and opened into the urethra.

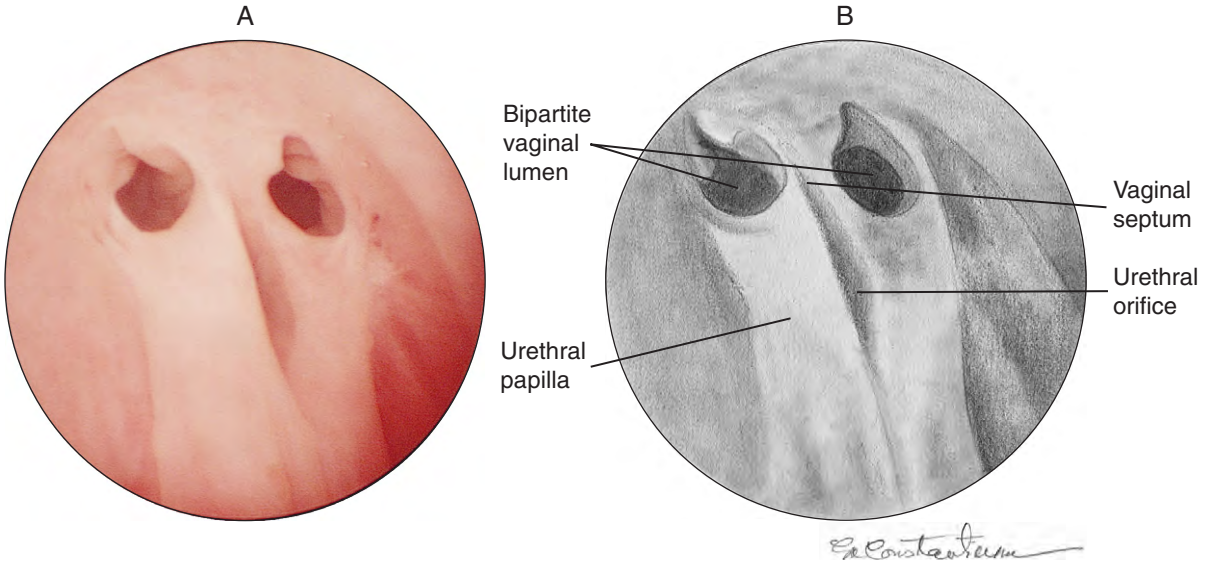



**Fig. 4–149**
A bipartite uterus in a female dog presented for incontinence. The two openings above the urethral orifice were confirmed to be vaginal openings by passing the endoscope cranially until the cervix was found on each side. The ureters in this case were normal in location and configuration.

An endoscope or a catheter can be passed into questionable structures until the presence or absence of a lumen is defined. Flow of urine from the stoma is confirmation that the opening is an ectopic ureter. Thick short vaginal webs at the level of the urethral opening can also cause confusion in defining openings of ectopic ureters (see Fig. 4-147). Passage of the endoscope through the openings on each side of the web defines this structure by visualization of the vaginal lumen through both openings. A case of bipartite uterus was diagnosed with TUC and appeared similar to a thick short vaginal web but each side of the weblike structure opened into its own cranial vaginal structure with its own cervix (Fig. 4-149). Ectopic ureters are most commonly seen in female dogs but can also be seen in the urethra of male dogs (Fig. 4-150). TUC is the procedure of choice for diagnosis and evaluation of ectopic ureters.

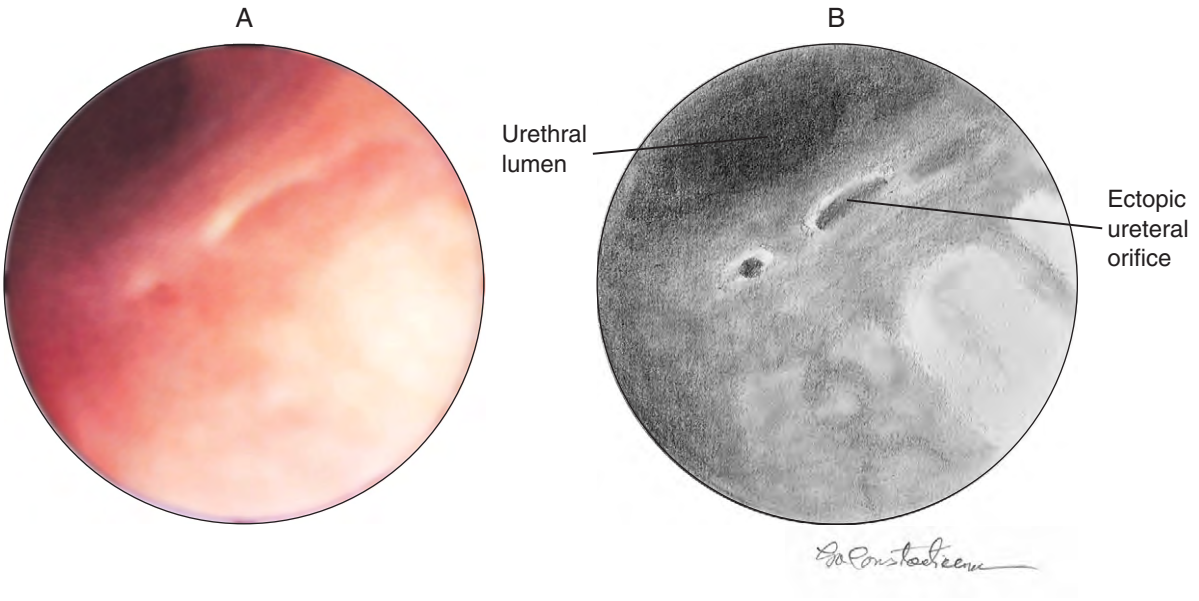



**Fig. 4–150**
An ectopic ureteral opening in the caudal pelvic urethra of a male dog examined with a flexible cystourethroscope.

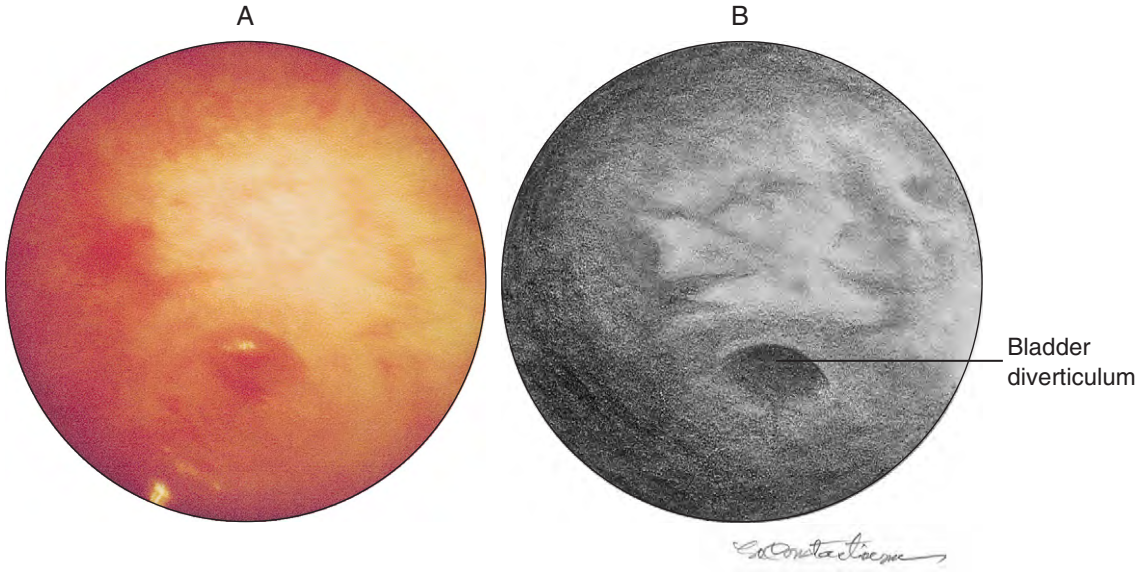



**Fig. 4–151**
A small bladder diverticulum (persistent urachus) in a female cat as seen by transurethral cystoscopy. The opening of the diverticulum is surrounded by inflammation that prevents visualization of the diverticular opening.

## Bladder Diverticula

Bladder diverticula can be defined with transurethral or percutaneous cystoscopy by the presence of a bladder wall defect lined with mucosal tissue. They are most commonly found in the cranioventral area of the bladder wall and in this location are most commonly urachal remnants. Many diverticula are too small to see without the aid of magnification provided by an endoscope. Very small lesions may appear only as a dimple in an area of thickened bladder mucosa that may be surrounded by hyperemic raised mucosa (Fig. 4-151). Larger diverticula are easily seen and with increasing size have a lower incidence of associated inflammatory reaction (Fig. 4-152). Diverticular size may vary with the extent of bladder distention.

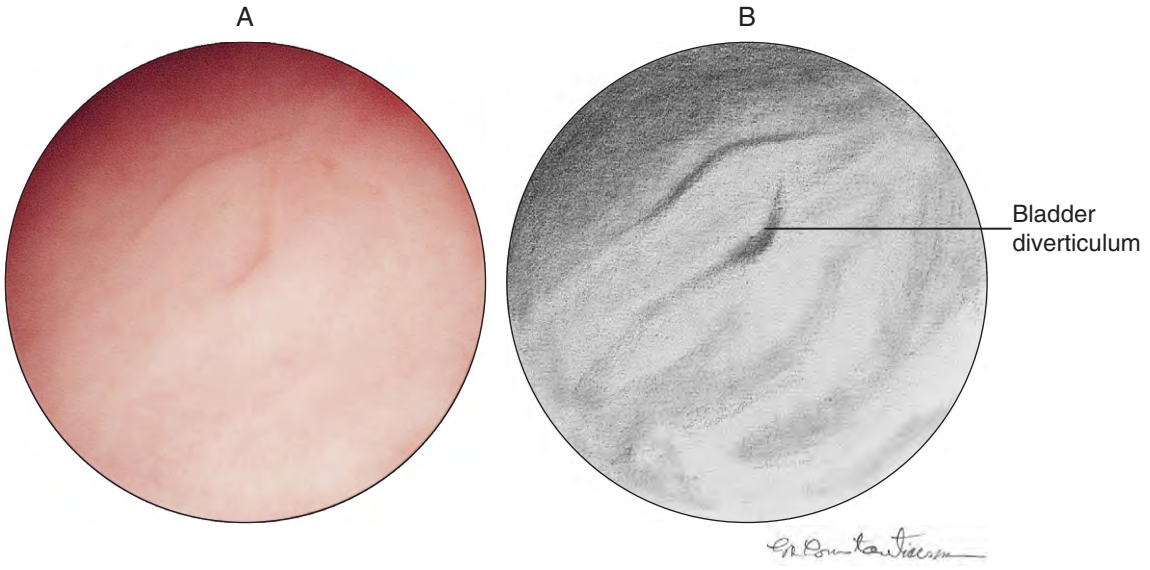



**Fig. 4–152**
A bladder diverticulum (persistent urachus) on the cranioventral wall of the bladder in a female dog as seen with transurethral cystoscopy.

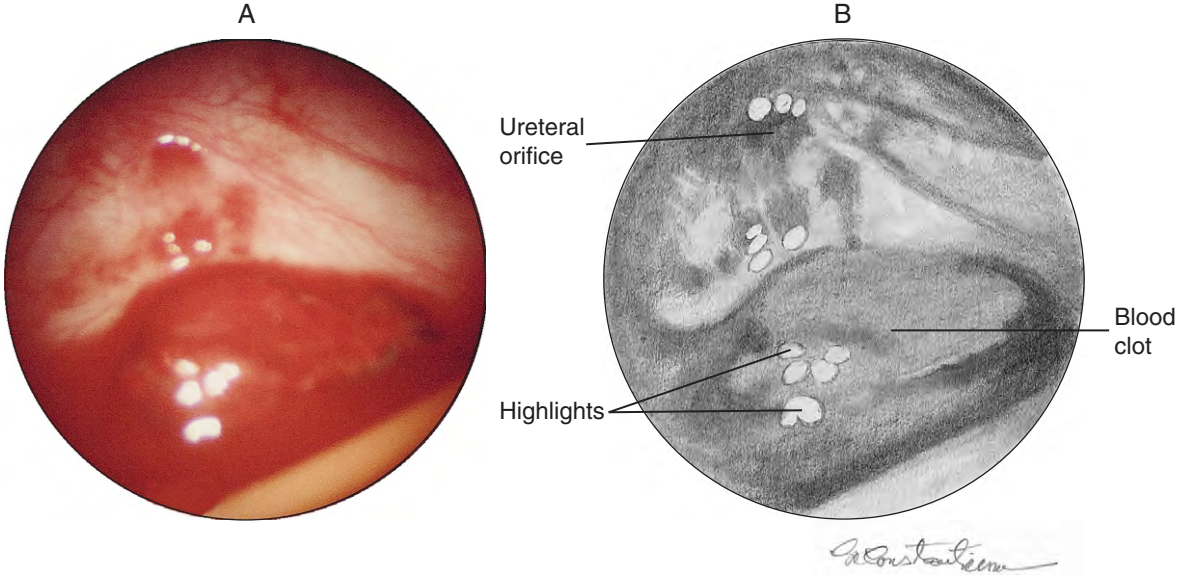



**Fig. 4–153**
The bladder of a male German Shepherd dog with familial renal hematuria as seen with prepubic percutaneous cystoscopy and using air for bladder distention. Bleeding in this dog was too extensive to permit examination through liquid and an adequate examination could not be completed transurethrally. A large blood clot is visible on the floor of the bladder and the left ureteral opening can be seen.

## Renal Hematuria

Idiopathic renal hematuria, also termed *benign essential hematuria*, is an uncommon condition that can be life threatening as a result of blood loss.[22-24] There is massive hematuria of renal origin that is not associated with trauma, and it is most commonly a unilateral disease, with no definable gross or histopathologic source of hemorrhage. With unilateral disease, the recommended treatment is nephrectomy of the involved kidney. Removal of the correct kidney is critical to successful treatment and patient survival. Determining which kidney is involved can be difficult as they appear grossly normal. The involved side can be easily, quickly, and accurately determined with cystoscopy (Figs. 4-153 and 4-154).

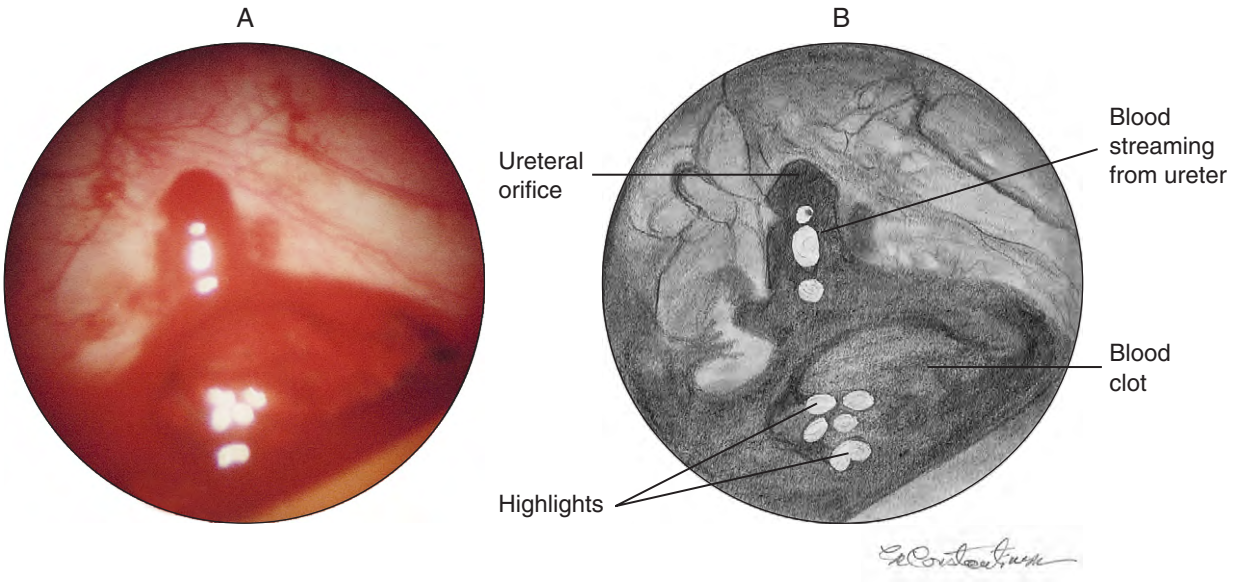



**Fig. 4-154**
The same bladder as seen in Fig. 4-153 with a pulsation of blood coming from the left ureter. This finding combined with visualization of clear urine coming from the right ureter confirmed that the left kidney was the one involved. Surgery was performed immediately after cystoscopy was completed.

## CONCLUSION

Cystoscopy is the most underused endoscopic technique available to veterinary medicine. These procedures are invaluable in practice, allowing better evaluation of disease processes of the lower urinary tract with decreased morbidity and mortality compared with surgery. When cystoscopy has realized its full potential in practice, its use will exceed the application of gastrointestinal endoscopy and will completely redefine understanding and management of lower urinary tract disease in veterinary medicine, allowing more effective case management based on improved diagnostic information obtained with less invasive and less traumatic technique.

## REFERENCES

1. Vermooten V: Cystoscopy in male and female dogs, *J Lab Clin Med* 15:650-657, 1930.
2. Biewenga WJ, van Oosterom RAA: Cystourethroscopy in the dog, *Vet Q* 7:229-231, 1985.
3. Brearley MJ, Cooper JE: The diagnosis of bladder disease in dogs by cystoscopy, *J Small Anim Pract* 28:75-85, 1987.
4. Cooper JE and others: Cystoscopic examination of male and female dogs, *Vet Rec* 115:571-574, 1984.
5. Senior DF, Newman RC: Retrograde ureteral catheterization in female dogs, *J Am Anim Hosp Assoc* 22:831-834, 1986.
6. Senior DF, Sundstrom DA: Cystoscopy in female dogs, *Compend Small Anim* 10:890-895, 1988.
7. Brearley MJ, Milroy EJG, Rickards D: A percutaneous perineal approach for cystoscopy in male dogs, *Res Vet Sci* 44:380-382, 1988.
8. McCarthy TC, McDermaid SL: Prepubic percutaneous cystoscopy in the dog and cat, *J Am Anim Hosp Assoc* 22:213-219, 1986.
9. Senior DF: Electrohydraulic shock-wave lithotripsy in experimental canine struvite bladder stone disease, *Vet Surg* 13:143-145, 1984.
10. Albata DM, Grasso M: *Color atlas of endourology,* Philadelphia, 1999, Lippincott-Raven.
11. Ballentine H, Carter MD: Instrumentation and endoscopy. In Walsh PC, Retik AB, Vaughan ED, Wein AJ, editors: *Campbell's urology,* ed 7, Philadelphia, 1998, WB Saunders.
12. Jenkins AD: Endourology. In Resnick MI, Older RA, editors: *Diagnosis of genitourinary disease,* ed 2, New York, 1997, Thieme.
13. Smith AD and others: *Smith's textbook of endourology,* St Louis, 1996, Quality Medical Publishing.
14. Sosa ER and others: *Textbook of endourology,* New York, 1996, WB Saunders.
15. Valli VE and others: Pathology of canine bladder and urethral cancer and correlation with tumor progression and survival, *J Comp Pathol* 113:113-130, 1995.
16. Barentsz J: Bladder cancer. In Pollack HM, McClennan BL, editors: *Clinical urology,* ed 2, Philadelphia, 2000, WB Saunders.
17. Jung I, Messing EM: Screening, early detection, and prevention of bladder cancer. In Vogelzang NJ, Scardino PT, Shipley WU, Coffey DS, editors: *Comprehensive textbook of*

*genitourinary oncology,* ed 2, Philadelphia, 2000, Lippincott Williams & Wilkins.
18. McCarthy TC: Cystoscopy for urinary tract assessment in dogs and cats with pelvic fractures. In *Proceedings of the Veterinary Orthopedic Society 21st Annual Conference*, Snowbird, Utah, February 26-March 5, 1994, p 29.
19. Selser BA: Urinary tract trauma associated with pelvic trauma, *J Am Anim Hosp Assoc* 18:785-793, 1982.
20. Phillips BS: Bladder tumors in dogs and cats, *Compend Cont Educ Pract Vet* 21:540-564, 1999.
21. Rocha TA and others: Prognostic factors in dogs with urinary bladder carcinoma, *J Vet Intern Med* 14:486-490, 2000.
22. Hawthorne JC and others: Recurrent urethral obstruction secondary to idiopathic renal hematuria in a puppy, *J Am Anim Hosp Assoc* 34:511-514, 1998.
23. Kaufman AC, Barsanti JA, Selcer BA: Benign essential hematuria in dogs, *Compend Contin Educ Pract Vet* 16: 1317, 1994.
24. Mishina M and others: Idiopathic renal hematuria in a dog; the usefulness of a method of partial occlusion of the renal artery, *J Vet Med Sci* 59:293-295, 1997.

## SUGGESTED READING

Cannizzo KL and others: Uroendoscopy, evaluation of the lower urinary tract, *Vet Clin North Am Small Anim Pract* 31:789-807, 2001.

Holt PE: *Color atlas of small animal urology,* London, 1994, Mosby-Wolfe.

Lulich JP and others: Canine lower urinary tract disorders. In Ettinger SJ, Feldman EC, editors: *Textbook of veterinary internal medicine,* ed 5, Philadelphia, 2000, WB Saunders.

Osborne CA and others: Feline lower urinary tract disease. In Ettinger SJ, Feldman EC, editors: *Textbook of veterinary internal medicine,* ed 5, Philadelphia, 2000, WB Saunders.

Park RD, Wrigley RH: The urinary bladder. In Thrall DE, editor: *Textbook of veterinary diagnostic radiology,* ed 4, Philadelphia, 2002, WB Saunders.

Pechman RD: The urethra. In Thrall DE, editor: *Textbook of veterinary diagnostic radiology,* ed 4, Philadelphia, 2002, WB Saunders.

Reuter HJ: *Atlas of urologic endoscopic surgery* (Translated by RJ Kohen and MA Reuter), Philadelphia, 1982, WB Saunders.

Senior DF: Cystoscopy. In Tams TR, editor: *Small animal endoscopy,* ed 2, St Louis, 1999, Mosby.

Willard MD: Urinary tract endoscopy. In Fossum TW, editor: *Small animal surgery*, ed 2, St Louis, 2002, Mosby.

# 5 Rhinoscopy: the Diagnostic Approach to Chronic Nasal Disease

*Timothy C. McCarthy*

Diagnosis of nasal problems is complicated by the similarity of signs and symptoms shown by most nasal diseases and by inaccessibility of the nasal cavity for direct examination. Rhinoscopy allows easy direct access to the nasal cavity and frontal sinuses for examination, for diagnostic sample collection, and, in some cases, for therapeutic procedures. Before successful application of rhinoscopy, full surgical exposure of the nasal cavity was required for anything but the most limited examinations. Morbidity and mortality associated with surgical exposure of the nasal cavity for diagnostic purposes is excessive. This is especially true when compared with rhinoscopy. Signs and symptoms of nasal disease include sneezing; mucoid, mucopurulent, bloody, or mixed nasal discharge; epistaxis; and nasal airway obstruction. These can be seen with a variety of nasal diseases but none are specific. Facial distortion or swelling is indicative of neoplasia and nasal pain suggests fungal infection, but neither can be relied on for a diagnosis. Adequate examination of the nasal cavity is therefore vital to establish a diagnosis.

Effective rhinoscopy is essential for assessment of the nasal cavity but cannot be relied on by itself to provide a diagnosis in all cases. A protocol has been developed that combines the necessary procedures to provide consistent success in establishing accurate diagnoses in cases of chronic nasal disease. History, physical examination, radiographs, culture and sensitivity, rhinoscopy, histopathology, fungal serology, allergy screening, and computed tomography (CT) scanning or magnetic resonance imaging (MRI) may all be necessary. The sequence of events in diagnostic evaluation of the nasal cavity is also important. Otherwise, essential diagnostic information can be altered or destroyed.

With a complete and sequential approach to chronic nasal disease, using rhinoscopy, a successful diagnosis has been achieved in more than 90% of cases without surgical exploration. This is similar to reported diagnostic success with rhinoscopy.[1-4] This high diagnostic yield can be primarily attributed to three things: using rhinoscopy as part of a complete diagnostic evaluation rather than as a technique by itself, using irrigation during rhinoscopy to enhance visualization, and using rigid telescopes rather than flexible endoscopes.

## INDICATIONS

A complete diagnostic approach to nasal disease is indicated when there is acute severe disease or when there is chronic or unresponsive disease. Persistent severe sneezing that has not responded to initial conservative treatment warrants diagnostic evaluation of the nasal cavity even when the condition is of short duration. Profuse epistaxis even if not life threatening is another acute condition in which a complete systematic approach to diagnosis is indicated, including evaluation of possible systemic etiologies. Acute conditions requiring complete nasal diagnostic evaluation are unusual. Reverse sneezing, commonly associated with nasopharyngeal disease, is also an indication for rhinoscopy. The most common indication for rhinoscopy is chronic unresolved disease that has not responded to treatment and when a diagnosis has not been established.

Common presenting complaints associated with nasal disease include sneezing, reverse sneezing, nasal discharge, epistaxis, difficult or noisy breathing, coughing, gagging or choking, rubbing or scratching at the nose or face, ulceration of the rhinarium, facial or nasal pain or sensitivity, facial swelling or distortion, nasal or oral odor, and knowledge of foreign body inhalation or ingestion (Box 5-1). Nasal disease may also be manifested systemically with nonspecific symptoms of malaise, lethargy, poor appetite, weight loss, and unkempt hair coat. Initial evaluation of patients with systemic symptoms is directed at differentiation of the primary disease process. Determining whether the nasal symptoms are an indication of primary nasal disease with secondary systemic involvement or whether the nasal signs are

**Box 5-1 Common Presenting Complaints Associated with Nasal Disease**

- Sneezing
- Nasal discharge
- Epistaxis
- Difficult or noisy breathing
- Coughing
- Gagging or choking
- Rubbing or scratching at the nose or face
- Ulceration of the rhinarium
- Facial or nasal pain or sensitivity
- Facial swelling or distortion
- Knowledge of foreign body inhalation or ingestion

**Box 5-2 Historical Information That Is Obtained for Nasal Disease**

- Duration of the problem
- Progression of disease
- The side or sides involved
- Whether the same side has been involved throughout the course of the disease
- The character of the discharge
- Whether it has been the same throughout the course of the problem and any changes that have taken place
- The occurrence and character of epistaxis
- The presence or absence of nasal pain
- Any scratching or rubbing at the nose or face
- Whether there has been any change in the shape or contour of the nose or face
- Dyspnea
- Increased breathing sounds
- The presence of any coughing, choking, or gagging

secondary is important to directing the course of the diagnostic evaluation. Information obtained during the evaluation may be required to make this differentiation.

Diagnostic approach to nasal disease can be divided into two segments, those studies and procedures that can be done in the awake patient and those requiring anesthesia. History, physical examination, and blood tests including blood chemistry profiles, complete blood count (CBC), coagulation assessment, thyroid function evaluation, allergy screening, and serologic testing for fungal infections are performed on the awake animal. Anesthesia is required for nasal and dental radiographs, nasal culture sample collection, nasal irrigation for cytology sample collection, rhinoscopy, surgical exploration, CT scanning, and MRI. Progression through the preanesthetic portion of this protocol may be required to determine whether the nasal signs are primary and whether completion of nasal workup is indicated.

A nasal disease specific history is outlined in Box 5-2. Physical examination is first directed at determining whether the nasal area is the site of the disease process. Attention is then directed at determining the extent, location, and character of the nasal disease. The character and side or sides of any nasal discharge is determined. Some dogs and cats lick discharge away from their nose so absence of discharge at the time of examination does not exclude nasal disease. Ulcerations on or around the external nares are significant and can be an extension from the primary disease or secondary to irritation and licking. Patency of the nasal passages is determined by evaluating the area of condensation on a microscope slide when held just in front of the nares, holding a tuft of hair or thread rostral to the external nares and observing movement with inhalation and exhalation, or by occluding one naris and observing for dyspnea or increased nasal airway sounds on auscultation. Facial or rostral nasal pain or sensitivity is evaluated. The entire nasal and facial area is carefully palpated and visualized for swellings, distortion, or soft areas resulting from bone lysis. The nasal cavity and pharyngeal area are auscultated and percussed for differences in density. Otoscopy is performed looking for possible masses, foreign bodies, or middle ear involvement. This is especially important in cats because of the incidence of nasopharyngeal polyps. Cats presenting with ear tumors are also candidates for nasal cavity assessment. Oral cavity examination is carefully performed and the upper dentition is inspected for diseased, damaged, or infected teeth or gums, masses or swellings, soft areas of bone lysis in the hard palate, and injuries. If oral examination cannot be completed successfully in the awake patient, sedation may be employed, or the examination may be completed after anesthesia is induced. The eyes are inspected for visual symmetry and function and are palpated for resistance to caudal displacement. Pharyngeal and prescapular lymph nodes are assessed. Examination of the patient to this point usually provides sufficient information to establish an ordered rule-out list of nasal diseases and systemic diseases if indicated, and to direct the course of further evaluation.

## INSTRUMENTATION

Rigid endoscopes used for rhinoscopy include a 1.9-mm diameter arthroscope (Karl Storz model #64301B) and a 2.7-mm diameter multipurpose rigid telescope (Karl Storz model #64018BS) (Fig. 5-1). Both telescopes have viewing angles of 30 degrees. The 1.9-mm diameter arthroscope has an overall length of 15.2 cm and a working length of 9.8 cm. The 2.7-mm diameter telescope has an overall

length of 23.3 cm and a working length of 19 cm. Arthroscopy and cystoscopy or operative cannulae can be used with each of these telescopes. The arthroscopy cannula (Karl Storz model #64128AR) for the 2.7-mm telescope has a 4-mm outer diameter, a working length of 14.3 cm, a single luer attachment with a stopcock for fluid irrigation, and locks to the telescope (Fig. 5-2). The cystoscopy or operating sheath (Karl Storz model #67065C) for this instrument has two luer irrigation ports with stopcocks, a 6-French biopsy channel, a working length of 16.5 cm, and an oval shape with dimensions of 4 mm × 5.5 mm (see Fig. 5-2). Dimensions for the 1.9-mm arthroscope cannulae are 3 mm diameter and 9.2 cm working length for the arthroscopy sheath (Karl Storz model #64302BN) and 3 mm × 3.7 mm diameter, with a 7-cm working length, and a 3-French biopsy channel for the cystoscopy sheath (Karl Storz model #61029D) (Fig. 5-3).

The size of these endoscopes and cannulae are well suited for rhinoscopy, allowing examination of the full range of small animal patients. The 2.7-mm multipurpose rigid telescope with its two cannulae can be used effectively for rhinoscopy in most cats and dogs. Very small dogs and small cats can be examined more easily with the 1.9-mm diameter arthroscope but its short length makes it inadequate for larger patients. For giant breeds of dogs, the length of the 2.7-mm instrumentation may be inadequate for complete examination of the nasal cavity and a cystoscope or other longer telescope may be required. A primary advantage of all of these instruments is the capacity for continuous high-flow irrigation during rhinoscopy to allow a clear view for examinations.

The primary advantages of arthroscopy cannulae over cannulae with biopsy channels are that they are smaller, they are round rather than oval, and they are easier to pass through the nasal cavity. The primary disadvantage

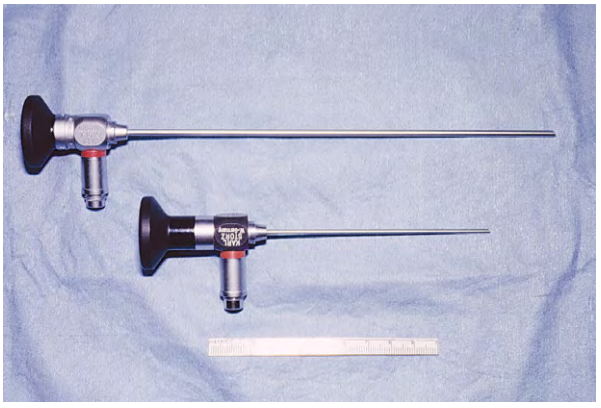


**Fig. 5-1**
Rigid telescopes used for rhinoscopy: 2.7-mm diameter multipurpose rigid telescope with 30-degree viewing angle and a working length of 19 cm and 1.9-mm diameter arthroscope with 30-degree viewing angle and a working length of 9.8 cm.

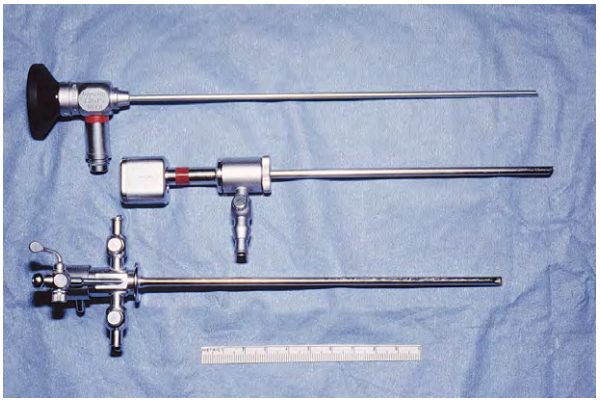


**Fig. 5-2**
The 2.7-mm multipurpose rigid telescope with cystoscopy and arthroscopy cannulae for use with this telescope. The cystoscopy sheath has a working length of 16.5 cm and oval cross-sectional dimensions of 4 mm × 5.5 mm (14 French). The biopsy channel accepts 5-French instrumentation. Dimensions of the arthroscopy cannula are a diameter of 4 mm with a working length of 14.3 cm. The arthroscopy cannula does not have a biopsy channel.

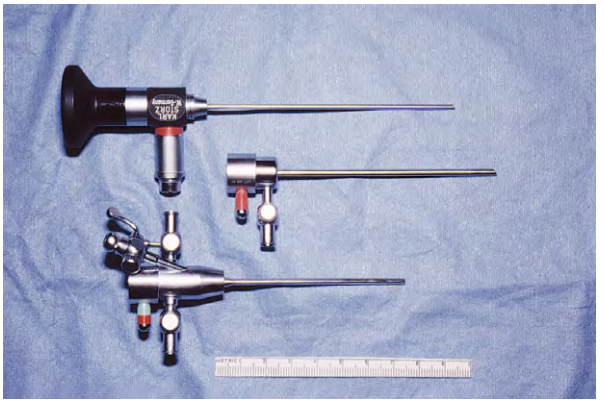


**Fig. 5-3**
The 1.9-mm arthroscope with cystoscopy and arthroscopy cannulae for use with this telescope. The cystoscope sheath has a working length of 7 cm, oval cross sectional dimensions of 3 mm × 3.7 mm (10 French), and it has a biopsy channel that will accept 3 French instrumentation. Dimensions of the arthroscopy cannula are a diameter of 3 mm with a working length of 9.2 cm. The arthroscopy cannula does not have a biopsy channel.

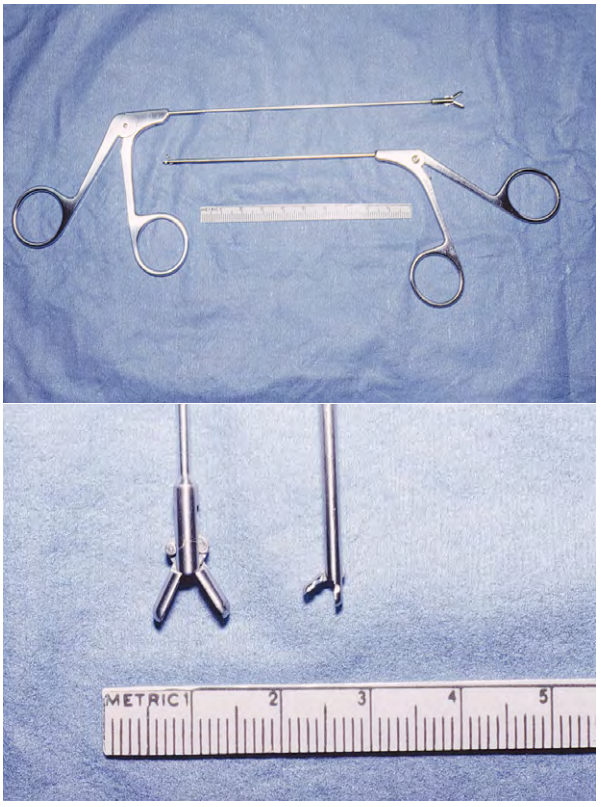



**Fig. 5–4**
A, Rigid biopsy forceps for use with the 2.7-mm and 1.9-mm telescope arthroscopy cannulae. The larger instrument is a 3-mm diameter apposing cup biopsy forceps with a working length of 14.5 cm and is used with the 2.7-mm system. The smaller instrument is used with the 1.9-mm telescope and has 2-mm diameter biopsy cups with a working length of 10 cm. B, Tips of the 3- and 2-mm rigid biopsy forceps showing the relative sizes of the biopsy cups.

of their use is that they do not have instrument or biopsy channels. Biopsy and other sample collection is performed by passing biopsy forceps or other instrumentation outside and parallel to the cannula. A variety of biopsy instrumentation has been employed for this technique, but the most frequently used and best suited instruments are a rigid 3-mm diameter apposing cup biopsy forceps (Karl Storz model #723033) with a 14.5 cm working length for the 2.7-mm system and a 2-mm diameter apposing cup biopsy forceps (Karl Storz model #64302L) with a 10-cm working length for the 1.9-mm system (Fig. 5-4).

Flexible biopsy forceps in 3-French (Karl Storz model #61071ZJ) and 5-French (Karl Storz model #67161Z) sizes are used with the cystoscopy cannulae (Fig. 5-5). Using cystoscopy cannulae with flexible biopsy forceps has the

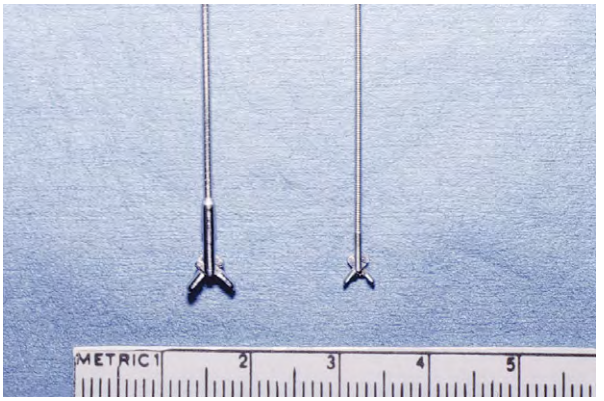



**Fig. 5–5**
Flexible biopsy forceps for use with the 2.7-mm and 1.9-mm telescope cystoscopy cannulae. The larger instrument is 5 French (1.6-mm diameter) and is used with the 2.7-mm telescope cannula. The smaller instrument is 3 French (1-mm diameter) and is used with the 1.9-mm telescope cannula.

advantage of facilitating placement of the biopsy forceps but has the disadvantages of obtaining much smaller biopsy samples than can be obtained with the rigid forceps, and the cannulae are larger making them more difficult to pass. Passing rigid biopsy forceps is a much more difficult technique to place but much larger tissue samples can be harvested.

Small, flexible fiberoptic endoscopes can also be applied to rhinoscopy. Bronchoscopes, pediatric bronchoscopes, flexible cystourethroscopes (Karl Storz model #60003VB) (Fig. 5-6), specifically designed flexible rhinolaryngoscopes, and other small flexible endoscopes in the 2.5- to 4-mm diameter range are applicable. These small, flexible instruments allow retrograde examination of the nasopharynx and caudal portions of the nasal cavity with advantages in this application over rigid instrumentation. Rigid instrumentation placed from the rostral approach can be effectively passed into the nasopharynx in most cases eliminating the need for flexible instrumentation. Flexible instruments may permit examination of the nasal cavity but they have limited or no ability for irrigation during examination, which impairs visibility and therefore effectiveness. Examination performed with rigid instruments is superior to that which can be performed with flexible endoscopes.

An extensive array of instrumentation is available for rhinoscopy, sinoscopy, pharyngoscopy, and laryngoscopy in humans but is not well suited for evaluation of small animals because of differences in size and anatomy. Most of the operative instruments are too large for application in small animal practice. Smaller rigid instruments are

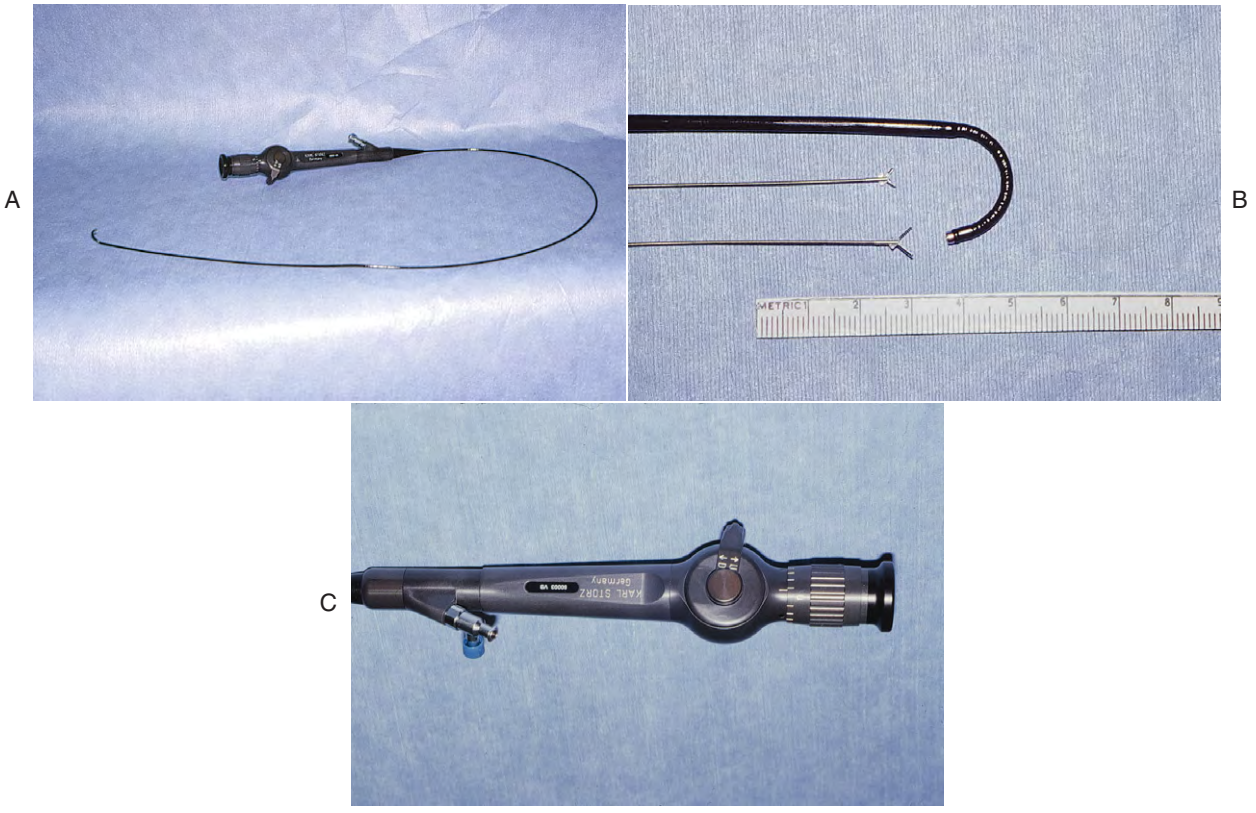



**Fig. 5-6**
A, Flexible veterinary specialty fiberscope applicable to small animal rhinoscopy with 2.5-mm/2.8-mm diameter (7.5 French/8.5 French), a working length of 100 cm, and a biopsy channel that accommodates 1 mm diameter (3 French) instrumentation, and two-way tip deflection control with a range of 170 degrees up and 90 degrees down. B, Tip of 2.5-mm/2.8-mm diameter flexible veterinary specialty fiberscope showing 170-degree deflection and instrumentation used with this endoscope. The distal controlled tip portion of the endoscope is 2.5 mm in diameter, and the major portion of the insertion tube is 2.8 mm in diameter. Instruments shown are 1-mm (3 French) biopsy forceps and graspers. C, Handpiece of the veterinary specialty fiberscope with the control lever for tip deflection control, operating channel access port, and focus ring.

applicable in size and design but are similar to the arthroscopes and do not provide any advantage over these instruments. The extent of irrigation necessary for rhinoscopy in animals is not used in humans, so the endoscopes are not designed with this need in mind; thus some may provide sufficient fluid flow and others would not. With the arthroscopes, continuous irrigation through the cannulae, which is essential for effective nasal examination, can be used during the entire procedure.

## PREPARATION OF THE PATIENT

A significant percentage of chronic nasal disease cases are in geriatric patients and an appropriate preanesthetic assessment is indicated, consisting of history, physical examination, blood chemistry profile, CBC, urinalysis, thoracic radiographs, and electrocardiogram (ECG). An additional segment of younger patients demonstrate signs of significant systemic disease, which may indicate similar preanesthetic evaluation. With completion of the general preanesthetic assessment of the patient and of that portion of the nasal specific diagnostic protocol not requiring anesthesia, the patient is anesthetized and the remainder of the nasal workup performed.

A surgical plane of general anesthesia is required for rhinoscopy. The nasal cavity is very sensitive and sedation or a light plane of anesthesia is inadequate to allow examination. If a surgical plane of anesthesia has not been achieved, violent sneezing can be induced during rhinoscopy, causing increased trauma to the patient's nasal cavity and possible damage to instrumentation. Proper patient positioning required for diagnostic nasal

radiographs cannot be achieved without anesthesia. Culture sample collection without risk of patient trauma and with minimal risk of sample contamination also requires general anesthesia. Some patients are higher anesthetic risks and care is taken, but with the currently available anesthetics and with adequate monitoring, the risk can be minimized. Stress to the patient is probably less with appropriate anesthesia than with sedation and physical restraint. Time savings and increased quality of diagnostic information is enhanced beyond the risk involved in most cases.

An anesthetic regimen used for rhinoscopy should be safe for the type of patient involved, should allow adequate depth and analgesia to prevent sneezing during rhinoscopy, should not require an excessive recovery period, and should not result in excitability during recovery. Patients are fasted for 12 hours before anesthetic induction and are preanesthetized with subcutaneous acepromazine and glycopyrrolate. If patient condition or concurrent disease contraindicates use of acepromazine, then diazepam or butorphanol are used. An indwelling intravenous catheter is placed. Anesthesia is induced with a short-acting intravenous anesthetic, a cuffed endotracheal tube is placed, and the cuff is inflated. A watertight tracheal seal is essential to prevent tracheal aspiration of fluid used for nasal irrigation during rhinoscopy. Isoflurane or sevoflurane are used for anesthetic maintenance. Appropriate monitoring (ECG, blood pressure, pulse oximeter, and capnometer) are initiated and intravenous fluids are administered.

## TECHNIQUE

An appropriate sequence of procedures is important to prevent distortion of information by previous diagnostic techniques. The oral cavity is examined carefully under anesthesia with particular attention being paid to the teeth, gums, hard and soft palates, caudal pharyngeal area, and to the nasopharynx. The soft palate is retracted rostrally with an ovariohysterectomy hook or other soft tissue retractor to allow evaluation of the caudal nasopharyngeal area. Radiography of the nasal cavity, frontal sinuses, and, if indicated, a dental series is the first diagnostic procedure. Bacterial and fungal cultures samples are then obtained. Rhinoscopy is performed last. If rhinoscopy is performed first, the irrigation used and bleeding that is induced alters the bacterial population in the nasal cavity and can change the radiographic appearance. Rhinoscopy introduces fluid density into the nasal cavity and onto the hair and skin outside the nasal cavity. Obtaining radiographs before rhinoscopy is also important to assess the location and extent of lesions for direction of the rhinoscopic examination to areas of interest. Collection of culture samples is done after radiographs are obtained because the sample collection technique can induce nasal bleeding that can alter radiographic appearance. Samples are collected during rhinoscopy for histopathology, cytology, and fungal culture if colonies are observed. If specific gross findings establish a diagnosis, or exclude any of the ruled out diagnoses, some of the samples can be discarded and tests eliminated without decreasing the potential for successful diagnosis. If there are no conclusive findings, all of the samples are submitted. This approach is more economical for the client and safer for the patient than reanesthetizing the patient to obtain additional samples.

### Radiographs

Radiographs are the initial diagnostic procedure performed after the patient is anesthetized. A series of four to six radiographic views are needed to adequately image the nasal cavity and frontal sinuses. Tabletop technique is used with high detail film and screens.

The first view is a straight lateral projection of the nasal cavity extending from the rostral tip of the nares to the caudal end of the soft palate, and from the frontal sinuses dorsally to and including the hard palate and teeth ventrally (Fig. 5-7). Accurate true lateral positioning can be consistently achieved by using the collimator light to align and superimpose the shadow of the upper (furthest away from the film) carnassial tooth over the lower (closest to the film) carnassial tooth (Fig. 5-8). The mouth is held open slightly during this procedure and the head is fixed in position with foam wedges or other positioning devices. The initial radiograph is obtained to give optimum exposure to the midnasal area for evaluation of the nasal turbinates. A second lateral film is obtained at a higher exposure to adequately image the nasopharynx because this area is underexposed on the initial film (Fig. 5-9).



**Fig. 5–7**
Lateral radiograph of a normal dog showing the area of the skull to be included on the initial view exposed for optimum detail of the nasal turbinates.

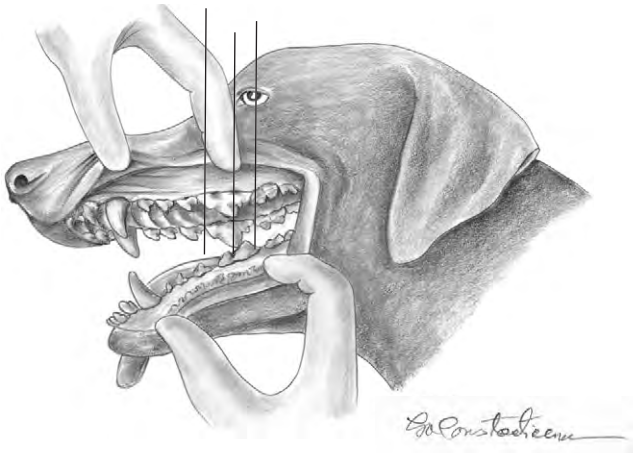


**Fig. 5-8**
Positioning for lateral radiographic projection of the nasal cavity showing the technique of dental shadow alignment for consistently accurate lateral positioning.

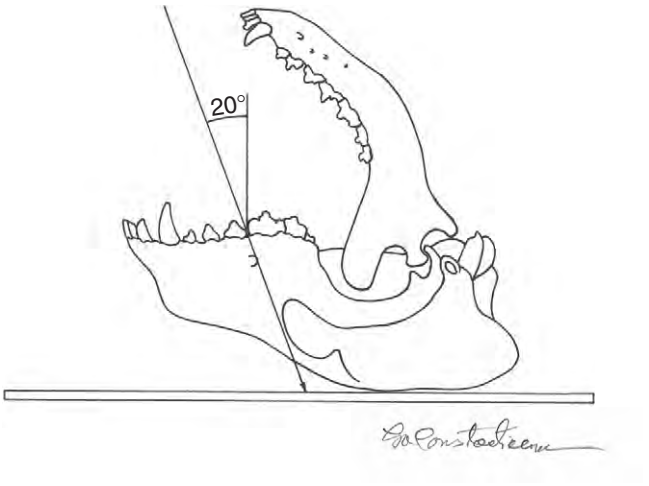



**Fig. 5-10**
Positioning for ventral 20-degree rostral dorsocaudal oblique open mouth projection of the nasal cavity. *(Redrawn from Ticer JW:* Radiographic technique in veterinary practice, *ed 2, Philadelphia, 1984, WB Saunders.)*



**Fig. 5-9**
Lateral radiograph of a normal dog showing the area of the skull to be included on the second lateral view exposed to image the nasopharyngeal area.




**Fig. 5-11**
Ventral 20-degree rostral dorsocaudal oblique open mouth projection of the nasal cavity in a normal dog showing the area of the nasal cavity that is imaged in this projection and the normal radiographic appearance of the nasal cavity.

A ventrodorsal film of the nasal cavity is best achieved using a ventrodorsal open mouth projection with the x-ray beam tilted 20 degrees toward the caudal end of the patient for dogs (Fig. 5-10) or 10 degrees for cats. To achieve this position, the patient is placed in dorsal recumbency. The rostral end of the upper jaw is fixed to the table with 1- or 2-inch wide adhesive tape stretched across the x-ray table and passing between the corner incisors and the canine teeth. A second tape is placed on the rostral end of the mandible. The endotracheal tube is disconnected from the anesthesia machine and the mandible is pulled caudally and ventrally until it is out of the path of the x-ray beam and the entire palate is lighted by the collimator light. The mandibular canine teeth can be used for alignment by positioning their shadows symmetrically on the soft palate. If the endotracheal tube is in the way of the x-ray beam, it can be folded caudally momentarily at the time of the exposure. This position moves the mandible completely out of the field and allows visualization of the entire nasal cavity extending caudally into the nasopharynx (Fig. 5-11).

In closed mouth ventrodorsal projections of the skull, more than half of the nasal cavity is obscured by the mandible.

Frontal sinus films are obtained using a rostrocaudal projection with the patient in dorsal recumbency and with the nose pointed up directly at the x-ray beam (Fig. 5-12). Slight dorsal angulation may be needed depending on individual anatomy of the patient. The mouth is held open by hand or with positioners, and the rostral end of the mandible is used to control head position. Accurate alignment can be aided by using the shadows of the upper canine teeth symmetrically on the palate or on the caudal pharyngeal area. Accurate positioning produces a skyline image of the frontal sinuses (Fig. 5-13).

Optional oblique films of the maxillary dentition are needed if dental disease is suspected as an etiology. In dolicephalic and mesocephalic breeds, positioning may be accomplished by allowing the ventral aspect of the head to roll toward the film until it reaches its natural position on the flat lateral surface of the face. The mouth is held open 4 to 6 cm, depending on the size of the patient, and the rostral end of the nose is held up so that the dorsal midline is parallel with the film. Bilaterally symmetrical oblique films can be obtained using this technique. Lateral oblique views of the frontal sinuses may also be required and can be imaged with this same positioning technique.

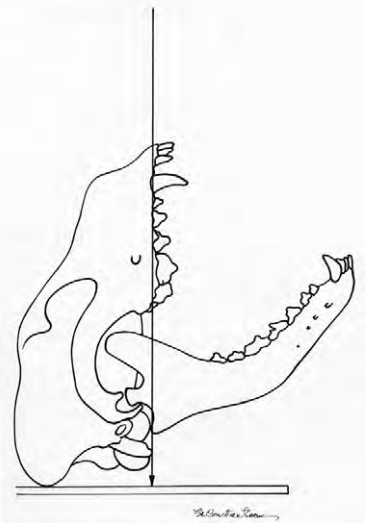


**Fig. 5-12**
Positioning for rostrocaudal projection of the skull for frontal sinus imaging. *(Redrawn from Ticer JW:* Radiographic technique in veterinary practice, *ed 2, Philadelphia, 1984, WB Saunders.)*



**Fig. 5-13**
Rostrocaudal projection of the skull demonstrating normal frontal sinuses.

## Culture Sample Collection

It is important to collect culture samples after radiographs have been obtained and before rhinoscopy is performed. Passage of a culture swab into the nasal cavity can induce bleeding that will change the appearance of radiographs. Culture samples are collected before rhinoscopy. Passage of the endoscope into the nasal cavity could potentially cause bacterial contamination. Reduction in bacterial population caused by copious saline irrigation used during rhinoscopic examination is a more likely consequence than the chances for bacterial contamination.

Two techniques can be used for nasal culture sample collection. Culture swabs can be passed through surgically prepared external nares or a catheter can be passed and a nasal wash performed. For the first technique, the external nares are surgically prepared with alternating povidone-iodine or Septisol and alcohol scrubs. A culture swab or microswab is passed through the nares into the nasal cavity as far as it can go easily or to the level of known pathology based on radiographic findings. The other technique uses a small-diameter (3 or 5 French) catheter, syringe, and sterile saline. The catheter is placed in the nasal cavity and the nasal cavity is irrigated with saline followed by aspiration. This technique is similar to that used for transtracheal wash sample collection. Part of this sample can be submitted for cytologic evaluation. Both techniques are acceptable and provide adequate samples for bacterial and fungal cultures.

The validity of nasal culturing has been debated due to the wide variety of normal bacterial flora[5] and the possibility of secondary bacterial growth unrelated to the

primary disease process. The validity of listed normal bacterial flora can be questioned because of the ability of dogs and cats to mask signs of nasal disease until an advanced stage is reached. Unless all the dogs and cats used for establishing what is considered normal received a complete diagnostic nasal evaluation, their "normal" status at the time of sample collection is subject to question.

## Rhinoscopy

After the aforementioned procedures have been completed, rhinoscopy is performed. The patient is placed in lateral recumbency with its head on an absorbent towel and the rostral end of the nose extending over the edge of the examination table. Either lateral recumbent position is acceptable, but if the condition being evaluated is unilateral, the diseased side is usually placed down. The chances for contamination of the normal side are minimal because of the copious quantities of irrigant used and easy access for drainage through the external nares and nasopharynx. Alternate positioning with the patient in ventral recumbency can be used depending on the preference of the examiner. A well-sealed tracheal airway is essential and an endotracheal tube with an inflated cuff must always be used. Effectiveness of the tracheal seal is always tested immediately before initiation of irrigation for rhinoscopy.

Table height is adjusted to allow the investigator to sit or stand comfortably during the examination. A waste container is placed under the table directly below the patient's nose to catch runoff irrigant. If the examiner is seated, the examiner's knees are covered with absorbent towels or waterproof drape material. Large quantities of irrigation solution are used (up to 4 L) during examination, and, if adequate preparation is not made, the examiner and surrounding area can become soaked.

Irrigation used for rhinoscopy uses the arthroscopy or cystoscopy cannulae with their luer connection ports, which are attached to a standard intravenous administration set, and liter containers of physiologic saline solution or Ringer's solution. The arthroscopy and cystoscopy cannulae are ideally suited for rhinoscopy because the design application for arthroscopy and cystoscopy requires similar fluid irrigation. Fluids containing dextrose are not recommended because cleanup after the procedure is difficult. The fluid container is placed as high above the patient as is convenient, usually about 70 cm, and the intravenous drip set control is opened fully. Fluid flow is then controlled with the endoscope cannula stopcock because it is more convenient for the operator.

With completion of the aforementioned preparation, rhinoscopy is begun. Fluid flow is initiated and the endoscope is passed into one of the external nares. If a bilateral disease process is present, the side examined first is not of importance. If unilateral disease is present, the normal side is usually evaluated first to minimize changes induced by fluid, exudate, and blood from examination of the abnormal side. Careful examination of a normal nasal cavity produces only limited bleeding and does not have a significant impact on the findings in the abnormal side. The order of examination is not critical and specifics of an individual case may indicate examination of the involved side first. If the patient is positioned in lateral recumbency with the normal side uppermost, the risk of contamination of the normal side to the extent that examination is affected is minimal.

A systematic approach to examination of the nasal cavity is taken to ensure visualization of all accessible areas. An attempt is not made to identify all normal anatomic structures and turbinates. Many of the disease processes produce distortion of the turbinates, and identification of normal structures is not possible. Depending on the size of the patient, a variable extent of the nasal cavity can be examined. In larger patients, a greater percentage of the nasal cavity is accessible for examination. The entire nasal cavity cannot be examined endoscopically with either rigid instrumentation or with currently available flexible endoscopes. A significant portion of the nasal cavity can, however, be examined even in small dogs and cats.

The size, shape, contour, and relative number of turbinates are evaluated. The presence of blood, blood clots, inflammation, foreign bodies, masses, fungal colonies, and exudate is assessed and the character of any exudate is evaluated. The area of nasal cavity involvement is determined, including whether the involvement is generalized or localized and whether there is unilateral or bilateral disease. If localized, the site and extent is defined. If there is unilateral involvement with neoplasia or with mycotic infection, the nasal septum is evaluated for penetration to the opposite side.

In the presence of copious exudate, extensive irrigation may be required before adequate examination can be carried out. Irrigation through the endoscope cannula is sufficient to clear the nasal cavity for examination in almost all cases. Additional irrigation or vigorous flushing with a syringe may occasionally be required when copious or thick exudate is present. If an examination is initiated and the nasal cavity cannot be cleared adequately, the endoscope is removed and a large quantity of saline is flushed through the nasal cavity. For small dogs and cats, a 12- to 20-ml syringe is used and for larger dogs a 60-ml catheter tip syringe is used. Three to five syringe-fulls of saline are flushed into each side of the nasal cavity. The endoscope is reintroduced and examination is again attempted. This procedure is repeated until the nasal cavities have been cleaned adequately for evaluation.

Bleeding does occur during rhinoscopy. With the irrigation technique described previously, the quantity of hemorrhage is rarely enough to interfere with examination. With high flow rate irrigation, the examination is done through the stream of clear irrigant and any blood is forced out of the field of view. Occasionally there is profuse bleeding after obtaining biopsy specimens that may make further examination or sample collection more difficult. For this reason, the entire examination is performed before biopsy samples are obtained. Increasing the rate of fluid flow by elevation of the fluid container or by placing the solution under pressure has occasionally been needed to complete sample collection. Bleeding induced by rhinoscopy has not produced sufficient blood loss to endanger any patients.

Biopsy samples are collected after a complete rhinoscopic examination has been performed on both sides of the nasal cavity. Arthroscopy cannulae do not have a biopsy channel, so biopsy forceps are passed into the nasal cavity beside and parallel to the endoscope. The endoscope and biopsy forceps are manipulated to place the desired lesions for biopsy and the cups of biopsy forceps within the field of view of the endoscope. This procedure works easily for most cases, allowing accurately placed sample collection. Rostral lesions and conditions with turbinate destruction that provide an open cavity for manipulation make this technique easier. Lesions located further caudally and smaller lesions are more difficult to biopsy. This technique is difficult and may be frustrating for the beginner, but with increased experience proficiency of sample collection increases. The cystoscopy sheath with its biopsy channel allows biopsy forceps to be passed directly to the lesion more easily. Both systems have advantages and disadvantages. The external parallel technique with the arthroscopy cannula allows larger biopsy samples to be obtained but is more difficult to perform. The internal biopsy channel technique using the cystoscopy sheath is easier to perform but restricts the size of the sample that can be collected.

Multiple biopsy samples are harvested to increase the quantity of tissue available for histopathology and to sample multiple tissue sites. For collection of multiple samples, the endoscope position can be maintained and the biopsy forceps removed and reinserted with each sample, or both the endoscope and biopsy forceps can be removed and reinserted together for each biopsy. The choice of technique may be dictated by the location or size of the lesion, by bleeding or exudate, or by patient size and conformation.

Tumors can be covered with organized hematomas and, if inadequately biopsied, accurate results will not be obtained. Sufficient tissue sample size, with adequate sample depth, from multiple sites is required to minimize diagnostic errors. In generalized inflammatory processes, many samples are obtained throughout the nasal cavity. The gross appearance of the mucosa may not be changed significantly to differentiate between normal and diseased tissue. Biopsy samples are obtained in all cases to define mild or moderate inflammatory processes. Any areas of inspissated exudate are sampled for histopathology along with any areas suspicious for fungal colonies.

If foreign bodies are found, they are removed with appropriate forceps. A pair of 6-inch alligator forceps works well in most cases. If the foreign material is small it can be removed rostrally through the external nares. Foreign bodies that are too large to remove rostrally must be pushed caudally through the nasopharynx for removal. Because there may be multiple foreign bodies, the entire nasal cavity is carefully assessed. Culture samples obtained before rhinoscopy are usually submitted when foreign bodies are found, but biopsy samples are generally not obtained. If there is doubt about concurrent disease, biopsy samples are submitted. An attempt is made during examination to therapeutically flush all of the exudate out of the nasal cavity.

As part of a complete examination of the nasal cavity, the nasopharynx and pharyngeal areas are examined. Complete filling of the nasopharynx with irrigation fluid may not occur, creating an air-liquid interface that interferes with visualization. When this occurs, irrigation is discontinued and examination is performed through air. Frequently, intermittent irrigation is used to clean the telescope lens and remove blood or exudate to maintain a clear visual field. In most medium- to large-sized dogs without large bilateral nasal masses, the rigid 2.7-mm diameter multipurpose rigid telescope can be passed through the nasal cavity and into the nasopharynx by rostral insertion through the external nares. In smaller dogs and in cats, the 2.7-mm instrumentation cannot always be manipulated through the nasal cavity into the nasopharynx and a 1.9-mm telescope is required. If a 1.9-mm endoscope is not available for these smaller cases, other options for examination can be used. Nasopharyngeal examination can be performed with a small flexible endoscope passed through the mouth and flexed around the caudal margin of the soft palate. The caudal portion of the nasopharyngeal area can be examined through the open mouth by retracting the soft palate rostrally using a nerve or tissue retractor (spay hook). This technique allows adequate assessment of the area in some cases. If exudate is present, irrigation is used for removal to allow examination. The endoscope can be used for irrigation and to assist visualization beyond what can be seen by direct examination. Another technique for nasopharyngeal examination uses percutaneous puncture in the area used for pharyngostomy tube placement. This allows direct access to and complete examination of the nasopharynx and caudal nasal cavity.

With availability of both 1.9-mm and 2.7-mm instrumentation, these techniques have been infrequently required and are inferior to passage of rigid instrumentation from the rostral approach into the nasopharynx.

When rhinoscopy has been completed, the pharyngeal area is cleaned to remove fluid, debris, and blood clots. The external nares and pharyngeal area are monitored for excessive bleeding. Patient recovery is allowed to be slow and quiet with minimal stimulus. Sedatives are used as needed. Narcotic induction agents, if used, are not reversed unless systemic complications warrant a more rapid recovery regimen. Intravenous fluids are administered during anesthesia and recovery.

It is strongly recommended that these patients be hospitalized for the night after the procedure even if they are adequately recovered from anesthesia for release. The stimulus and excitation produced by reunion with their owner and release from the hospital can frequently induce epistaxis when they are sent home on the same day as the procedure. Postrhinoscopy epistaxis has not been sufficient to be a risk for the patient, but epistaxis combined with sneezing and excitement can cause considerable anxiety for the owner. If patients are allowed to rest quietly overnight after rhinoscopy, epistaxis is minimal.

Nasal biopsy sample collection can also be achieved by multiple other routes and techniques. These techniques are unpredictable in their results and have an unacceptably low yield of diagnostic material. Cytologic samples can be obtained by irrigation of the nasal cavity and collection of the effluent. Solid tissue samples from tumors or fragments of fungal colonies can sometimes be dislodged by forceful irrigation of the nasal cavity. Needle aspiration and needle biopsy procedures may be effective for sample collection from tumors that have penetrated bone and can be palpated through the skin or hard palate. Rostral or caudal approaches to the nasal cavity for needle aspiration or needle biopsy require blind placement with no control of the location of sample collection. Blind catheter biopsy collection using a stiff polypropylene catheter cut to produce a sharp cutting edge and passed into the external nares with multiple jabbing motions to cut cores out of tumors has the same disadvantages as the needle aspirate and needle biopsy techniques. With generalized inflammatory processes or with extensive tumors or fungal colonies, this approach may produce diagnostic samples. Small tumors or fungal colonies can be missed and inflammatory histopathology findings cannot be differentiated between an accurate diagnosis and a missed lesion. Adequate samples may be obtained from large lesions but smaller ones may be missed. Foreign bodies, dental disease, and other conditions may also be missed.

Rhinoscopy, on the other hand, allows direct visualization of the nasal cavity and provides for gross diagnosis and selection of appropriate sample sites before sample collection. Biopsy forceps can be accurately placed with direct visualization to obtain samples of representative tissues greatly enhancing accuracy of histopathologic results. Multiple samples can be obtained from the same biopsy site or multiple biopsy sites can be selected. Fungal colonies can be biopsied to assist in identification of fungal species both by histopathology and culture. Fungal cultures grown from biopsy samples of fungal colonies obtained by rhinoscopy produce a high rate of successful growth on laboratory media when compared with samples obtained by irrigation and by culture swab collection from the nasal cavity. Ability to see lesions for biopsy with rhinoscopy and its low morbidity and mortality make rhinoscopy the procedure of choice for nasal biopsy sample collection.

Surgical exploration of the nasal cavity may also be used for biopsy sample collection. Direct visualization is achieved with open surgical exploration of the nasal cavity, allowing gross diagnosis before sample collection and accurate sample site selection, but its morbidity far exceeds that of rhinoscopy. Exploratory rhinotomy is not recommended unless all other approaches have failed to produce a diagnosis. Since rhinoscopy was added to the diagnostic protocol for chronic nasal disease, surgical exploration has only been performed once in more than 400 cases spanning an 18-year period, and in that case surgery did not provide any additional information beyond what was obtained with rhinoscopy.

## Frontal Sinoscopy

The frontal sinuses can be examined endoscopically directly through the nasal cavity with the rostral approach in some cats and dogs. Loss of turbinates from the disease process facilitates access to the frontal sinuses from the nasal cavity. Most cases require access percutaneously by trephining a 3- to 5-mm diameter hole in the dorsal free wall of the involved frontal sinus. Evaluation can be performed dry, through air, or with fluid irrigation. If significant pathology is present, fluid irrigation must be used for adequate visualization. When irrigation is used, the diameter of the trephine hole is made large enough to allow free flow of irrigant out around the endoscope cannula. The normal nasosinus communication may be occluded when significant pathology is present, so the only place for fluid egress is around the endoscope. If biopsies are done, the trephine hole is made large enough to allow passage of biopsy instrumentation beside the endoscope. If there is generalized pathology, in which the location of the sample is not critical, a smaller hole can be used and samples can be obtained blindly without endoscopic visualization. Therapeutic debridement of some frontal sinus pathology, such as fungal colonies or bone sequestra, can be accomplished through this approach.

## NORMAL NASAL CAVITY AND FRONTAL SINUSES

The normal nasal cavity is free of exudate or blood and may contain small quantities of free mucus, which is not sufficient to occlude any of the airways or interfere with visualization. Normal turbinates are smooth and evenly spaced, and their contours are gently curving (Fig. 5-14). Turbinate branching is commonly visible (Fig. 5-15). The ethmoid turbinates have a characteristic crumpled appearance but their placement is organized with even turbinate thickness and spacing (Fig. 5-16). Normal turbinates almost completely fill the nasal cavity with very little space between them. Airways between the turbinates are narrow but are well defined and unobstructed (Fig. 5-17), and they can be followed caudally with the endoscope

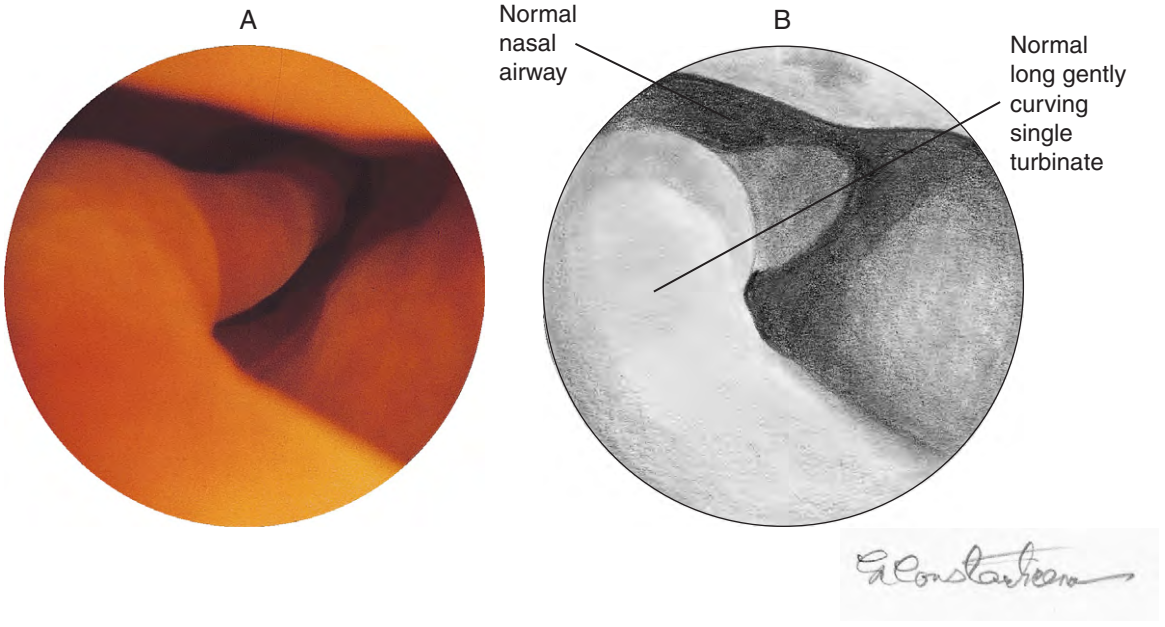



**Fig. 5-14**
Normal nasal turbinates demonstrating smooth pink mucosa, turbinate structure, and absence of exudate. *(All rhinoscopic photographs hereafter taken through saline with a 2.7-mm telescope unless otherwise indicated.)* A long gently curving single turbinate is shown here.

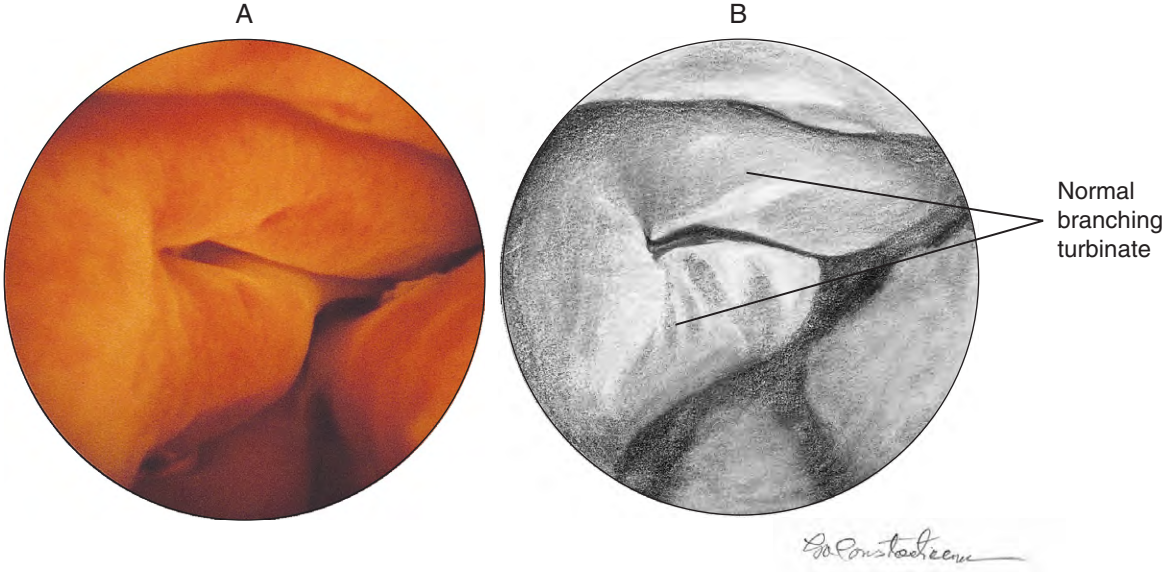



**Fig. 5-15**
Branching of turbinates, as seen in this figure, is common.

without interference, except in smaller patients. The nasal septum is mostly smooth and flat (Fig. 5-18), except for a normally roughened area caudally (Fig. 5-19), and it is complete with a concave caudal margin (Fig. 5-20). The ventral and middle meatuses are followed most easily, particularly through their medial portions. The nasopharynx is most easily entered ventromedially and appears as a cylindrical smooth cavity that is slightly flattened dorsally and ventrally (Fig. 5-21). Openings of the eustachian tubes can be seen as longitudinal slits on the lateral walls of the nasopharynx (Fig. 5-22). Openings of the nasolacrimal ducts can be found in the rostral nasal cavity (Fig. 5-23).

The nasal mucosa is smooth and has a variable pink to red coloration. When examined through air, the mucosa is a bright pink to red color; when examined through irrigant, the mucosa is a paler color, ranging from medium to pale pink. The difference can be appreciated by initiating examination without irrigation and then starting

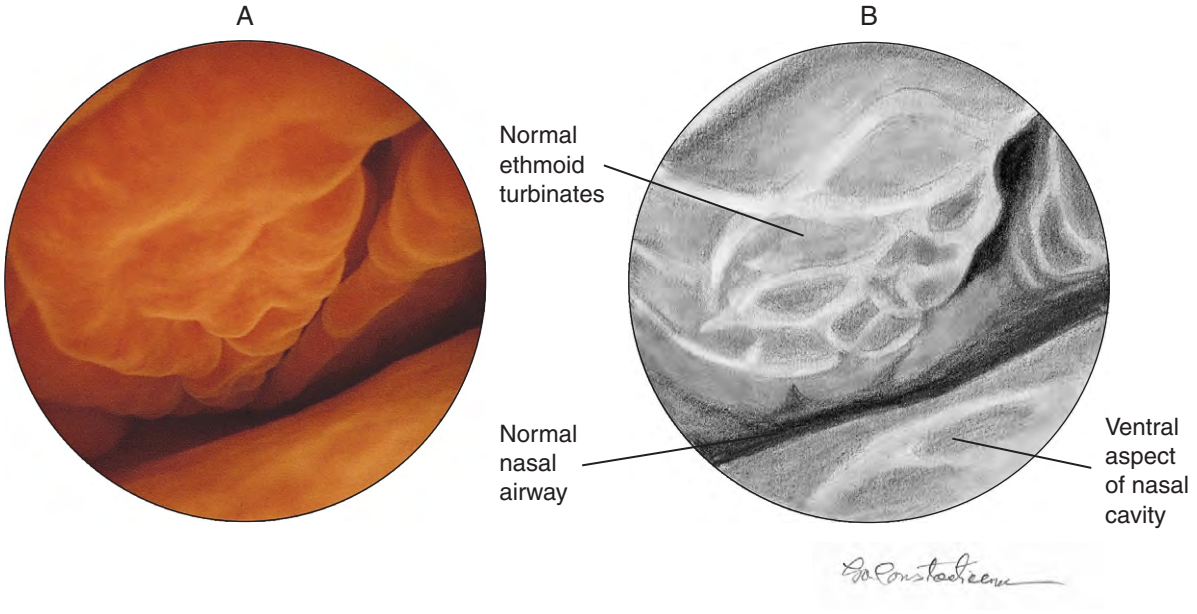



**Fig. 5-16**
Normal ethmoid turbinates with their characteristic crumpled appearance.

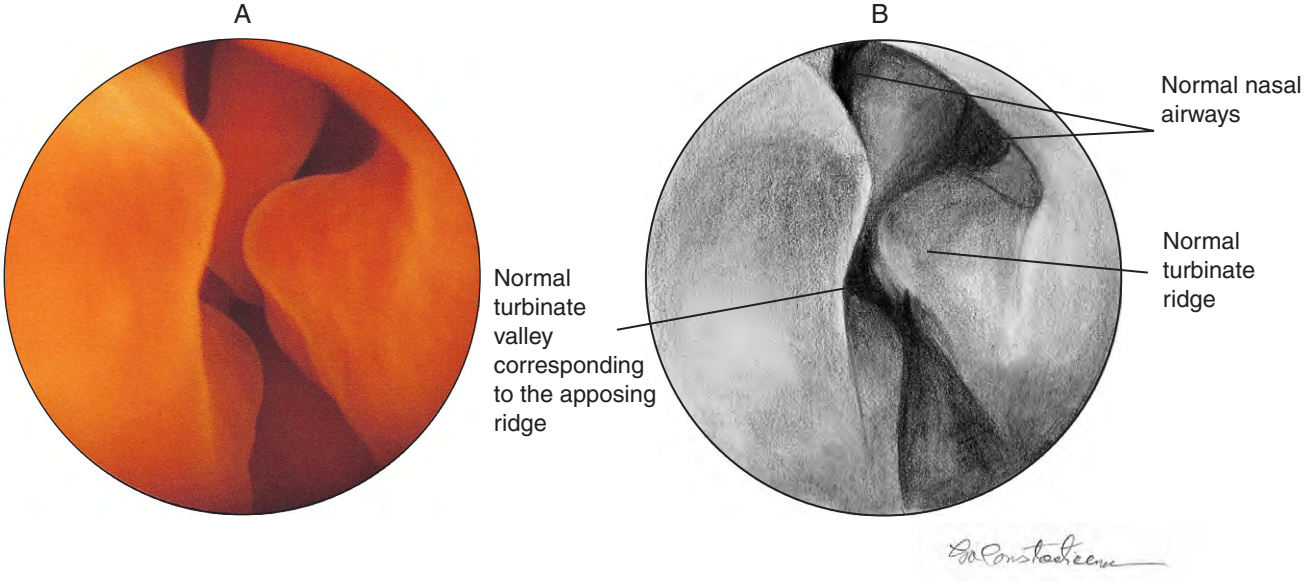



**Fig. 5-17**
Normal airways between the turbinates are narrow but are well defined and unobstructed. Turbinate ridges and valleys are matched with congruency and have the appearance of fitting together.

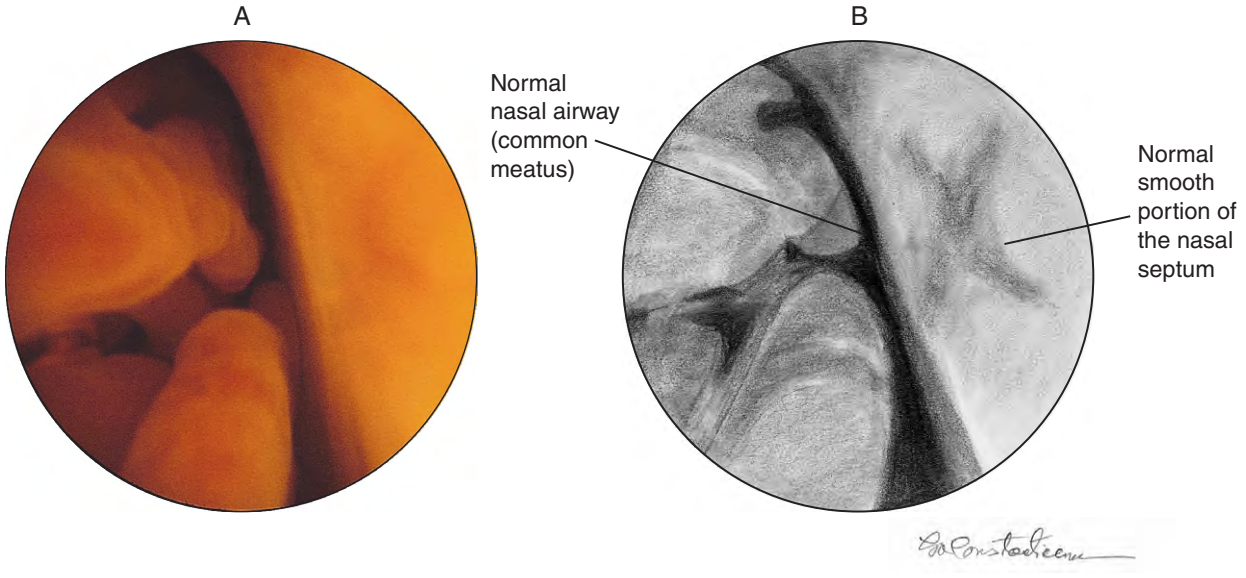



**Fig. 5–18**
Normal smooth flat portion of the nasal septum.

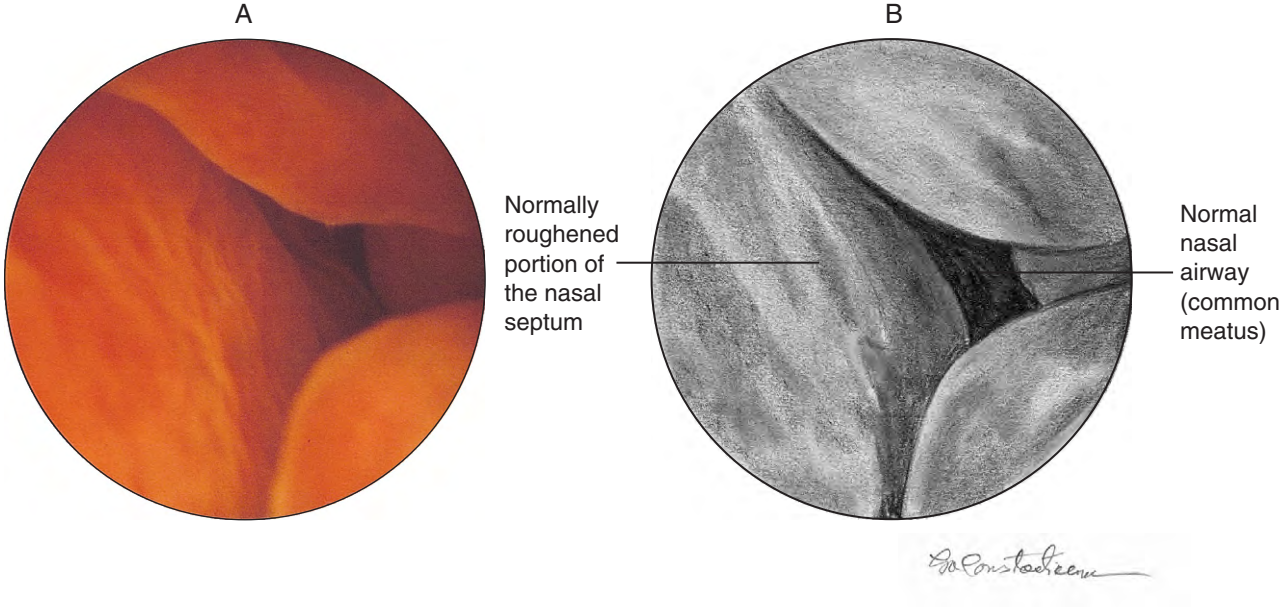



**Fig. 5–19**
Normally roughened area of the caudal portion of the nasal septum.

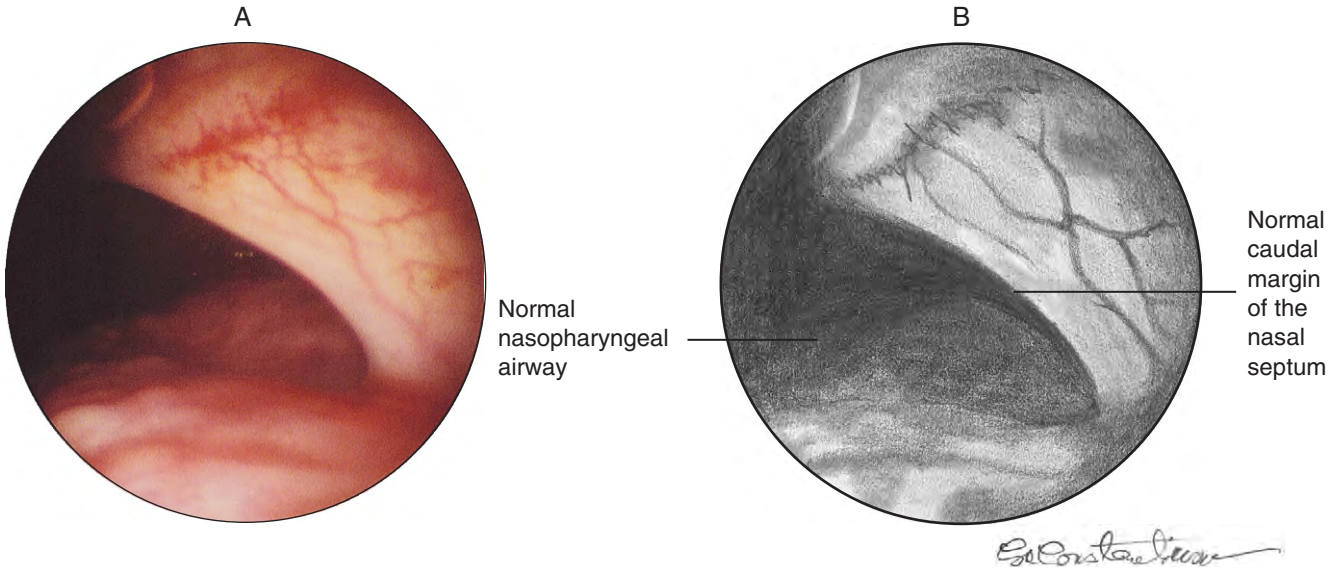



**Fig. 5-20**
Normal concave caudal margin of the nasal septum.

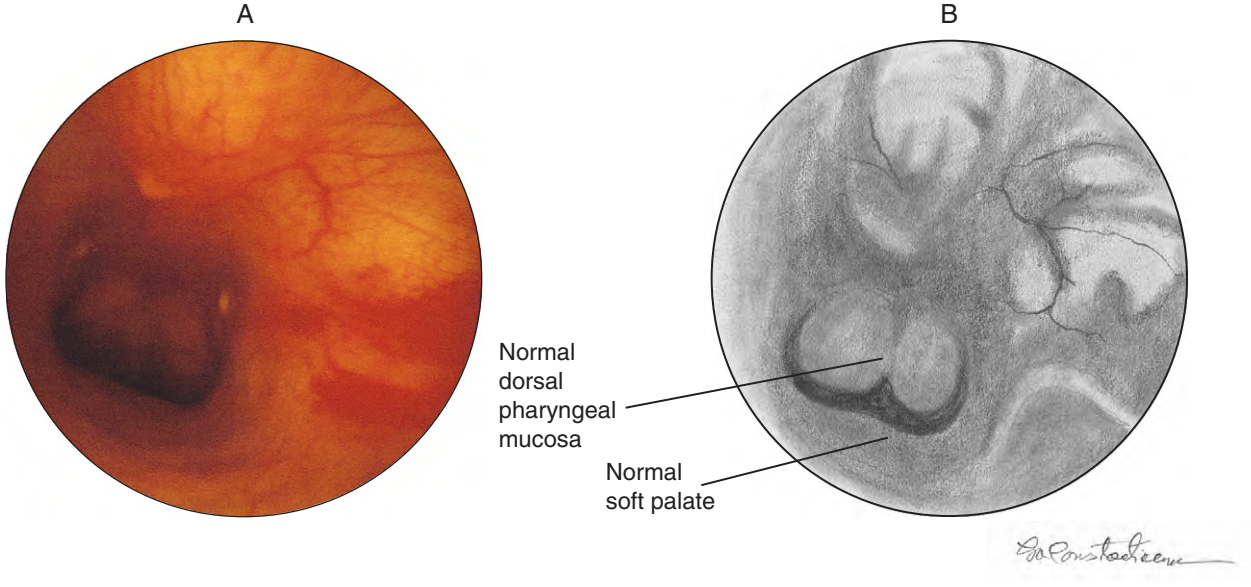



**Fig. 5-21**
Normal nasopharynx seen through air.

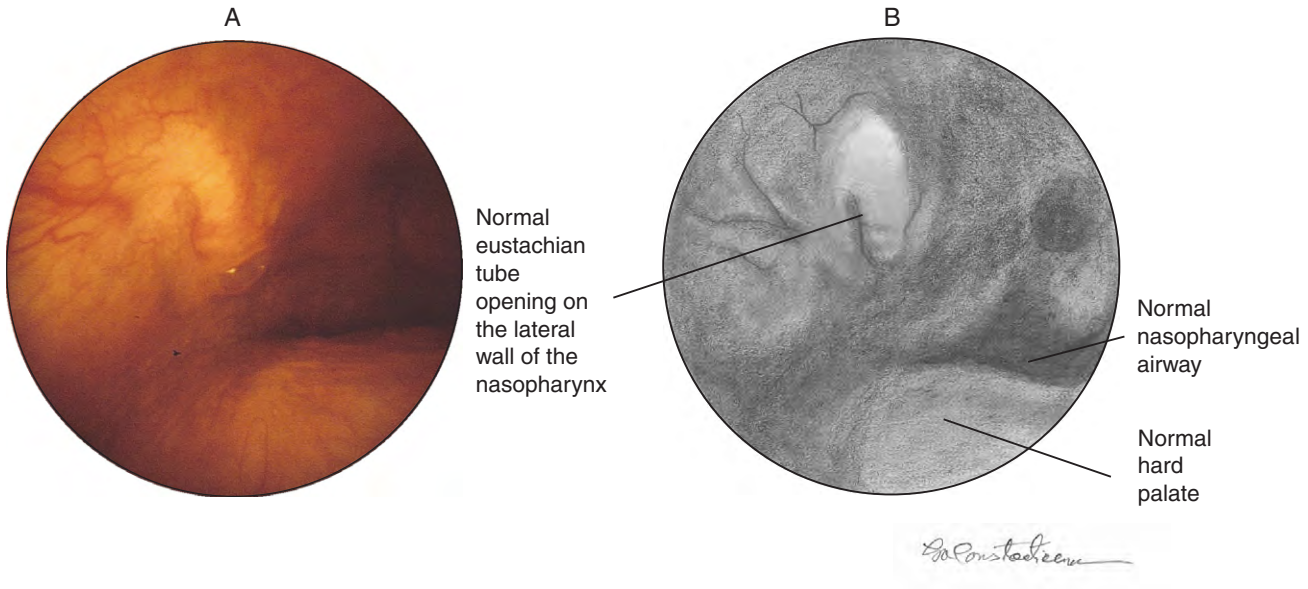



**Fig. 5-22**
Normal openings of the eustachian tubes on the lateral wall of the nasopharynx seen through air.

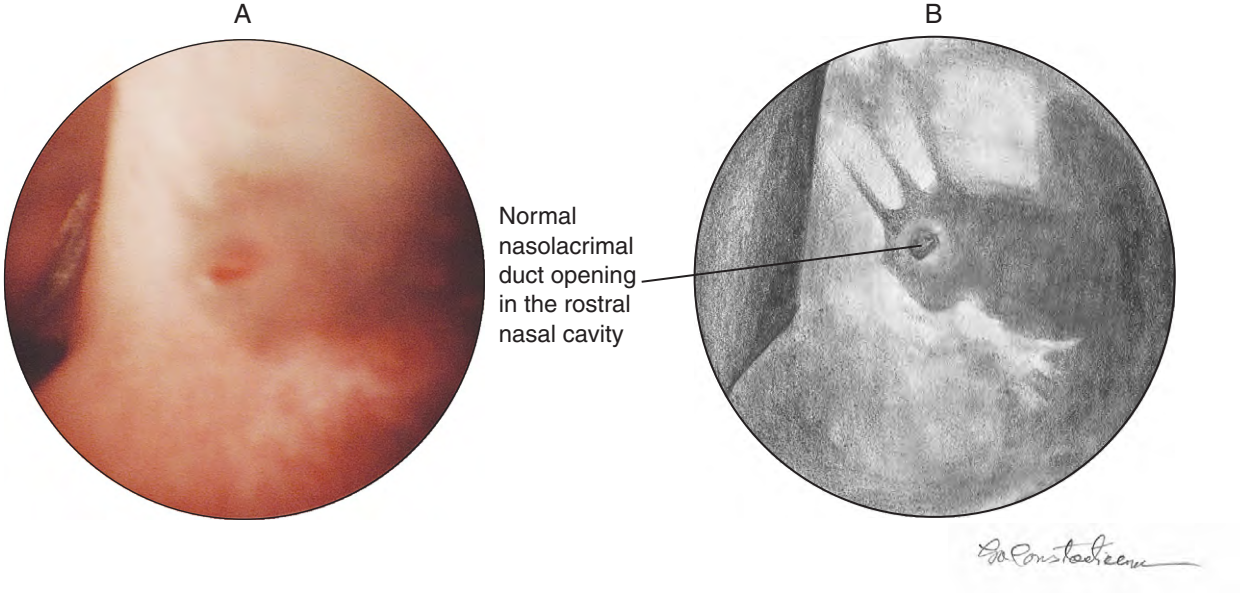



**Fig. 5-23**
Normal nasolacrimal duct opening in the rostral nasal cavity.

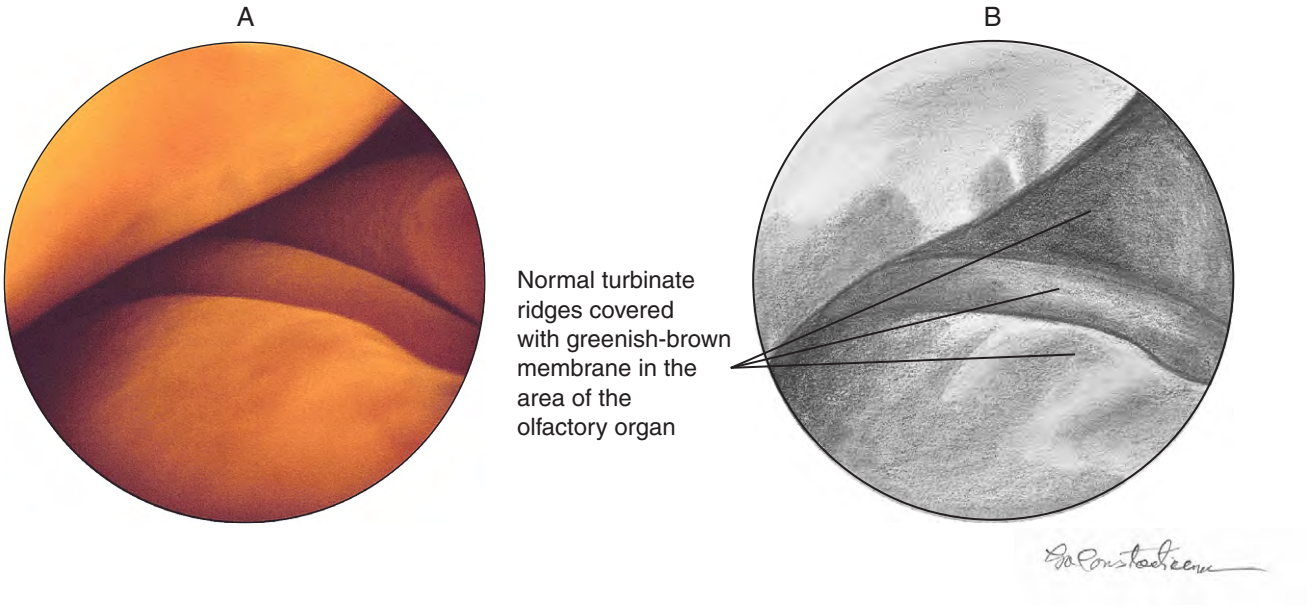



**Fig. 5-24**
Normal greenish-brown membrane in the area of the olfactory organ.

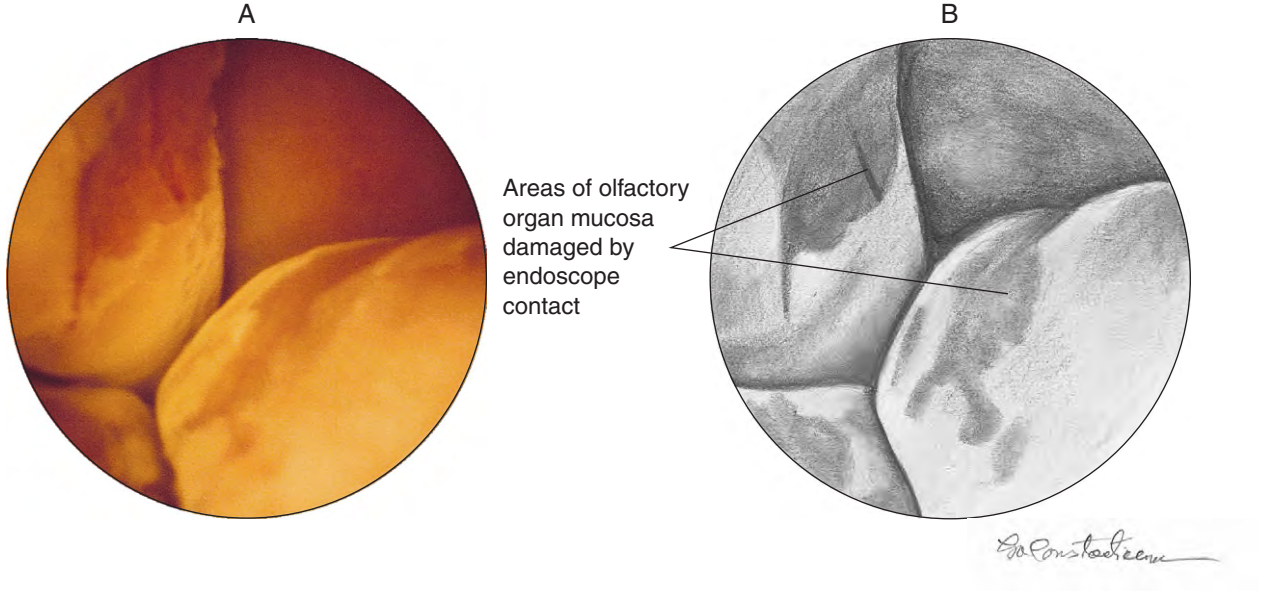



**Fig. 5-25**
An area of the normal olfactory organ membrane that was disturbed with the endoscope during examination.

fluid flow while visualizing the mucosa. An immediate color change can be observed and is believed to be due to vasoconstriction with exposure to cold irrigation solution. Character of the mucosa is uniform throughout most of the nasal cavity with consistent color and texture. There are two areas of particular exception. One is dorsally and laterally where the mucosa is covered with a greenish-brown membrane (Fig. 5-24). This membrane is in the area of the olfactory organ (where nerve endings are for the sense of smell) and is smooth and uniform in thickness, and follows the surface of the mucosa accurately. The membrane can be disturbed easily with the endoscope without damaging the underlying mucosa (Fig. 5-25). The other area of exception is caudally and medially on the nasal septum where there is a natural area of roughening (see Fig. 5-19).

Blood vessels can be seen in some areas of the mucosa in various sizes and configurations. The vessels are arranged in random configuration and appropriate branching that would be expected in a vascular tree. Vascular

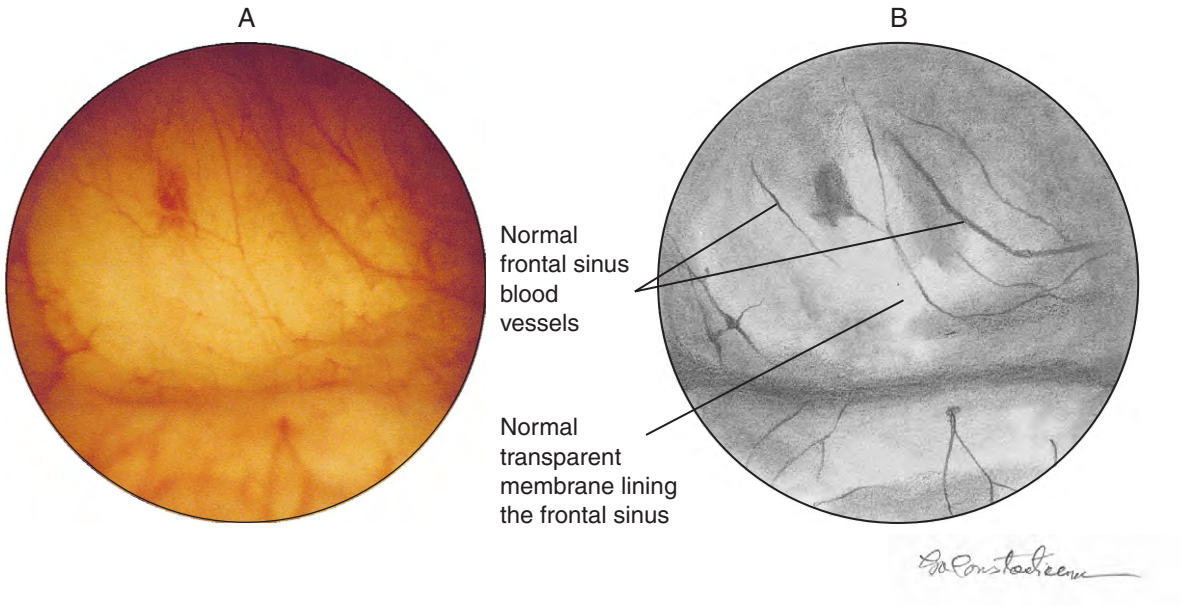



**Fig. 5-26**
Normal air-filled frontal sinus cavity with a thin transparent lining membrane and no fluid, exudate, tissue, or debris.

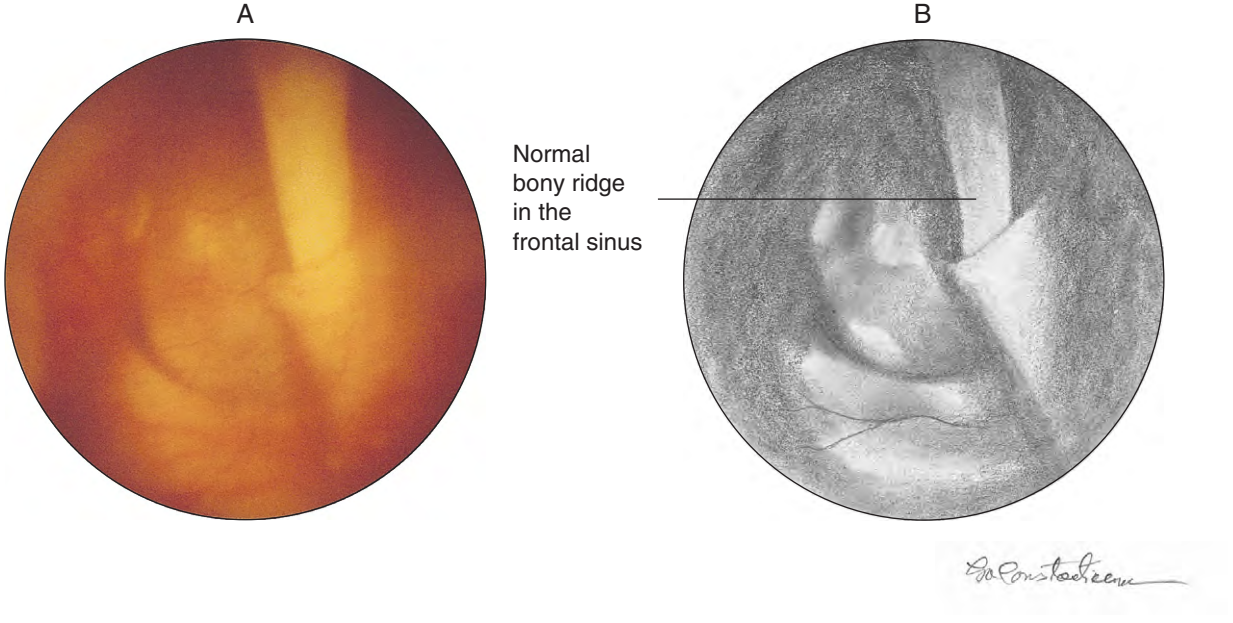



**Fig. 5-27**
Normal bony ridge extending into the frontal sinus.

tortuosity is not normally expected and clusters of irregularly arranged blood vessels are not normally seen.

The nasal mucosa is delicate and is susceptible to trauma with the endoscope. Bleeding is normally induced by rhinoscopy but is usually not sufficient to obliterate visualization when irrigation is used. Biopsy specimens obtained from normal mucosa produce a moderate quantity of bleeding that again is not generally enough to interfere with examination. The bleeding produced by examination and biopsy of the normal nasal cavity usually stops when the examination is finished and does not present a problem during or after recovery.

The normal frontal sinus is air filled and contains no fluid, exudate, tissue, or debris. The cavity is lined with a thin transparent membrane and a fine network of clearly visible blood vessels (Fig. 5-26). There are multiple bony ridges extending into the sinus cavity (Fig. 5-27). The transition to nasal turbinate mucosa can be seen in

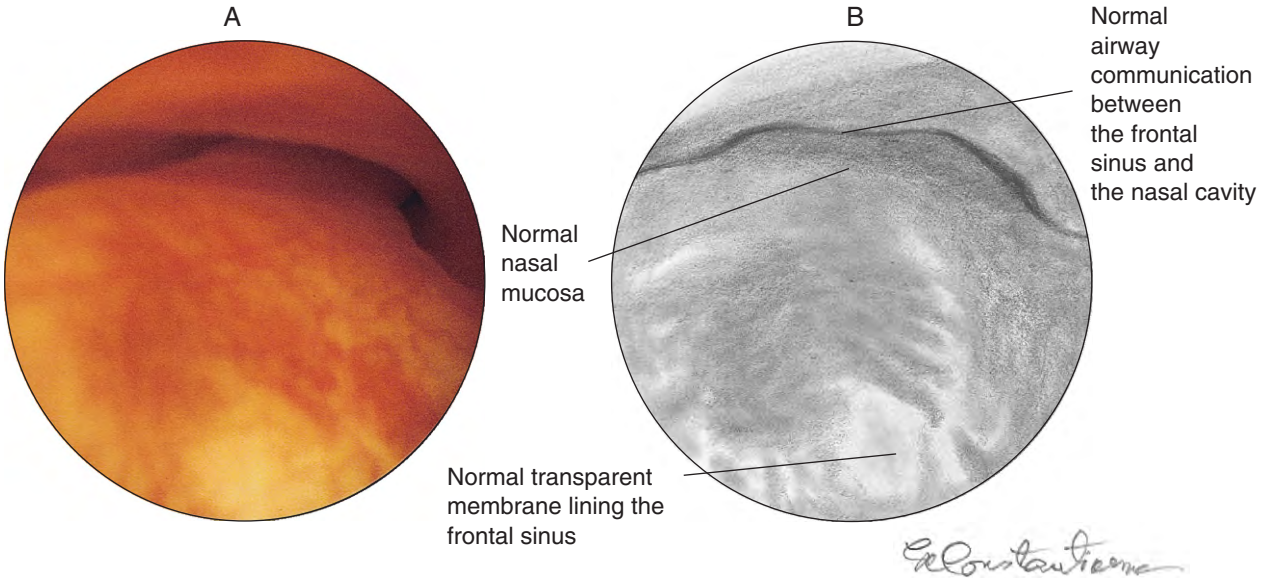



**Fig. 5-28**
Normal transition from the thin transparent frontal sinus lining membrane to normal nasal mucosa in the rostral portion of the frontal sinus.

the rostral portion of the sinus (Fig. 5-28) and in some larger dogs the endoscope can be passed into the nasal cavity.

## NASAL PATHOLOGY

The primary abnormalities found in the nasal cavity include neoplasia, mycotic rhinitis and sinusitis, foreign bodies, rhinitis secondary to dental disease, bacterial rhinitis and sinusitis, allergic rhinitis, parasitic rhinitis, rhinitis and nasopharyngitis secondary to otitis, and idiopathic rhinitis or rhinitis of undetermined origin. Systemic conditions that can be manifested as nasal signs include viral infections, coagulopathies, hypertension, erlichia, idiopathic vasculitis, and other nonspecific generalized systemic debilitating illnesses.

### Neoplasia

Most nasal masses are found easily with rhinoscopy. By the time signs of nasal disease become apparent, tumors are commonly well established and are of significant size. A large number of different tumor types occur in the nasal cavity and can originate from any tissue type found in the nasal cavity or can metastasize to the nasal cavity from other areas of the body. Nineteen different histologically defined nasal tumor types were diagnosed using rhinoscopy for gross tumor identification and biopsy collection in a series of 100 consecutive cases (Box 5-3). These have included 11 different kinds of sarcomas, five different types of carcinomas, and three varieties of benign tumors. The location of tumors is highly variable, as is their color, shape, contour, and consistency. There is very poor correlation between gross appearance and tumor type, with a few exceptions. Most tumors are surrounded by mucoid or mucopurulent exudate that is relatively easy to remove with endoscopic irrigation. Some tumors are surrounded by active bleeding or blood clots from previous bleeding episodes. The amount of organization of resulting blood clots affects their appearance and ranges from being freshly formed bright red obvious blood clots to being chronic, well-organized tissue-like structures that cannot be grossly differentiated from tumor tissue (Fig. 5-29).

Tumor surface appearance is highly variable in color, contour, texture, and vascularity. Tumors can be smooth, avascular, and either cystic (Figs. 5-30 and 5-31) or solid (Figs. 5-32 and 5-33); smooth and cystic with obvious enlarged blood vessels (Fig. 5-34); smooth solid vascular masses (Fig. 5-35); or combinations of these (Fig. 5-36). Tumors can also be lobulated (Fig. 5-37), roughened (Fig. 5-38), ragged (Fig. 5-39), webs with turbinate destruction (Fig. 5-40), irregular (Fig. 5-41), or fimbriated (Figs. 5-42 and 5-43). Tumor surface color can be white (Figs. 5-32, 5-33 and 5-37), pink (Figs. 5-42, 5-43, and 5-44), red (see Fig. 5-39), purple (Fig. 5-45), brown (Fig. 5-46), and greenish grey (Fig. 5-47). Tumors may display combinations of these descriptions (Figs. 5-45 and 5-48) and different areas of the same tumor may have different surface appearances and colors (see Figs. 5-38,

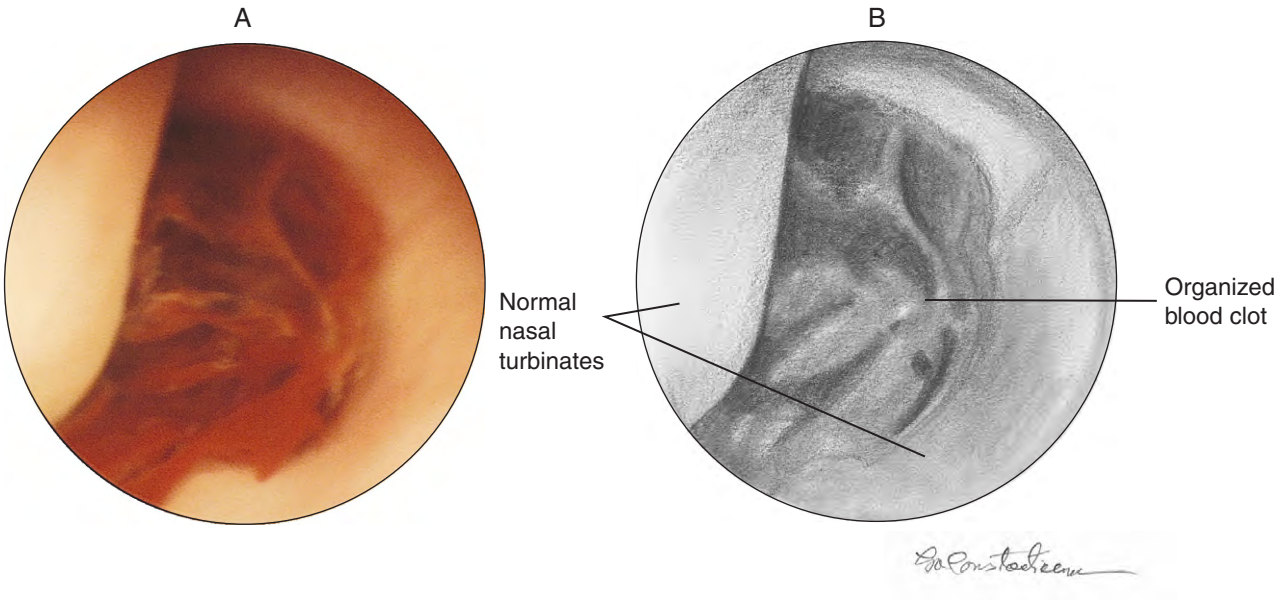



**Fig. 5-29**
An organized blood clot with the appearance of tissue seen in the nasal cavity of a dog with a nasal osteosarcoma.

**Box 5-3** **Tumor Types Diagnosed in the Nasal Cavity Using Rhinoscopy in 100 Consecutive Cases Seen from 7/14/82 to 10/29/96**

**Carcinoma**
- Respiratory carcinoma
- Adenocarcinoma
- Undifferentiated carcinoma
- Squamous cell carcinoma
- Epidermoid nasal carcinoma

**Sarcoma**
- Lymphosarcoma
- Chondrosarcoma
- Fibrosarcoma
- Undifferentiated sarcoma
- Melanoma
- Osteosarcoma
- Neurofibrosarcoma
- Mast cell tumor
- Malignant schwannoma
- Histiocytic sarcoma
- Rhabdomyosarcoma

**Other**
- Inflammatory polyp
- Chondroma
- Adenoma

5-45, and 5-48). Areas of dark purple irregular tumor surface that may be streaked with white (see Fig. 5-29) may be organized blood clots and caution is used in biopsying these areas to avoid inaccurate diagnostic information.

The internal tissue of malignant tumors commonly has a uniform appearance when the tumor is broken open during rhinoscopy. Broken tissue surfaces are generally friable, resemble the coloration of the outer surface, and have a fibrous appearance as visualized under endoscopic magnification. Internal blood vessels can range from few to highly vascular. This appearance is lost in areas of tumor necrosis and in fimbriated or cystic areas of tumors. Infrequent benign tumors tend to have a more dense, less friable tissue but this is not consistent.

Nasopharyngeal polyps in cats are characteristically pink with a roughened, lobulated, or fimbriated surface and variable vascularity (Fig. 5-49). They may also be dark purple or greenish purple with mottled areas of white to pink (Fig. 5-50). Combinations of the two appearances may also be seen in one polyp (Fig. 5-51). They have variable friability with internal tissue color resembling outer surface coloration. Nasopharyngeal polyps in cats are generally unilateral in their origin but frequently produce bilateral signs by producing partial or complete nasopharyngeal airway obstruction (see Fig. 5-49). Using rhinoscopy, the stalk of feline nasopharyngeal polyps can sometimes be visualized as it exits from the eustachian tube (Fig. 5-52). Nasopharyngeal polyps can frequently be visualized, biopsied, or removed by rostral retraction of the soft

*Text Continued on p. 168.*

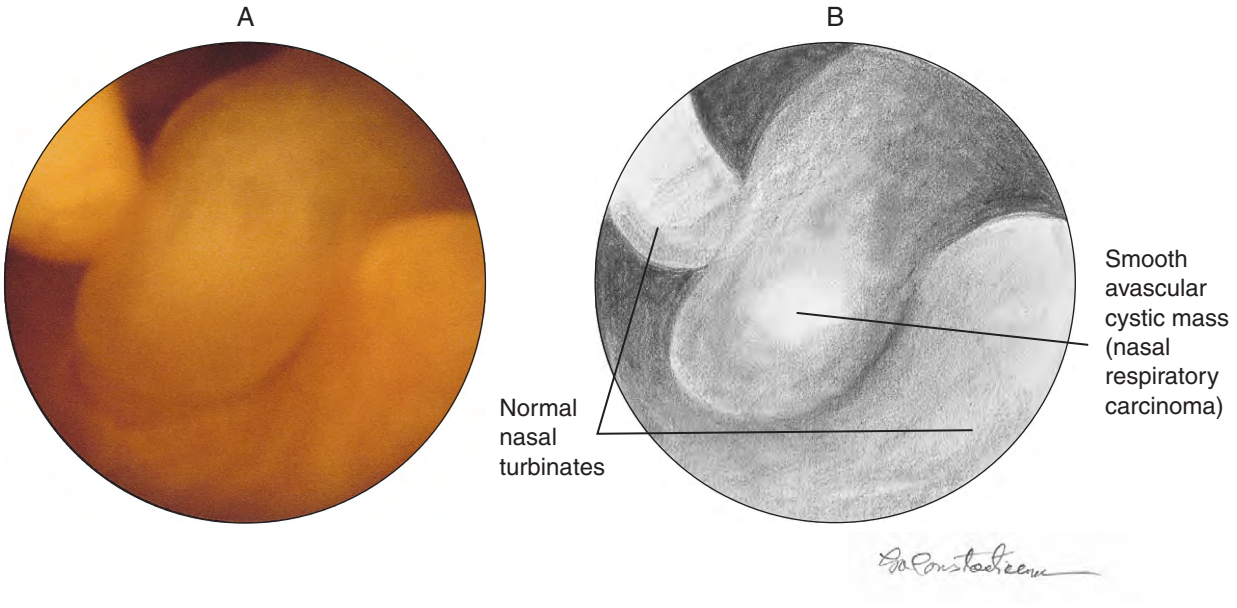



**Fig. 5-30**
A nasal respiratory carcinoma with a smooth avascular cystic appearance in a dog.

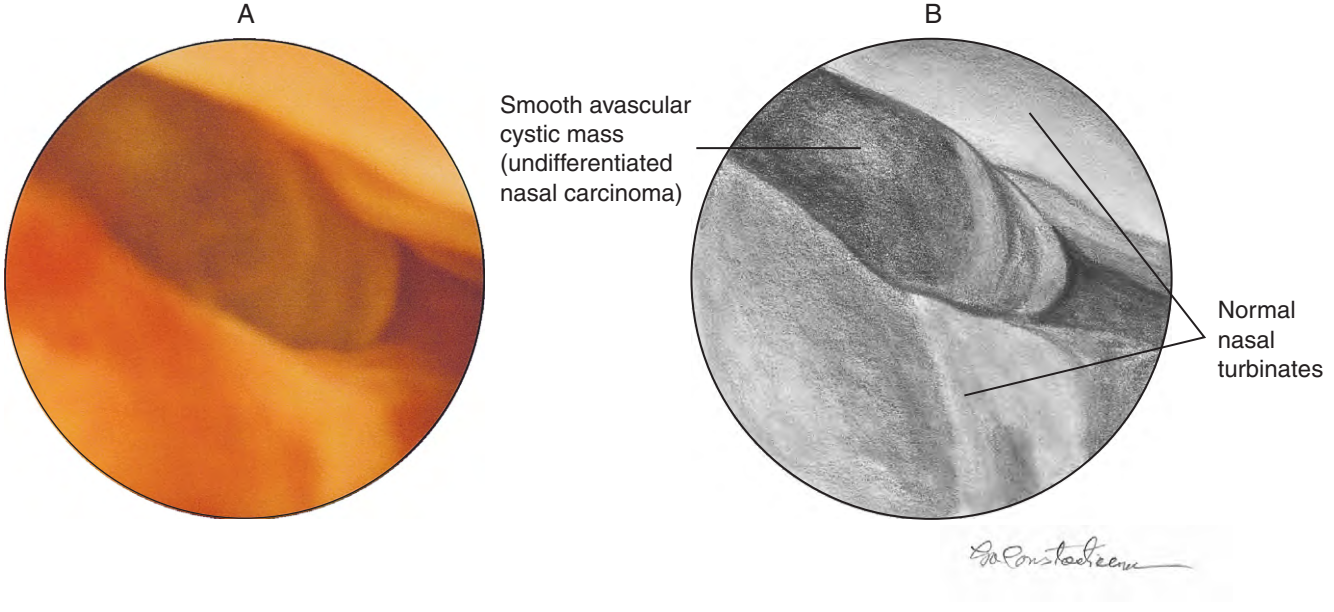



**Fig. 5-31**
An undifferentiated nasal carcinoma with a smooth avascular cystic appearance in a dog.

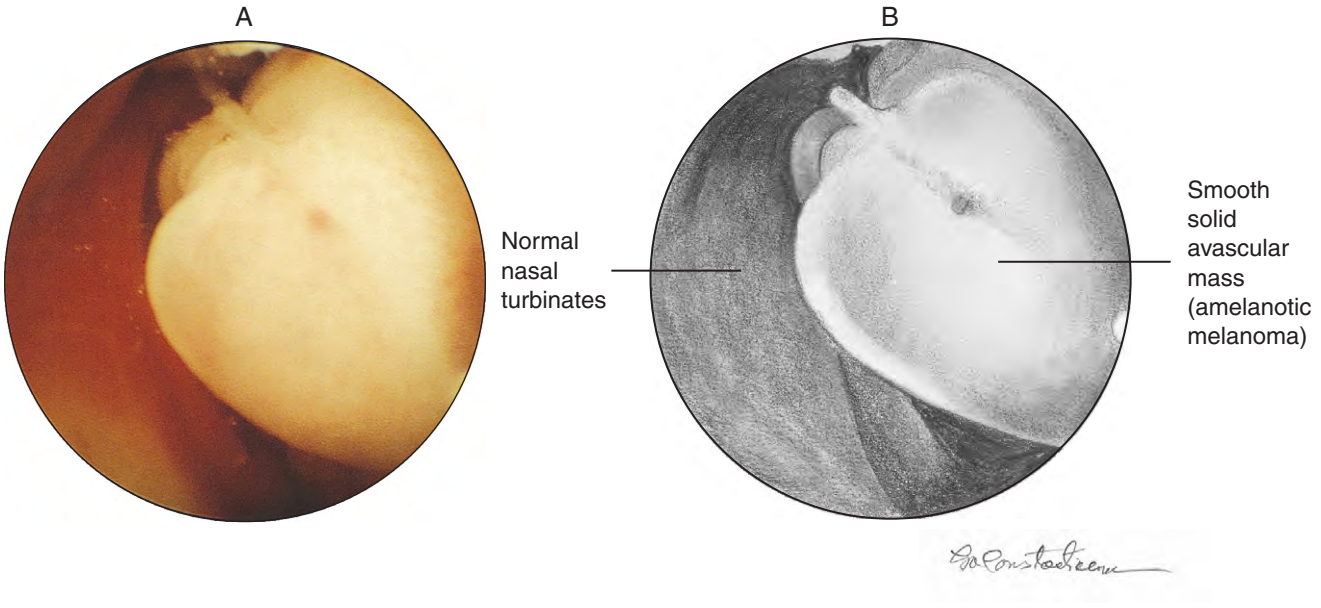



**Fig. 5-32**
A nasopharyngeal amelanotic melanoma with a smooth solid avascular appearance.

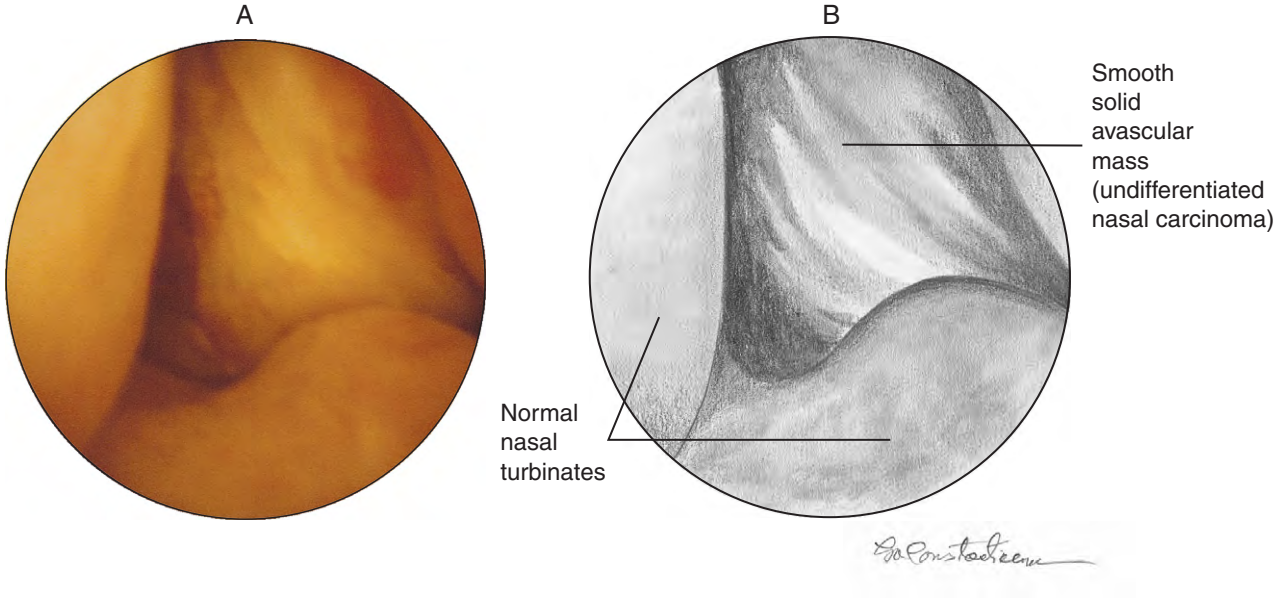



**Fig. 5-33**
An undifferentiated carcinoma with a smooth avascular appearance in the nasal cavity of a dog.

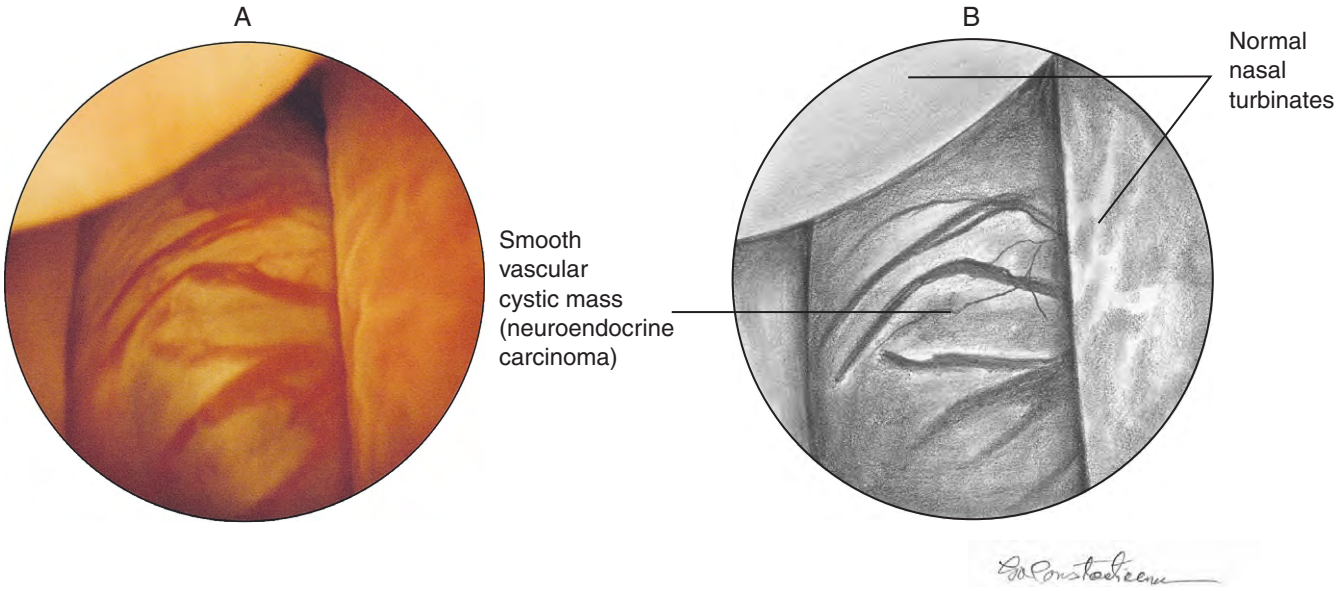



**Fig. 5-34**
A neuroendocrine carcinoma in the nasal cavity of an 11-year-old Labrador Retriever showing a cystic-appearing smooth tumor surface with enlarged blood vessels.

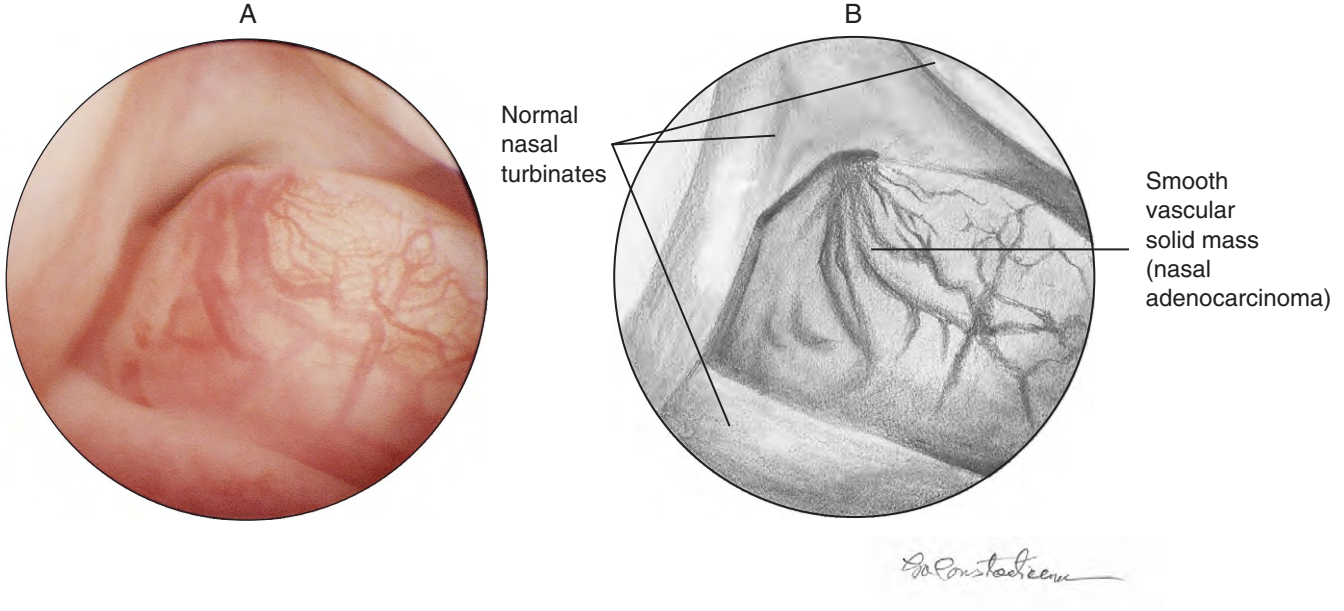



**Fig. 5-35**
An adenocarcinoma with a solid appearing smooth surface with enlarged blood vessels in the nasal cavity of a dog.

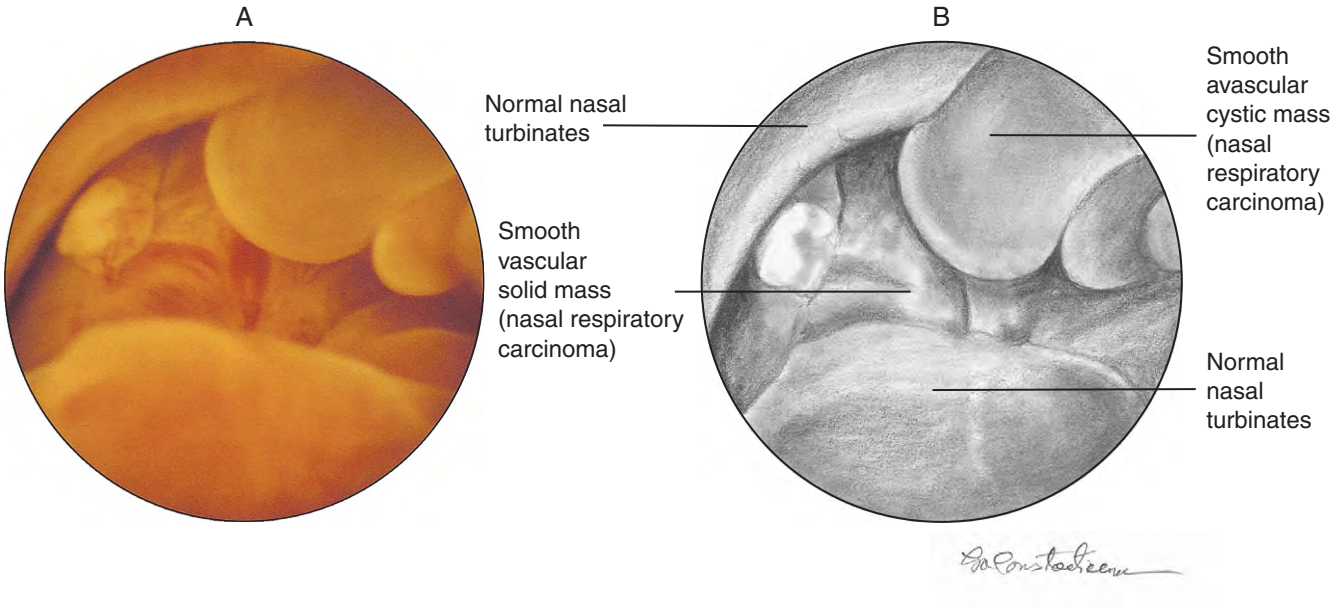



**Fig. 5–36**
A nasal respiratory carcinoma with smooth avascular cystic areas and smooth solid vascular areas.

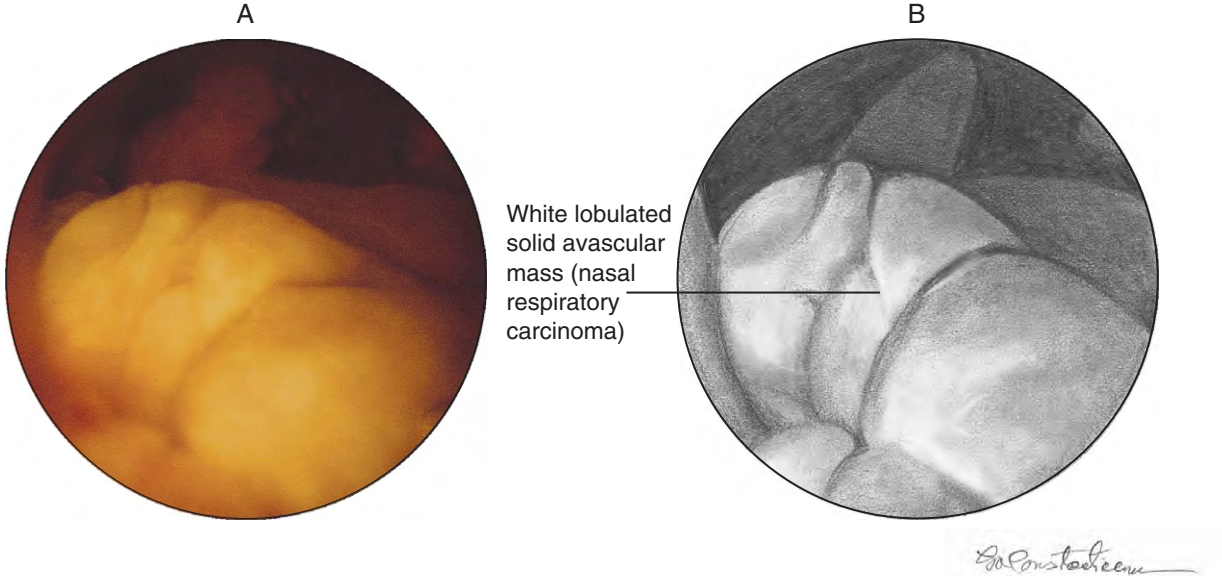



**Fig. 5–37**
A nasal respiratory carcinoma with a white lobulated solid avascular surface in a dog.

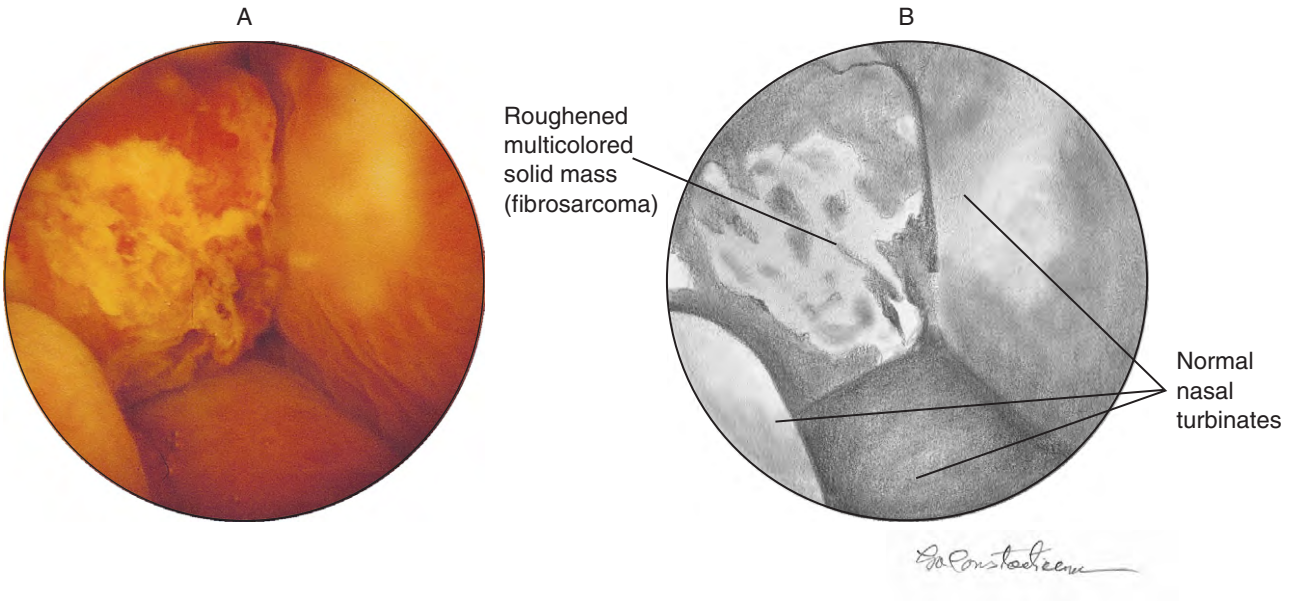



**Fig. 5-38**
A fibrosarcoma with a multicolored roughened surface seen in the nasal cavity of a dog.

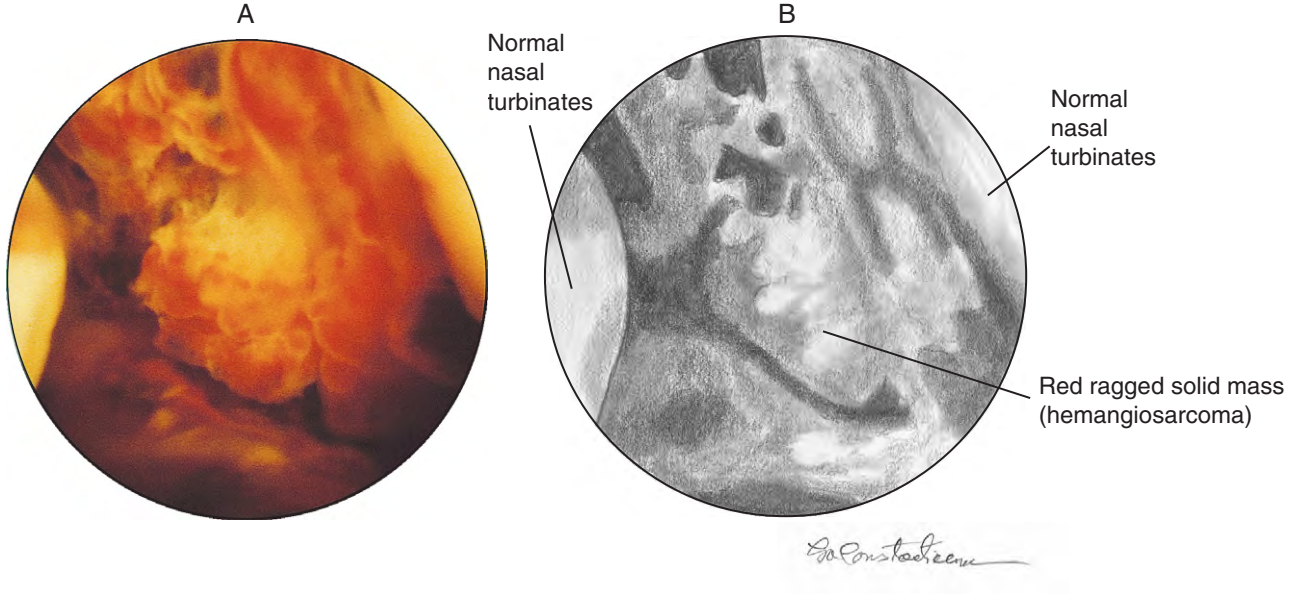



**Fig. 5-39**
A hemangiosarcoma with a red, ragged surface appearance seen in the nasal cavity of a cat.

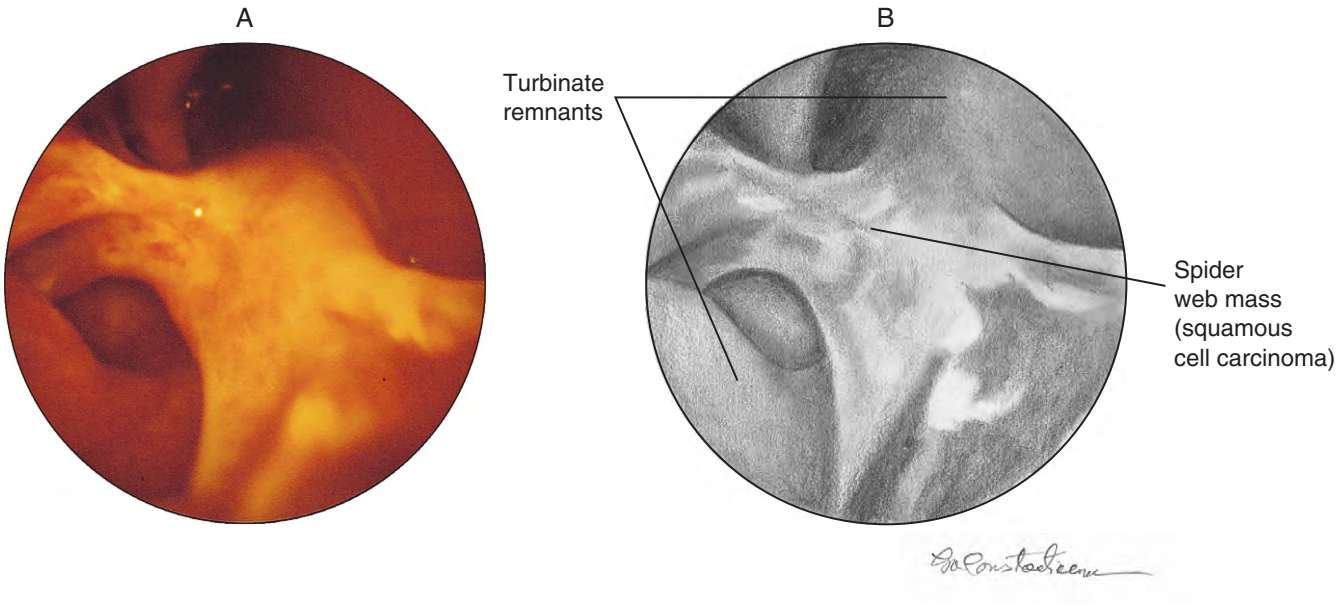



**Fig. 5–40**
A nasal squamous cell carcinoma appearing as a web of tissue with turbinate destruction in the nasal cavity of a dog.

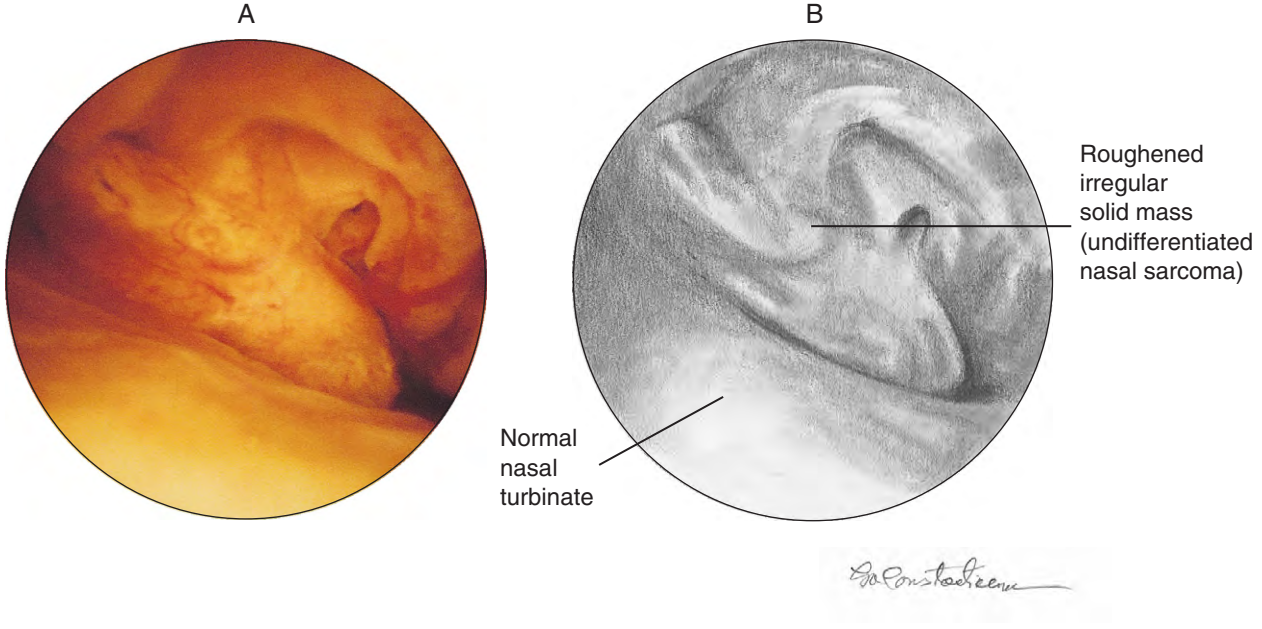



**Fig. 5–41**
An undifferentiated nasal sarcoma demonstrating a roughened and irregular tumor surface in an 8-year-old cat.

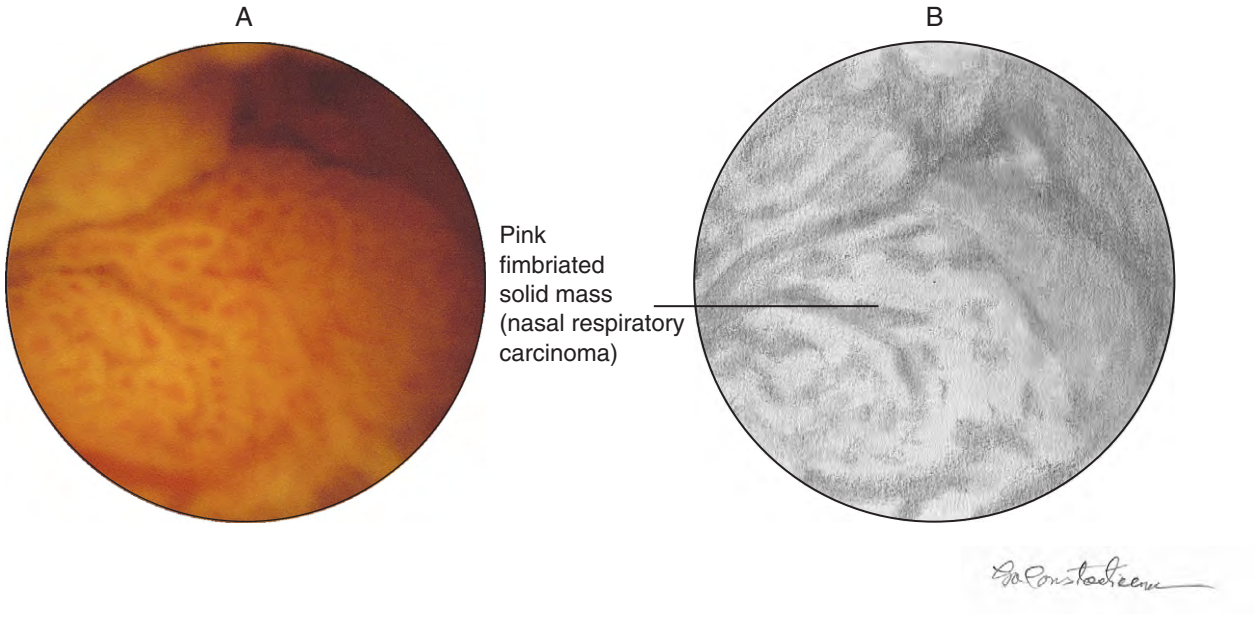



**Fig. 5-42**
A nasal respiratory carcinoma with a pink fimbriated surface seen in a dog.

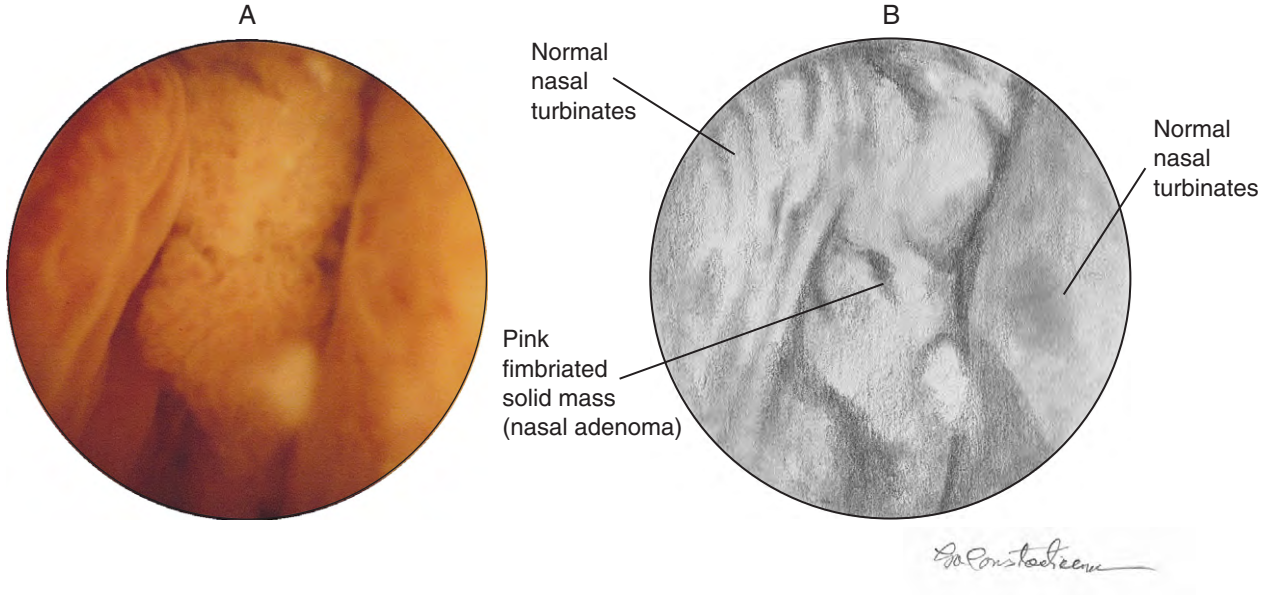



**Fig. 5-43**
A benign nasal adenoma with a pink fimbriated surface appearance seen in the nasal cavity of a 14-year-old mixed-breed dog presented for nasal obstruction.

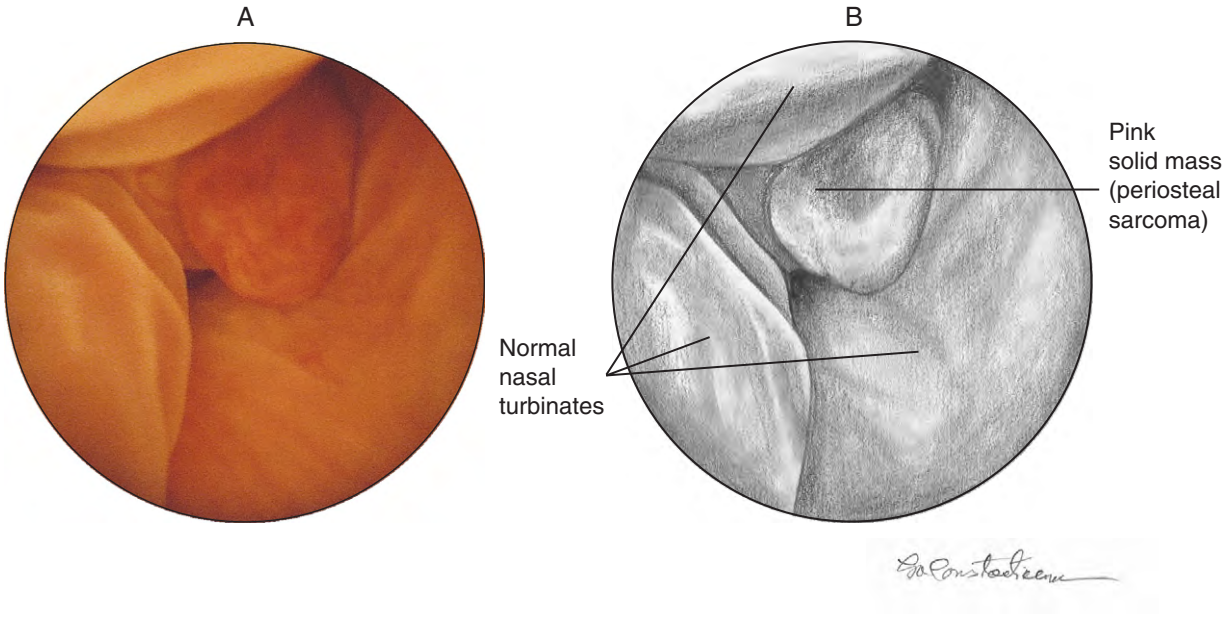



**Fig. 5-44**
A periosteal sarcoma with pink surface color in the nasal cavity of a dog.

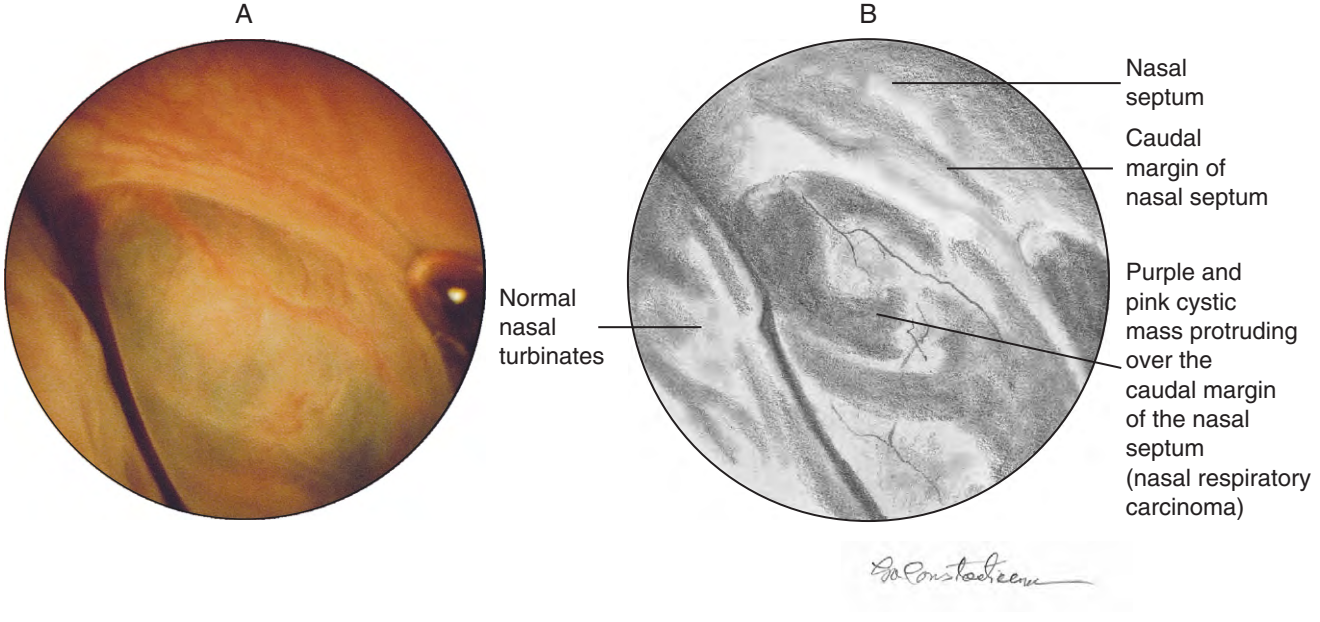



**Fig. 5-45**
A nasal respiratory carcinoma with purple and pink surface color seen projecting beyond the caudal margin of the nasal septum into the nasopharynx as seen from the contralateral nasal cavity.

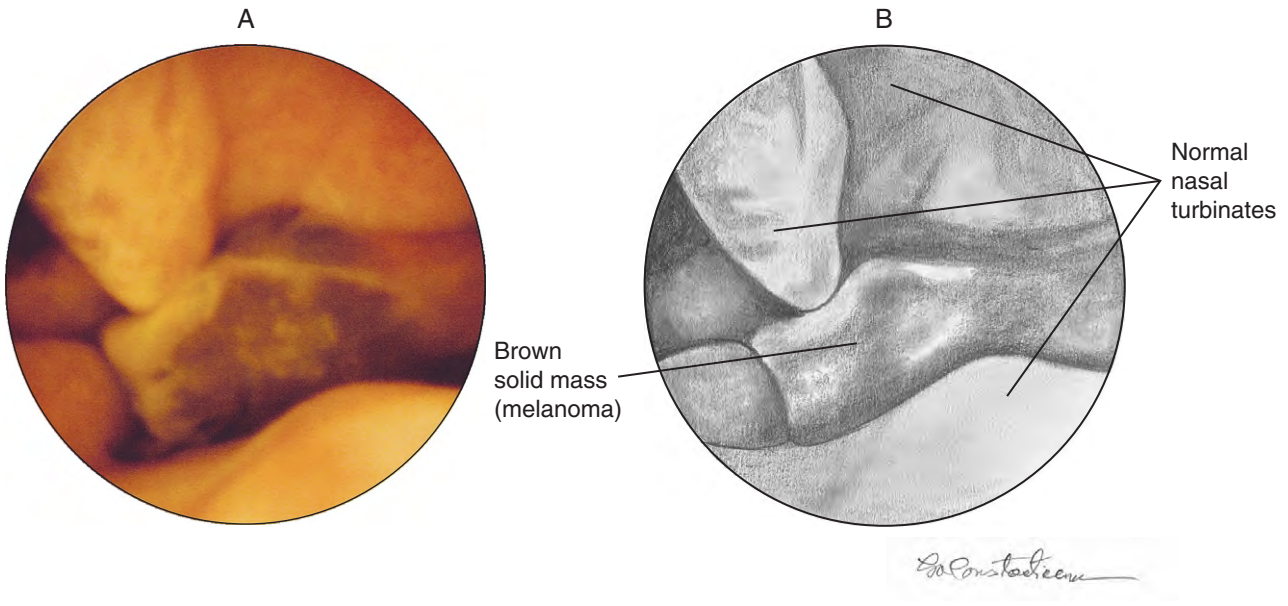



**Fig. 5-46**
A nasal melanoma with brown pigmentation seen in the nasal cavity of a dog.

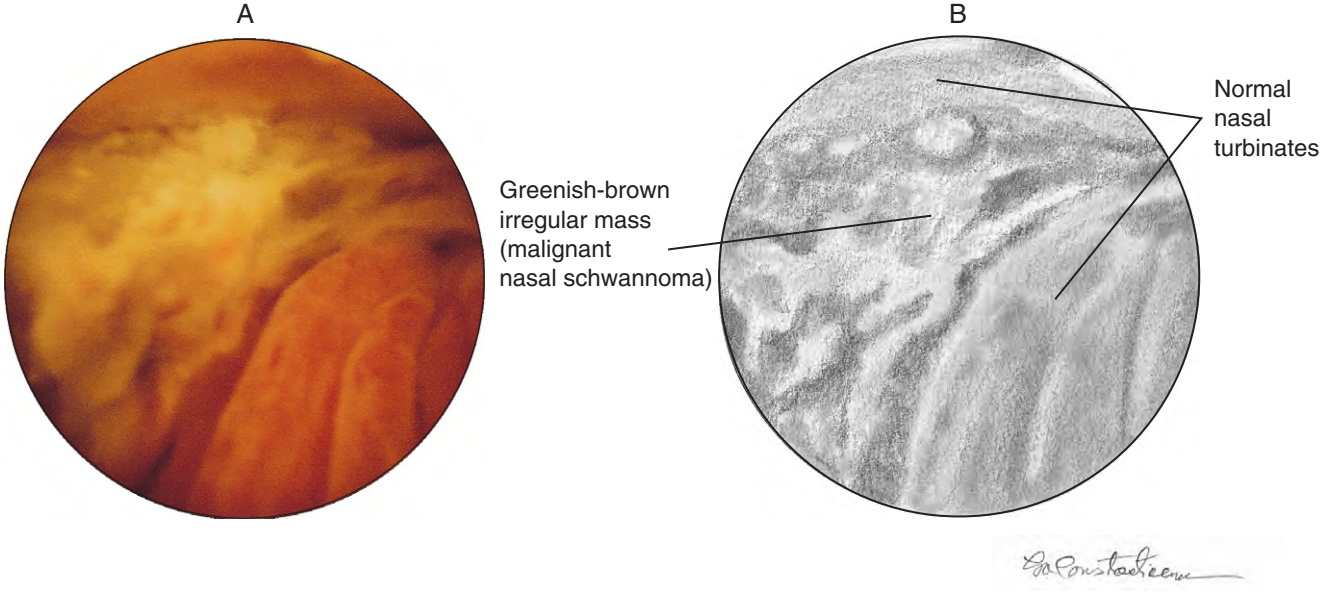



**Fig. 5-47**
A malignant schwannoma with greenish-brown coloration characteristic of the mucosa in the area of the olfactory organ in the nasal cavity of a dog.

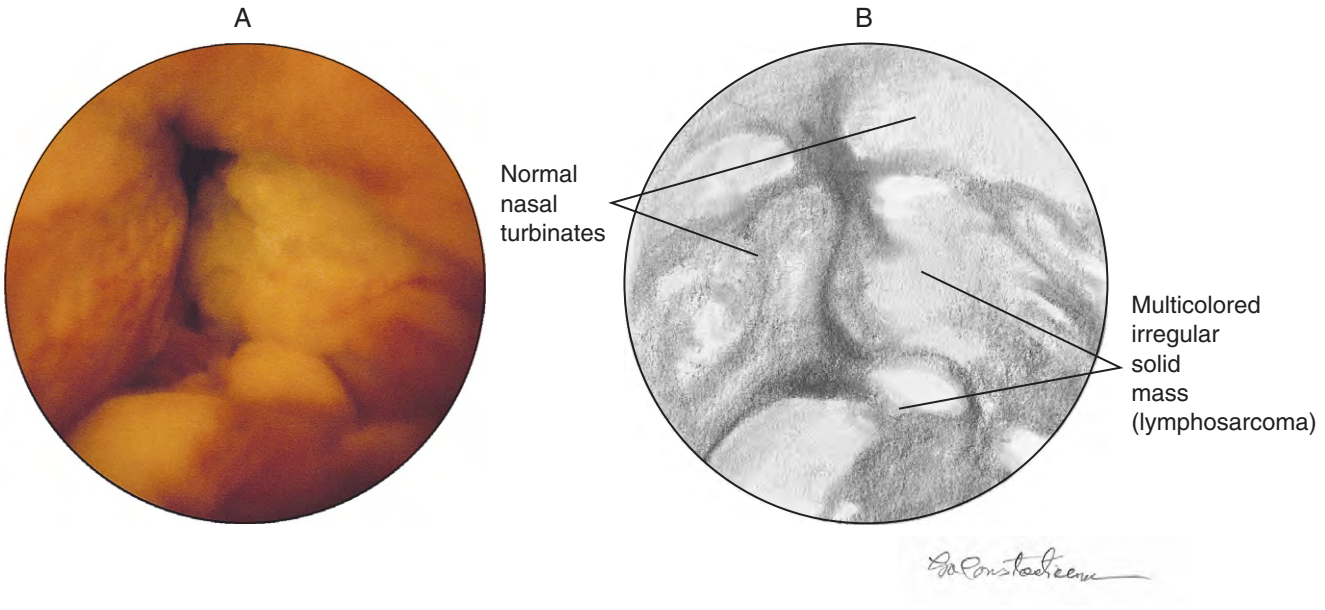



**Fig. 5–48**
Lymphosarcoma with a multicolored irregular surface appearance in the nasal cavity of a cat.

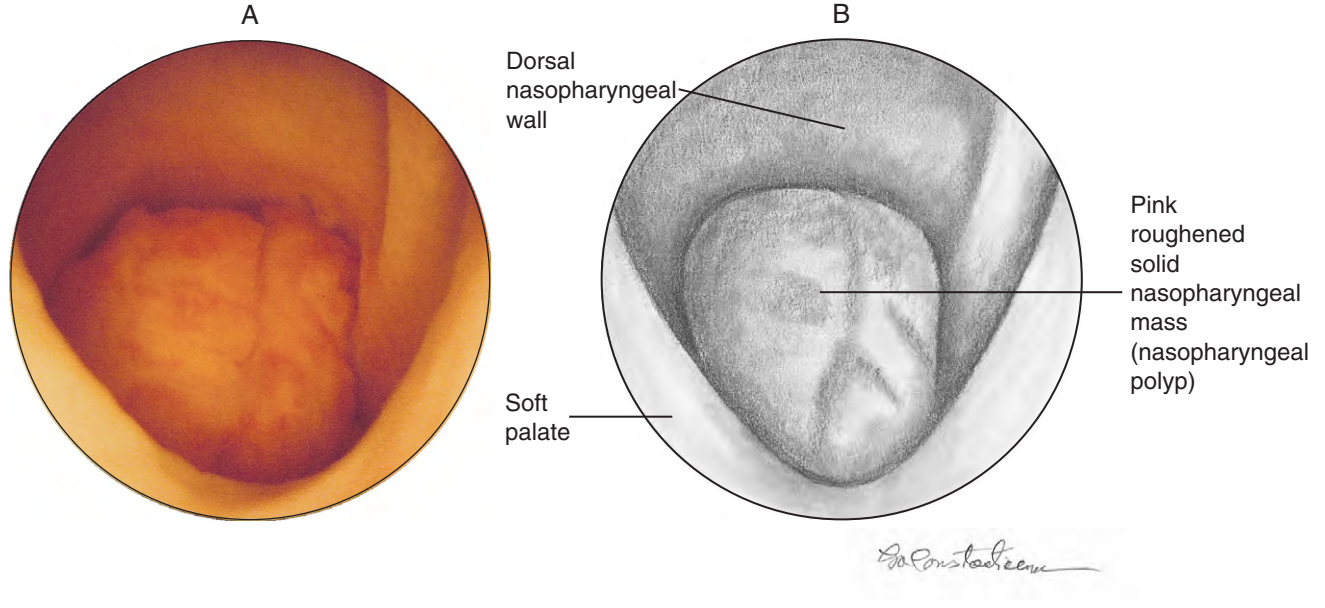



**Fig. 5–49**
An inflammatory nasopharyngeal polyp, as seen in the nasopharynx of a cat, with a pink, slightly roughened surface and producing complete nasopharyngeal airway obstruction.

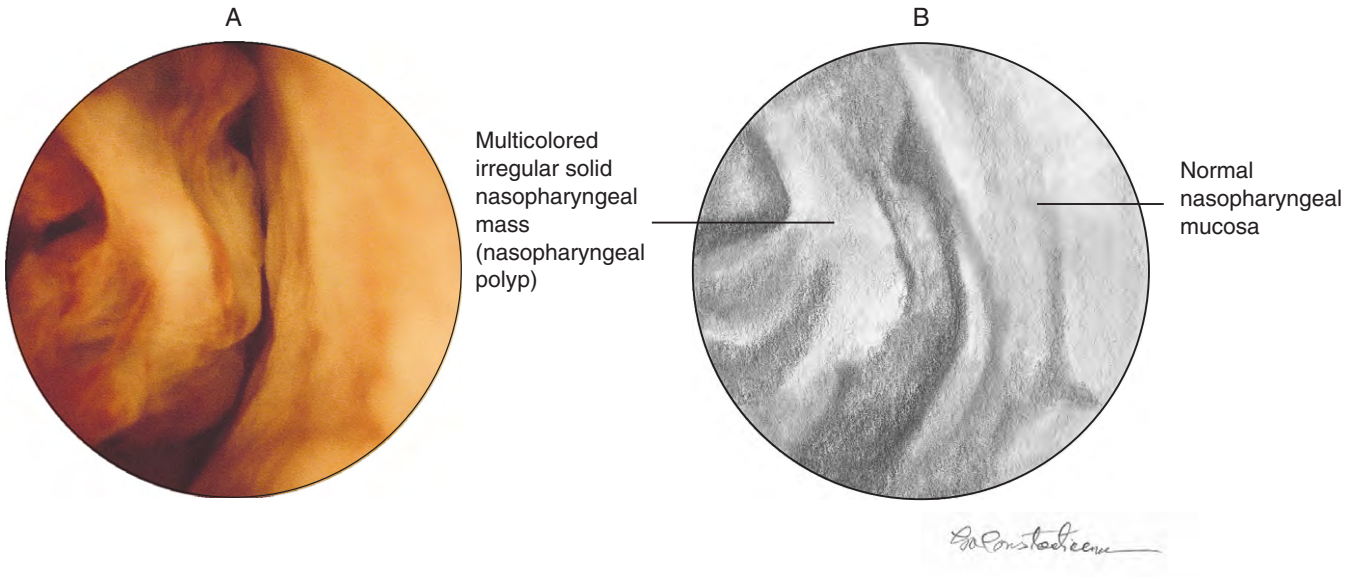



**Fig. 5-50**
An inflammatory nasopharyngeal polyp with a multicolored surface seen in the nasopharynx of a cat.

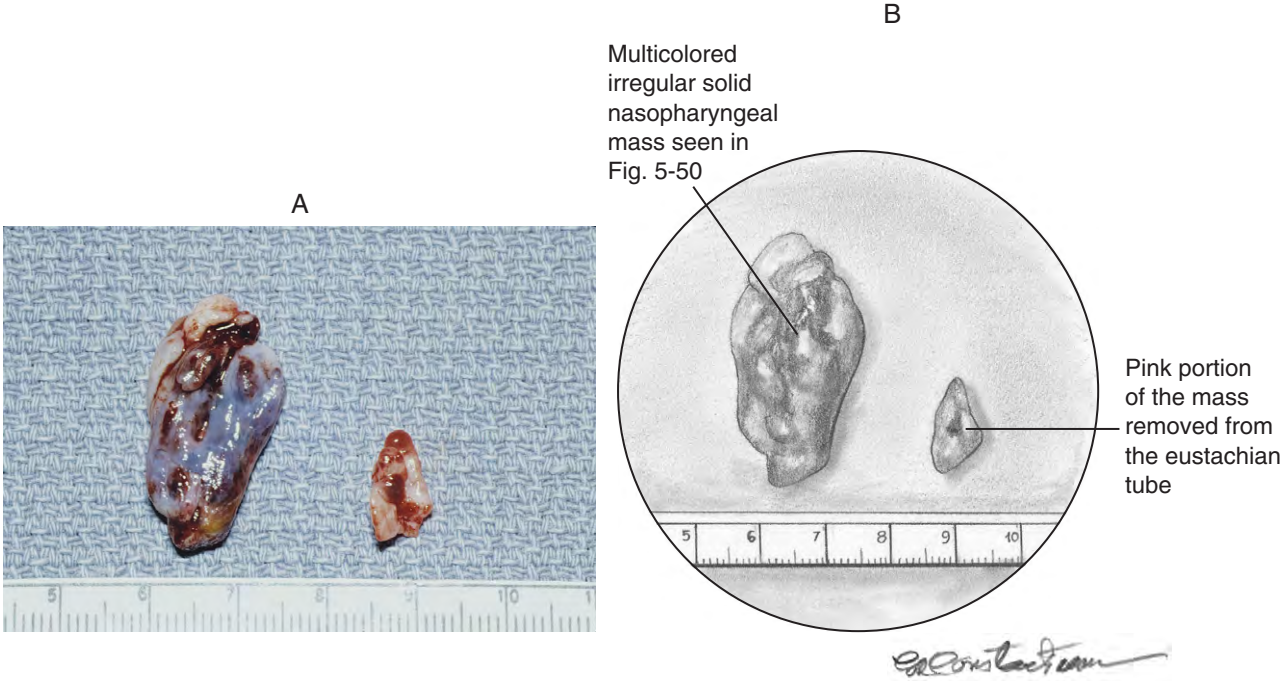



**Fig. 5-51**
Two parts of a nasopharyngeal polyp that were removed from a cat with rhinoscopy. The two parts have completely different appearances. One is purple and the other is pink.

palate (Fig. 5-53). Nasopharyngeal polyps can also be removed with rhinoscopy by applying traction using biopsy forceps or by pushing on the polyp with the endoscope or with biopsy forceps. Retracting the soft palate rostrally provides access to the eustachian tube in cats for endoscopic examination and for removal of the eustachian tube and middle ear portions of the polyp. The eustachian tube is usually enlarged secondary to the presence of the polyp stalk and access to the middle ear is possible with a 1.9-mm or smaller rigid endoscope and with biopsy forceps.

There is sufficient variability in the pattern of nasal tumors to prevent accurate gross tissue type identification. Histopathology must always be done to identify nasal tumor type. The shape of nasal tumors is influenced by

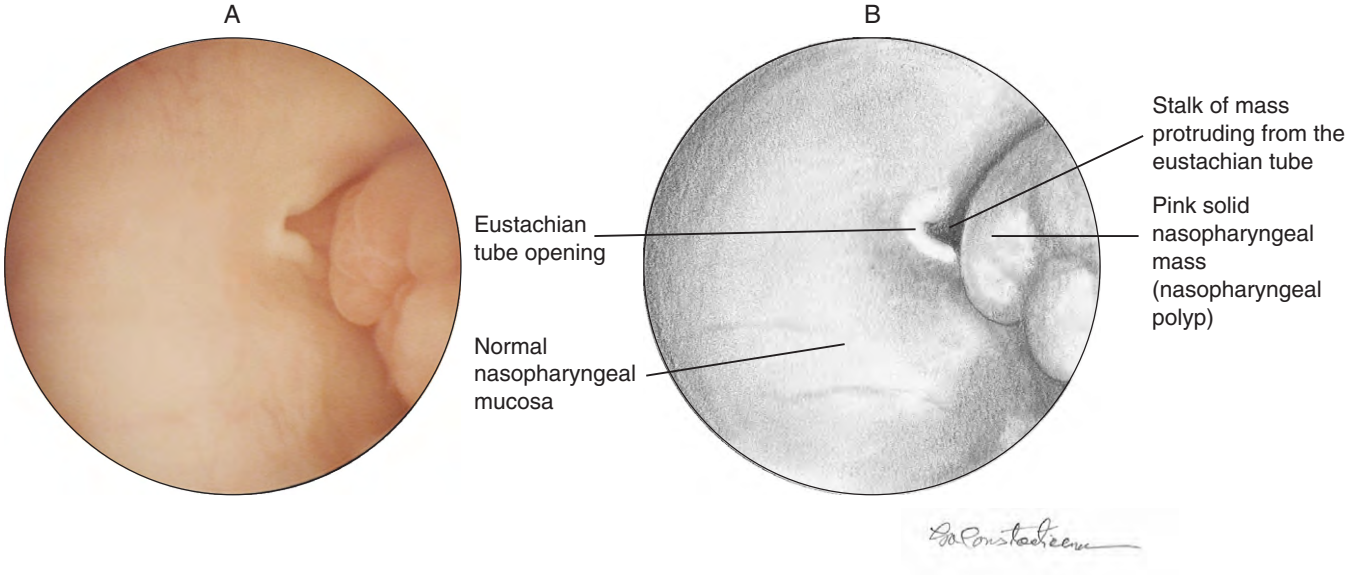



**Fig. 5-52**
A nasopharyngeal polyp attached to the stalk where it exits from the eustachian tube in a cat.

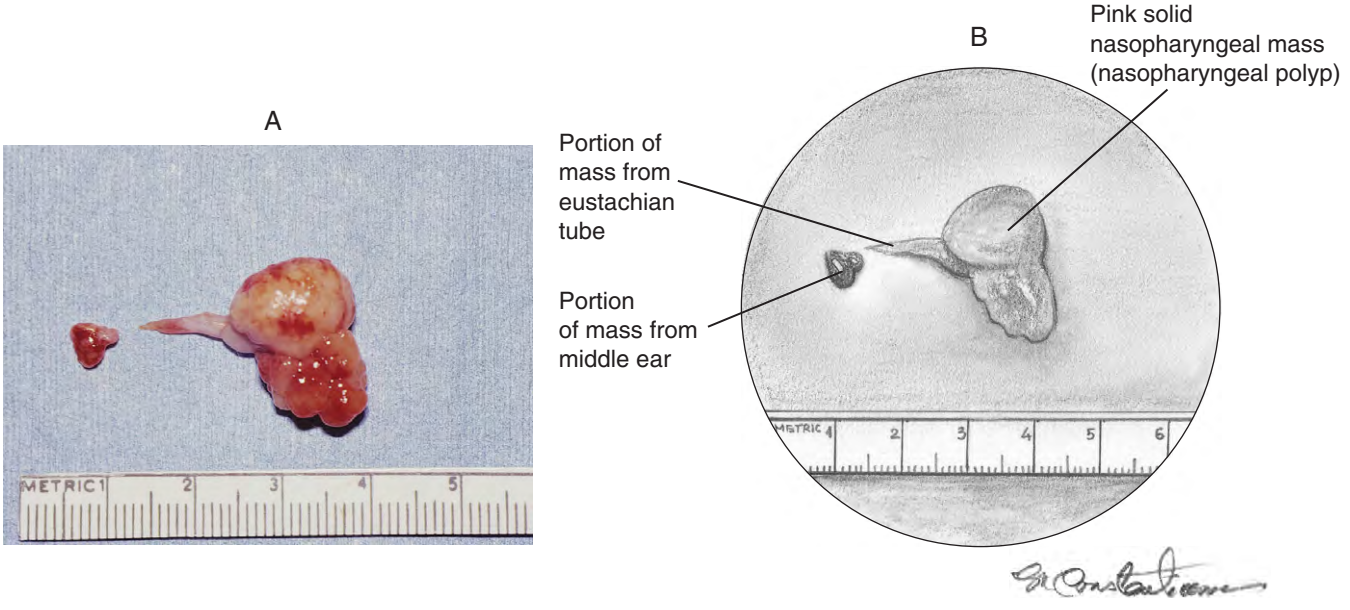



**Fig. 5-53**
The three parts of a nasopharyngeal polyp that was removed from a cat using rhinoscopy. The larger nasopharyngeal portion was removed with grasping forceps under guidance with rhinoscopy. The eustachian tube portion came loose with the nasopharyngeal portion. The smaller middle ear portion was removed by passing a 1.9-mm diameter arthroscope through the eustachian tube.

nasal cavity shape and anatomy of the turbinate structures. Tumors can be seen as narrow sheets extending between turbinates without appreciable turbinate displacement or destruction (see Figs. 5-30, 5-31, 5-34, 5-43, and 5-44). They may also be seen as a mass with significant and sometimes extensive turbinate destruction, deformation, or invasion (see Figs. 5-40 and 5-48). Large tumors are more commonly associated with extensive turbinate changes but this may be difficult to appreciate via endoscopy because of lack of space for examination. The entire extent of a tumor of any appreciable size is also difficult to assess, again due to lack of space for examination. The caudal extent of unilateral tumor involvement can sometimes be evaluated by examination of the nasopharyngeal area through the contralateral nasal cavity. If the tumor mass extends caudal to the border of the nasal septum, it can be seen as a mass extending into the nasopharynx (see Fig. 5-45). Unilateral tumors can produce bilateral nasal airway obstruction by extending into and completely filling the nasopharyngeal airway and by occlusion of the contralateral airway by displacement of the soft caudal portion of the septum.

Evaluation of the caudal extent of tumors can also be performed through the oral cavity with rostral retraction of the soft palate or by retroflexing a flexible endoscope dorsal to the soft palate into the nasopharyngeal area.

With unilateral tumor involvement, evaluation of the contralateral surface of the nasal septum may reveal a normal septal surface with no displacement, distortion, or penetration, or there may be changes associated with tumor invasion. The earliest indication of septal involvement is an inflammatory reaction on the contralateral surface that produces adhesions of the adjacent turbinates to the nasal septum (Fig. 5-54). Displacement or distortion of the septum toward the normal side with or without mucosal penetration by the tumor may occur. There may also be discrete penetration of the septum by tumor invasion without distortion or displacement of the septum. Small penetrating lesions are usually white to pink in color and are usually lighter than the normal surrounding mucosa (Fig. 5-55). They may appear as smooth, raised, or flat lesions, or they may be irregular and lobular in shape. As the extent of tumor involvement or extension to the opposite side increases, the mass becomes more like the primary side in its appearance.

## Mycotic Rhinitis and Sinusitis

*Aspergillus* spp. have been the most common mycotic organisms found producing pathology in the nasal cavity and frontal sinuses. Changes found with aspergillus infections include mucopurulent exudation involving one or both sides of the nasal cavity, mucosal hyperemia, mucosal inflammation, increased mucosal friability, inflammatory polyps, turbinate distortion, turbinate destruction, and granuloma formation. A variable quantity of fungal material may be found. The amount of mucopurulent exudation is generally extensive and is

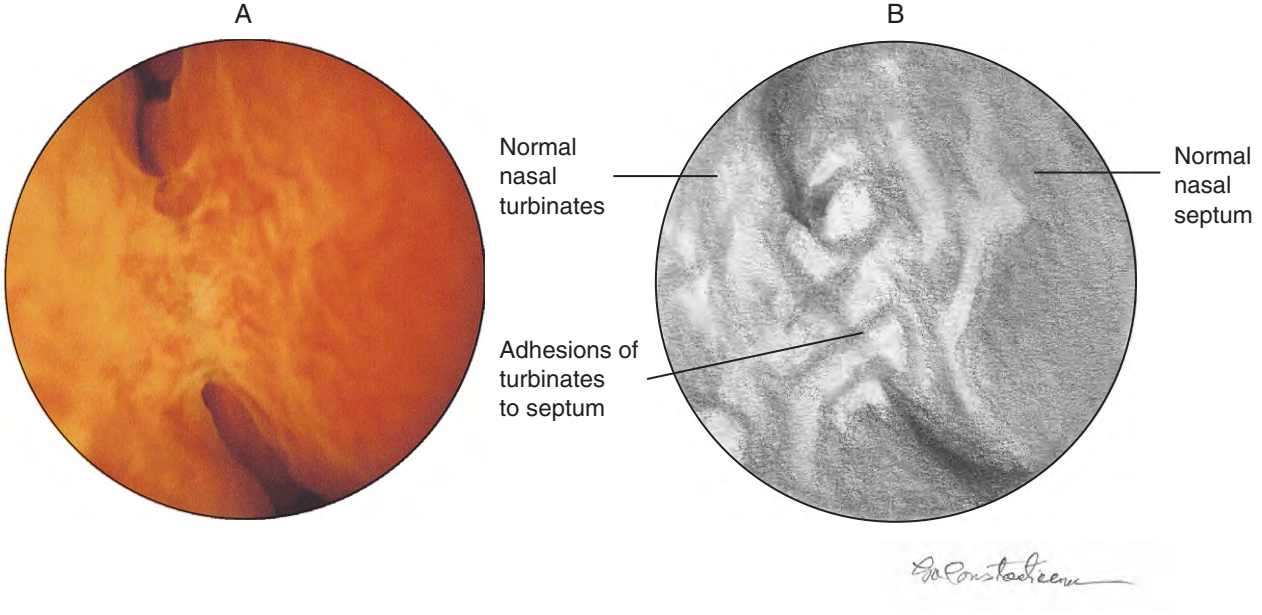



**Fig. 5-54**
Adhesions of the medial surface of the turbinates to the nasal septum on the contralateral side of the nasal septum in a dog with a nasal chondrosarcoma. This is the earliest sign of tumor penetration to the contralateral nasal cavity.

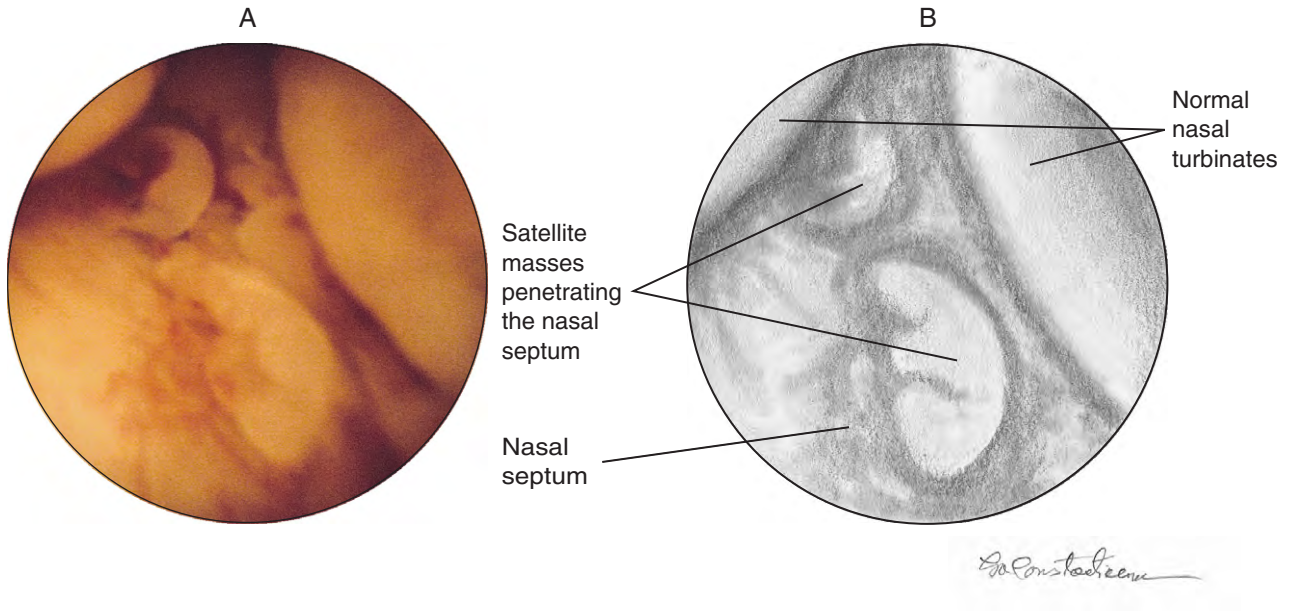



**Fig. 5–55**
Multiple discrete satellite tumor masses that have penetrated through the nasal septum.

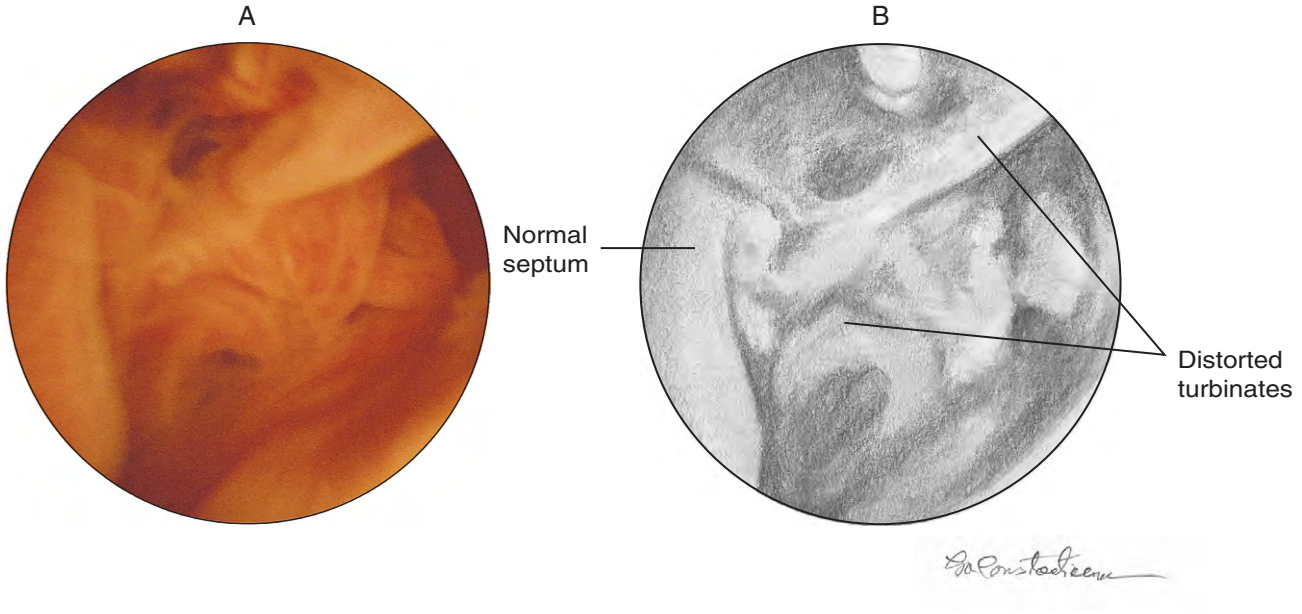



**Fig. 5–56**
Turbinate distortion caused by mycotic rhinitis in a 12-year-old mixed-breed dog.

more than that seen with neoplasia. In unilateral involvement, there may be significant mucopurulent discharge in the contralateral nasal cavity even in the absence of identifiable fungal colonies. Discharge may contain blood, but there is rarely evidence of extensive bleeding or blood clots. Inflammatory, granulomatous, and fibroplastic response associated with chronic fungal infections results in turbinate destruction and distortion. In mild or relatively acute cases, there is more distortion than destruction. Early, mild destruction may not be obvious, but examination may seem easier than in a normal dog because of increased space between turbinates. Distortion first becomes evident in the ethmoid turbinates, which take on a crumpled, shrunken appearance (Fig. 5-56).

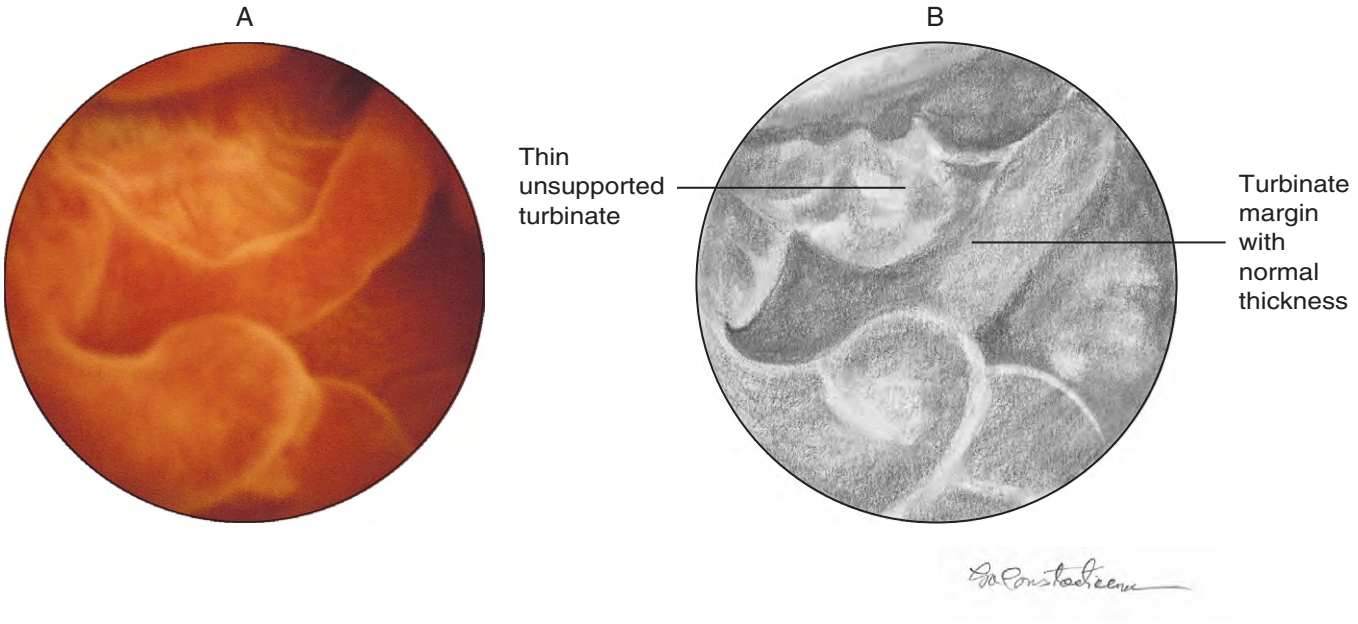



**Fig. 5-57**
Loss of cartilage support of turbinates in a German Shepherd dog with recurrent nasal aspergillosis.

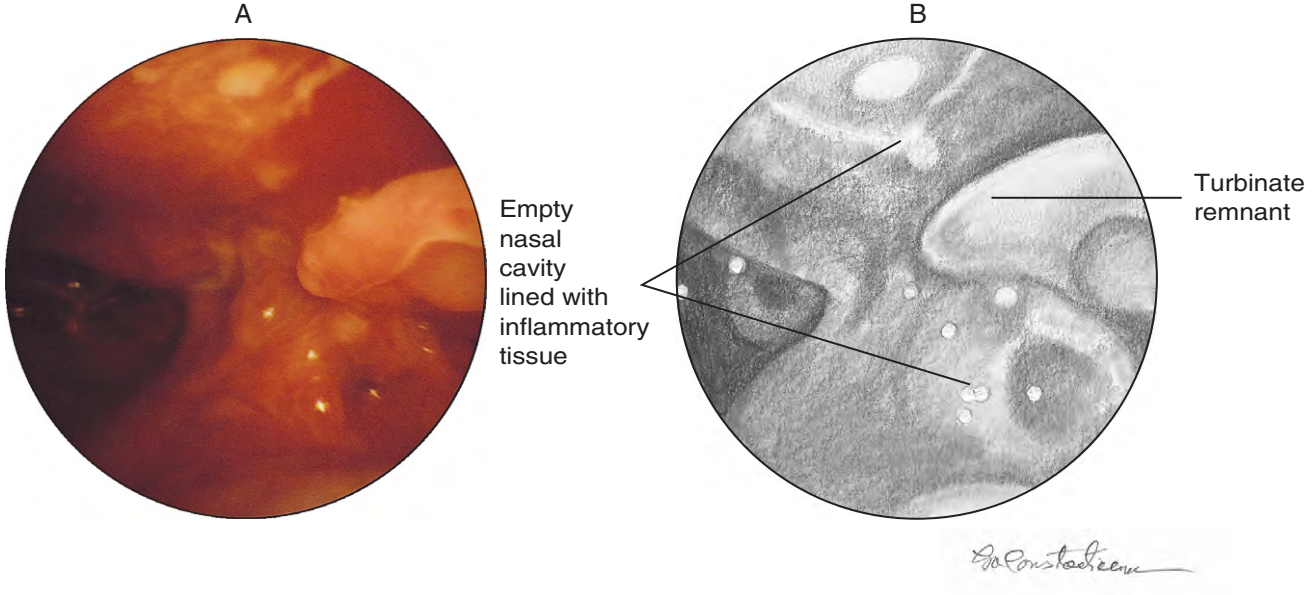



**Fig. 5-58**
Extensive turbinate destruction in a dog with chronic nasal aspergillosis.

With progression, the turbinates appear unsupported as cartilage is lost (Fig. 5-57); they may seem to float in the fluid stream coming from the endoscope. With further progression of disease, there is additional loss of turbinate mass and further distortion. A basically empty nasal cavity lined with rough, irregular, inflammatory granulation tissue is the endpoint of the destructive process (Fig. 5-58).

Mucosal changes include hyperemia (Fig. 5-59), increased vascularity (see Fig. 5-57), and friability, with greatest severity of mucosal involvement in the areas of fungal colonies. Changes occur throughout the involved nasal cavity and extend to the contralateral side. There is early formation of an underlying bed of granulation tissue, with the mucosa becoming thickened with a roughened surface, and progressively increasing friability and vascularity.

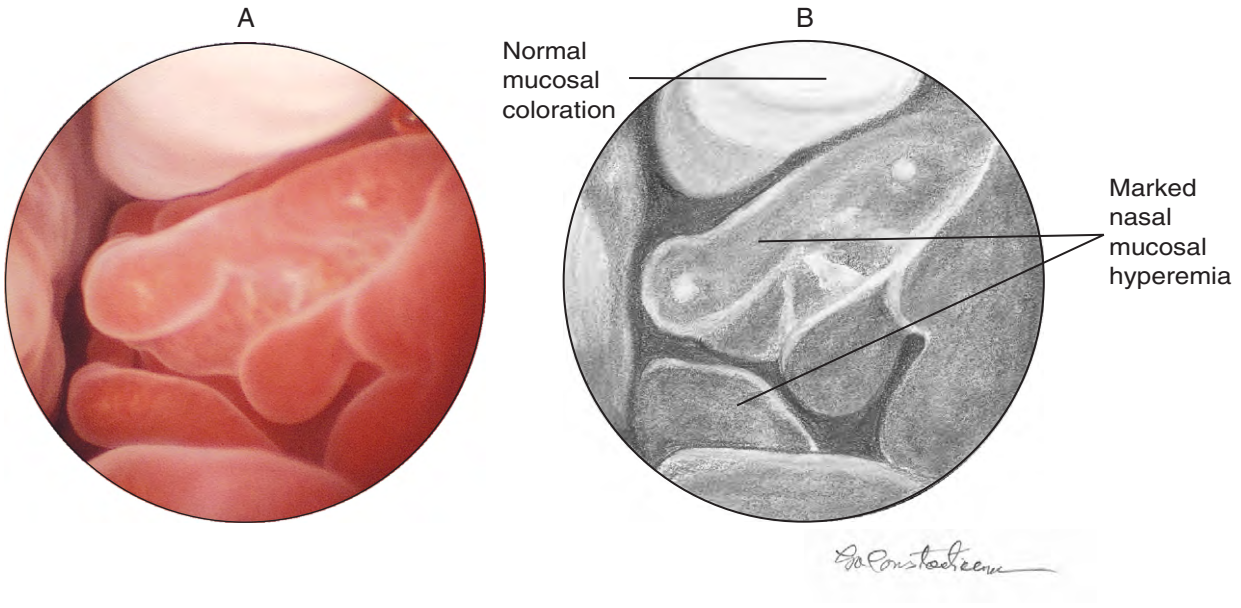



**Fig. 5-59**
Mucosal hyperemia and mild turbinate distortion resulting from nasal *Aspergillus* infection.

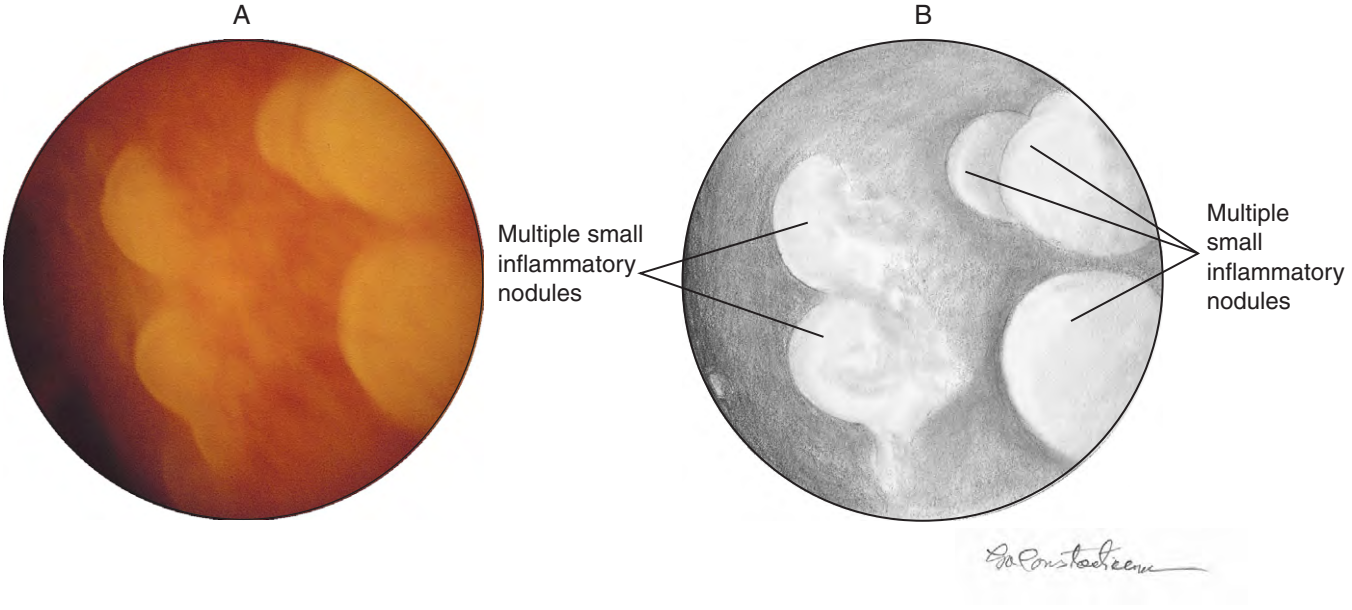



**Fig. 5-60**
Individual small, white, inflammatory nodule polyps resulting from nasal *Aspergillus* infection.

As the extent and severity of the disease progresses, a greater portion of the nasal mucosa becomes involved with the granulomatous inflammatory process, until there is complete turbinate destruction and lining of the entire nasal cavity with inflammatory tissue (see Fig. 5-58).

Inflammatory polyp formation can occur secondary to fungal infections. Polyps are found as individual small, smooth, white nodules on turbinates (Fig. 5-60), as sheets of contiguous larger polyps (Fig. 5-61), or as large masses in nasal cavities with extensive turbinate loss (Fig. 5-62). Tumor-like masses can also occur as a result of *Aspergillus* spp. infections (Figs. 5-63 and 5-64), but they are more common with *Cryptococcus* spp. infections in either dogs (Fig. 5-65) or cats (Figs. 5-66 and 5-67).

With advanced disease, there is destruction and penetration of the nasal septum. Initial changes seen in the septum are generally related to loss of cartilage support, with the septum appearing as a loose, free-floating curtain

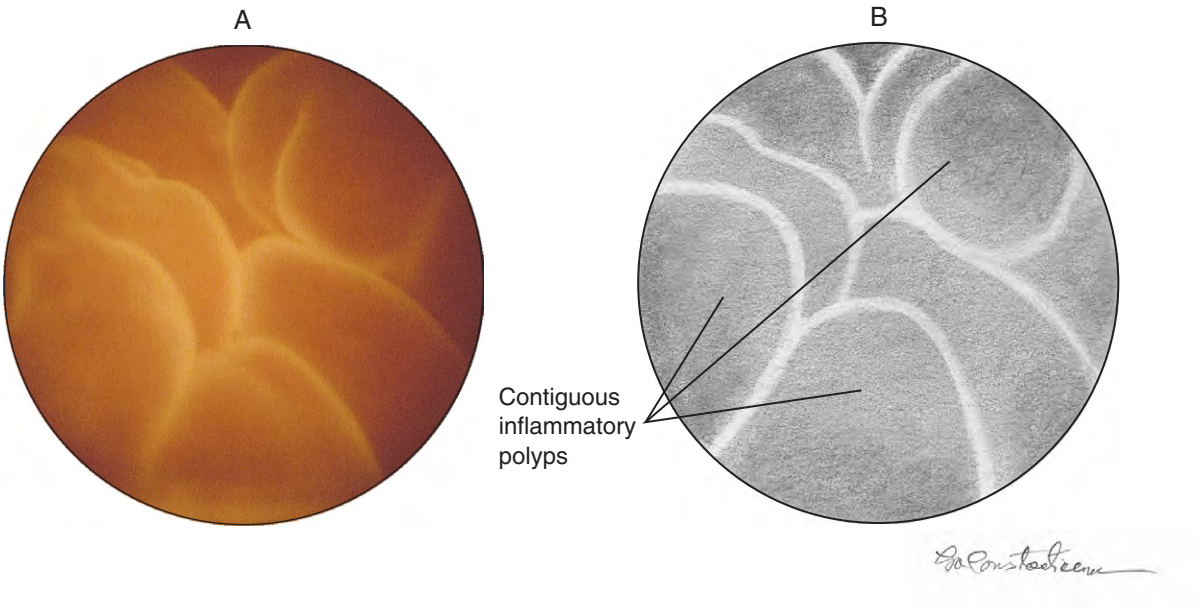



**Fig. 5-61**
Contiguous sheet of inflammatory polyps in a case of nasal aspergillosis.

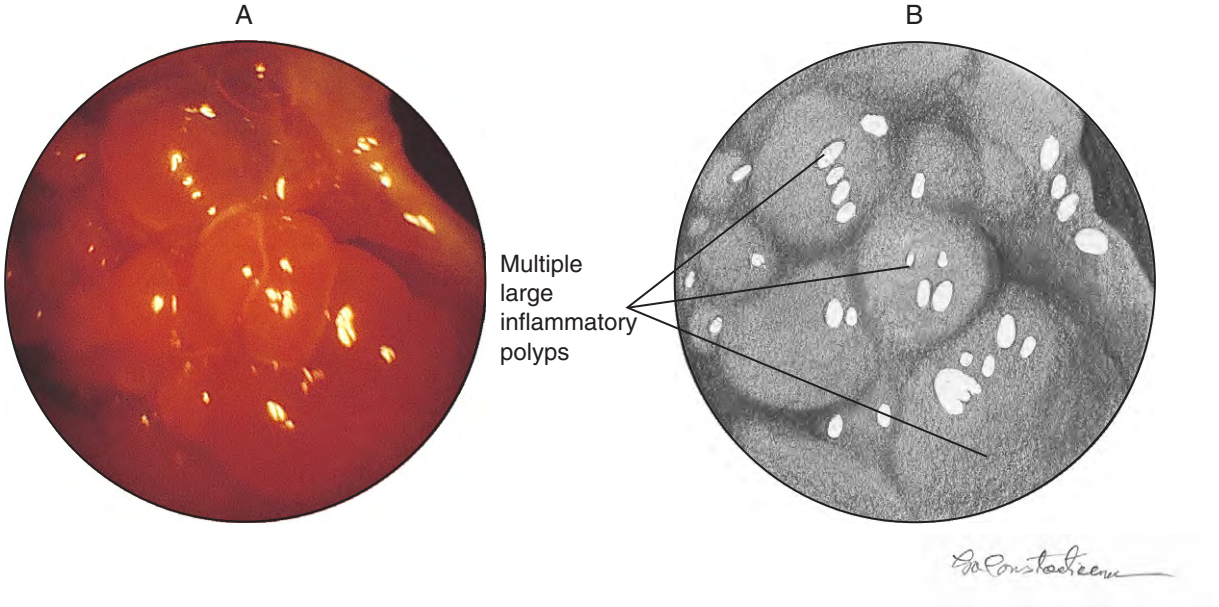



**Fig. 5-62**
A large mass of inflammatory polyps in the nasal cavity of a dog with end-stage turbinate destruction caused by nasal aspergillosis.

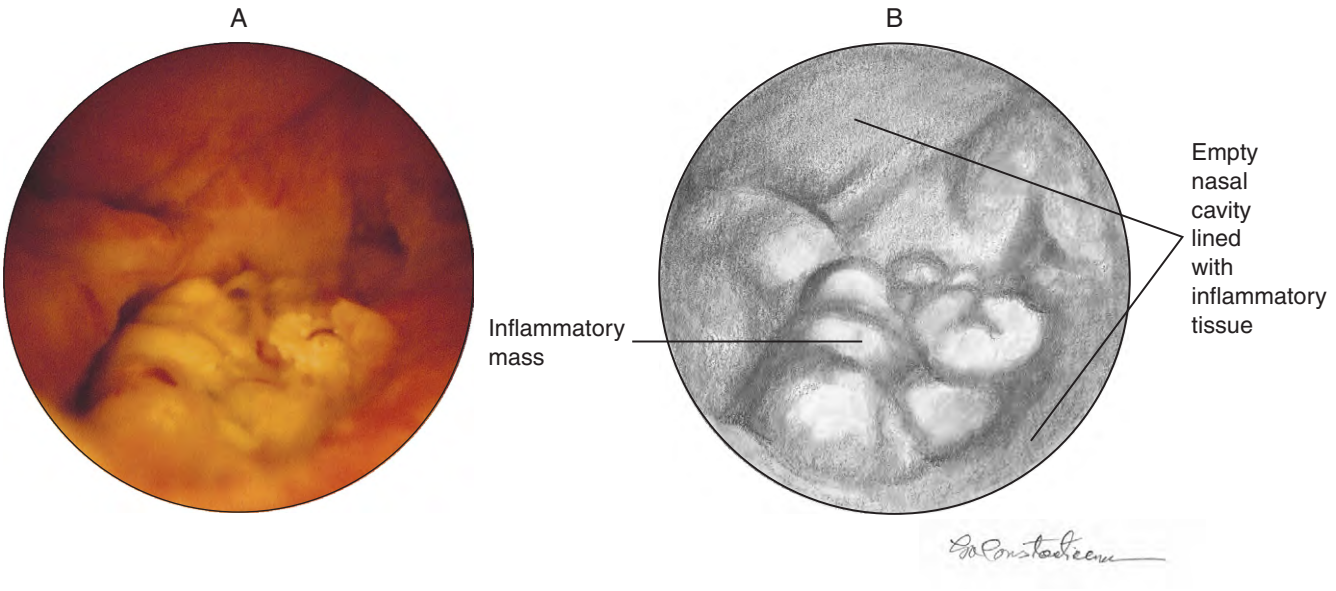



**Fig. 5-63**
A tumor-like mass in the nasal cavity of a dog with aspergillosis.

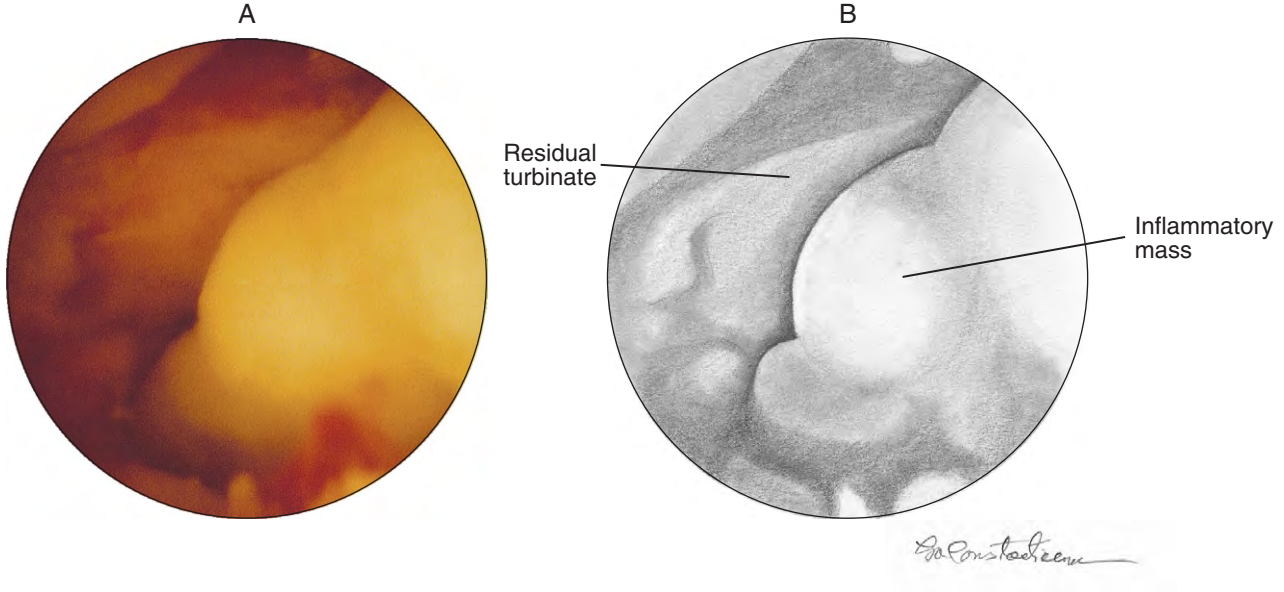



**Fig. 5-64**
A tumor-like mass in the nasal cavity of a cat with aspergillosis.

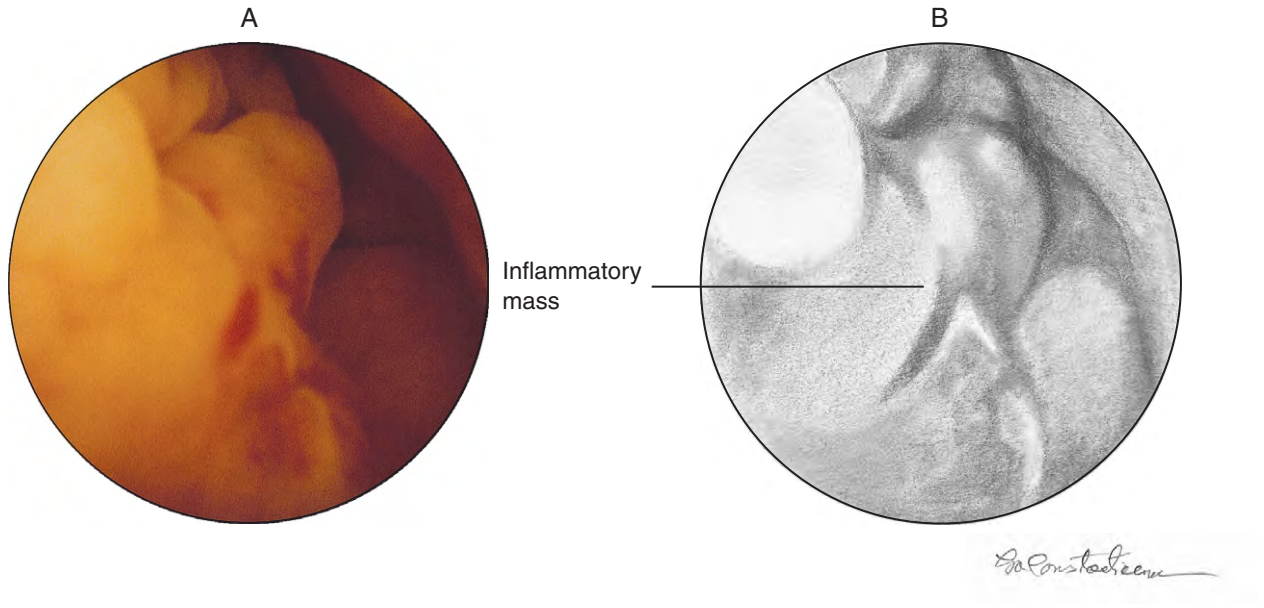



**Fig. 5-65**
Nasal cryptococcosis having the appearance of a tumor-like mass in a dog.

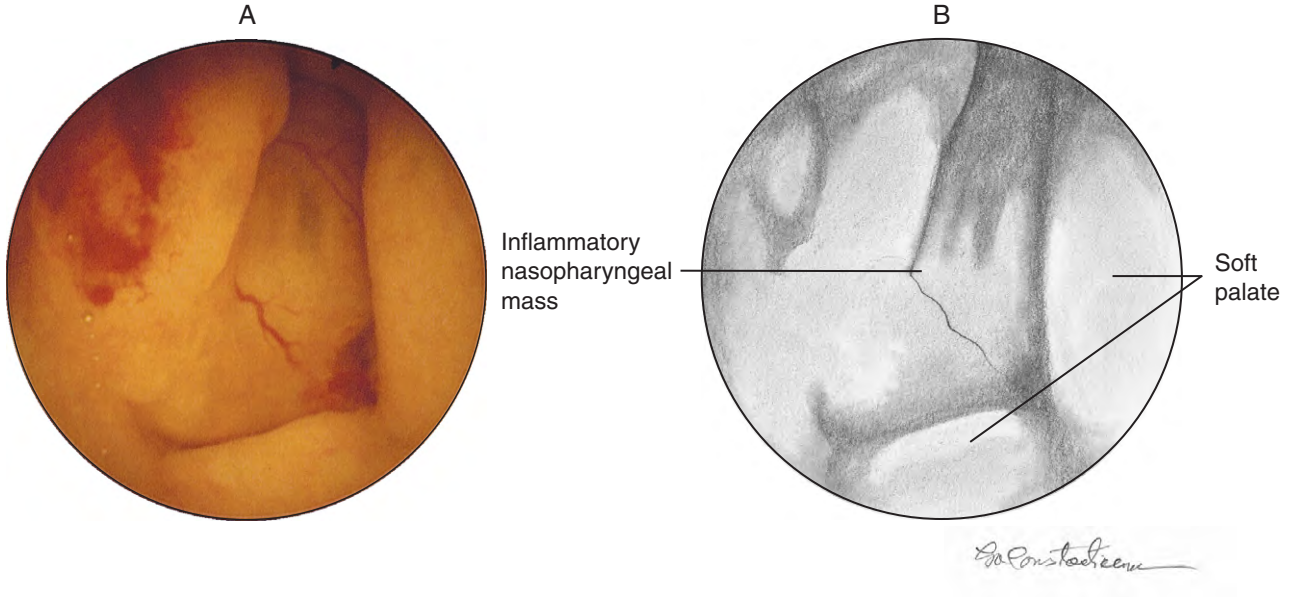



**Fig. 5-66**
In a cat, nasal cryptococcosis having the appearance of a tumor-like mass as seen in the nasopharynx from the rostral side. Fungal masses in this area can be differentiated from nasopharyngeal polyps by their wide base of attachment.

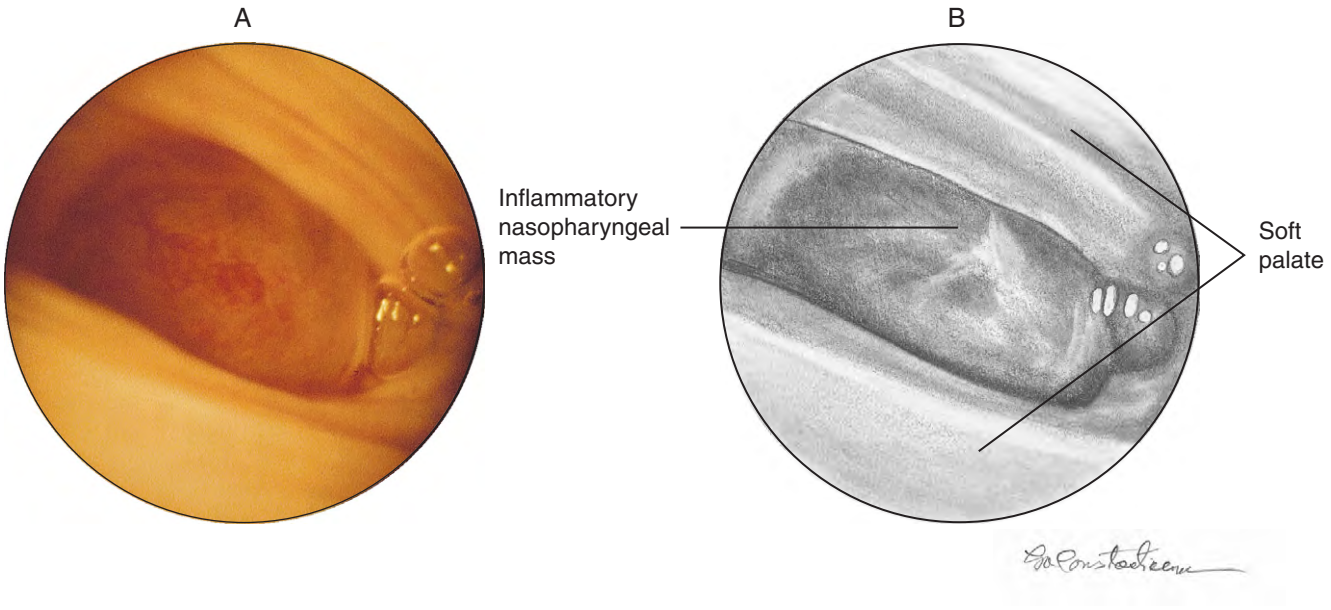



**Fig. 5-67**
In a cat, nasal cryptococcosis having the appearance of a tumor-like mass seen from the caudal aspect with the soft palate retracted rostrally and with the endoscope placed into the nasopharynx through the oral cavity.

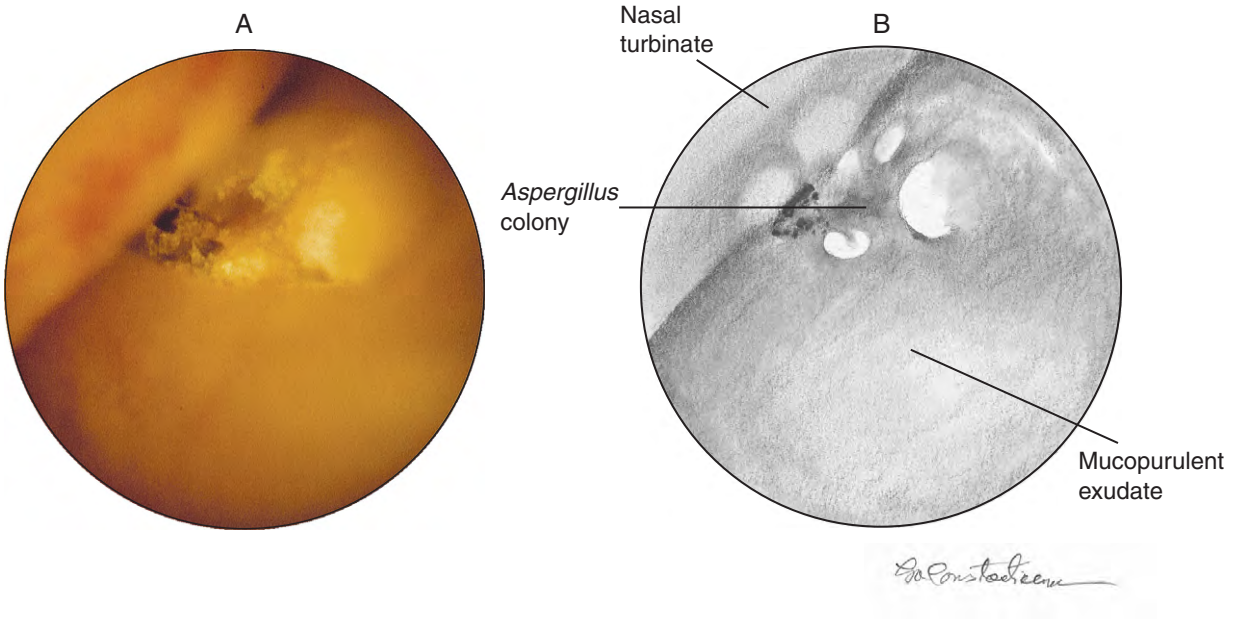



**Fig. 5-68**
An *Aspergillus* spp. colony hidden in mucopurulent exudate in a dog with nasal aspergillosis. The metallic or silver coloration is the earliest visible indication of fungal colonies.

rather than as a rigid wall. The destructive process eventually penetrates the septum in one or more locations and progresses until the septum is completely destroyed. At this point, the nasal cavity becomes one large cavity without turbinate or septal tissue (see Fig. 5-58).

Fungal colonies may or may not be seen in early cases. With increasing chronicity and severity, the likelihood of finding fungal colonies increases. The earliest indication of fungal involvement may only be seen as iridescent silver or white metallic flashes in the exudate as it is moved around in front of the endoscope by the irrigation solution (Fig. 5-68). This phenomenon can be seen at any stage of involvement of fungal growth or turbinate destruction but is less commonly seen as the disease

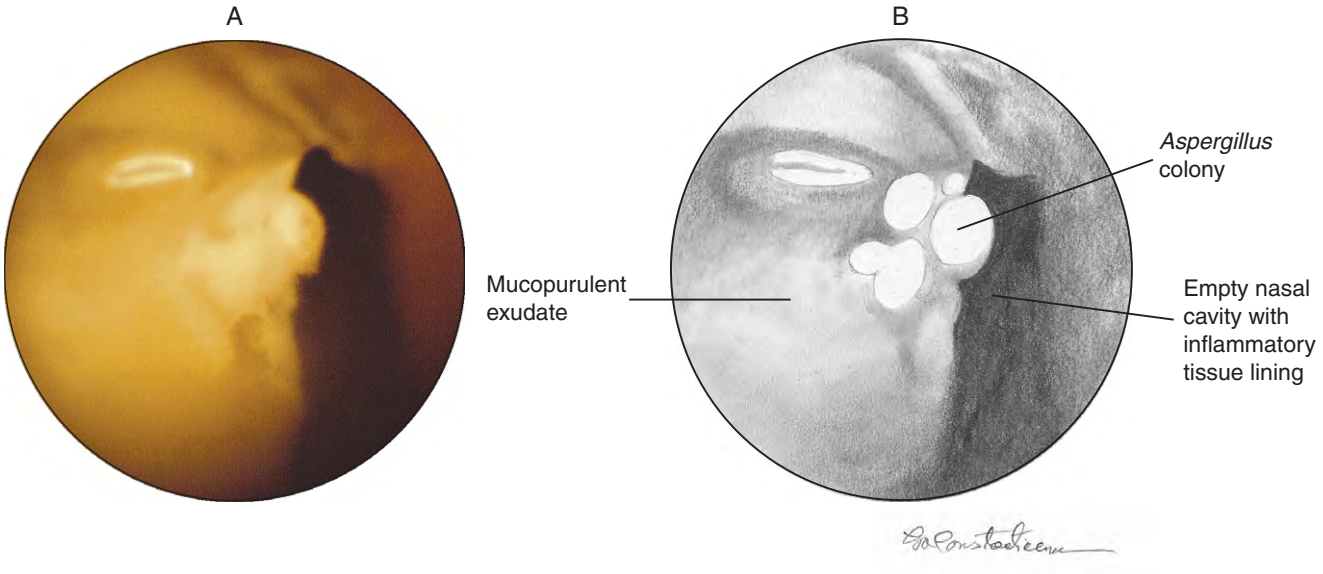



**Fig. 5-69**
An upright spherical *Aspergillus* spp. colony in the nasal cavity of a dog. The colony is siting on a layer of mucopurulent exudate.

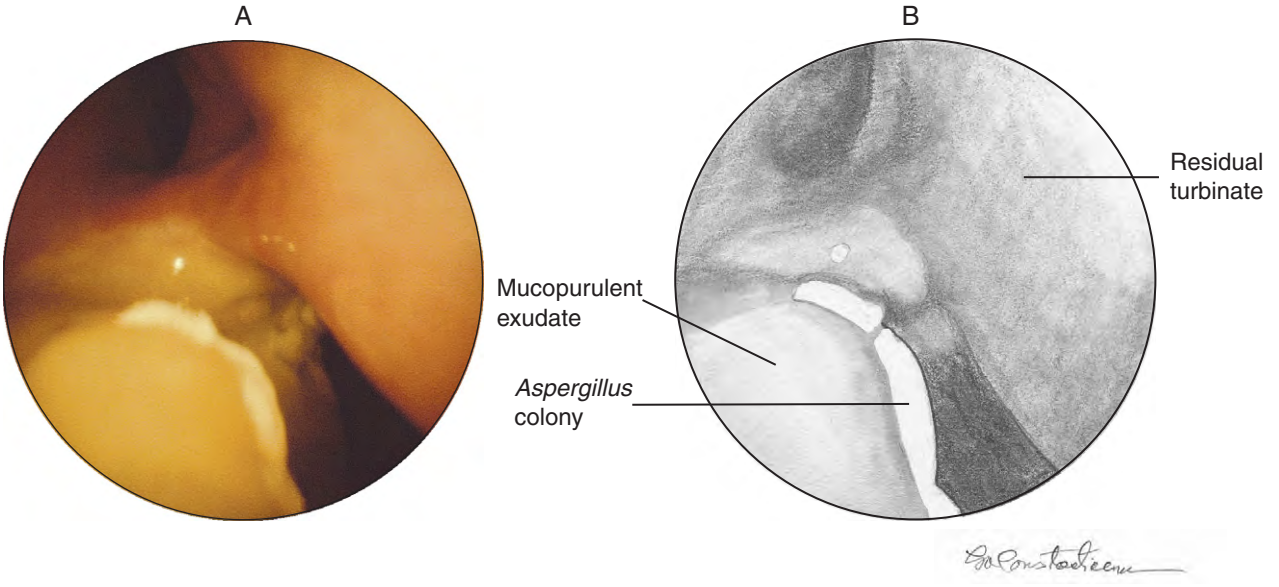



**Fig. 5-70**
A flat, irregular *Aspergillus* spp. colony.

progresses, fungal colonies enlarge, and the nasal cavity becomes more open. Actual fungal colonies may or may not be seen at this early stage of involvement. Small early fungal colonies appear as white dull or shiny masses sitting directly on the mucosa or more commonly on a bed of granulation tissue covered with a layer of mucopurulent exudate (Fig. 5-69). Fungal colonies can be flat and irregular with a bright white, nonglistening surface (Fig. 5-70), upright spherical structures (see Fig. 5-69), or fimbriated colonies (Fig. 5-71) sitting on top of flat fungal colonies or directly on the underlying mucopurulent exudate. With this progression, there may be less free fungal material in the exudate or the examination may be done over exudate and fungal colonies that are more adherent to the granulation tissue surface. As *Aspergillus niger* colonies enlarge, they develop a grayish to black color and become solid sheets of fungal material covering significant areas of the nasal cavity

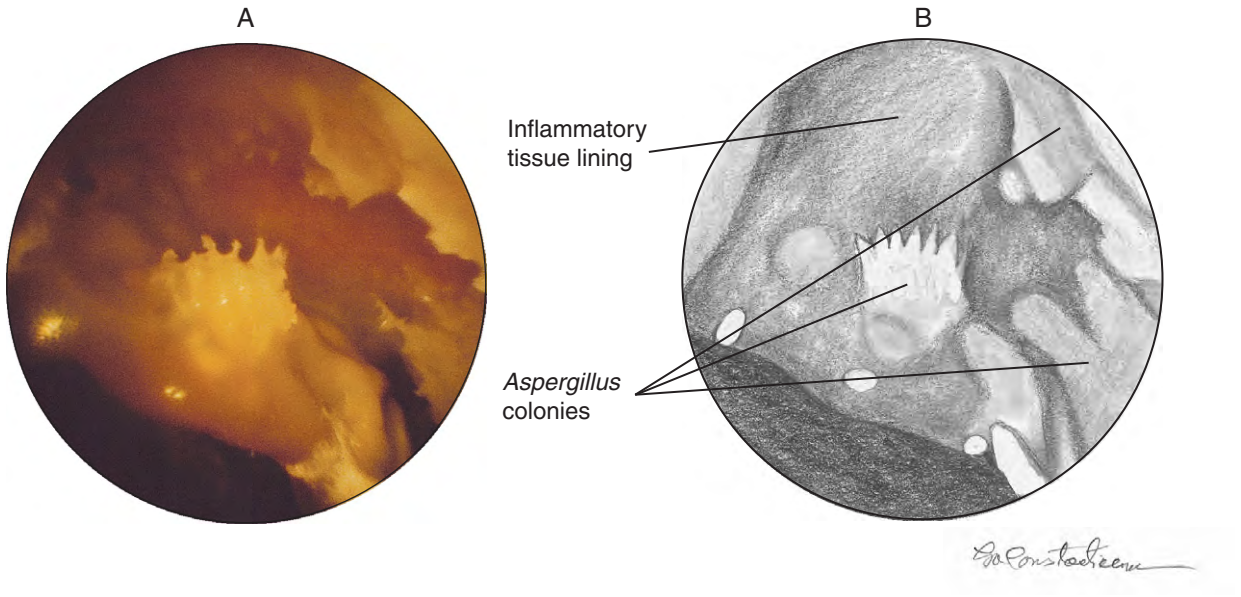



**Fig. 5–71**
A small, fimbriated *Aspergillus* spp. colony.

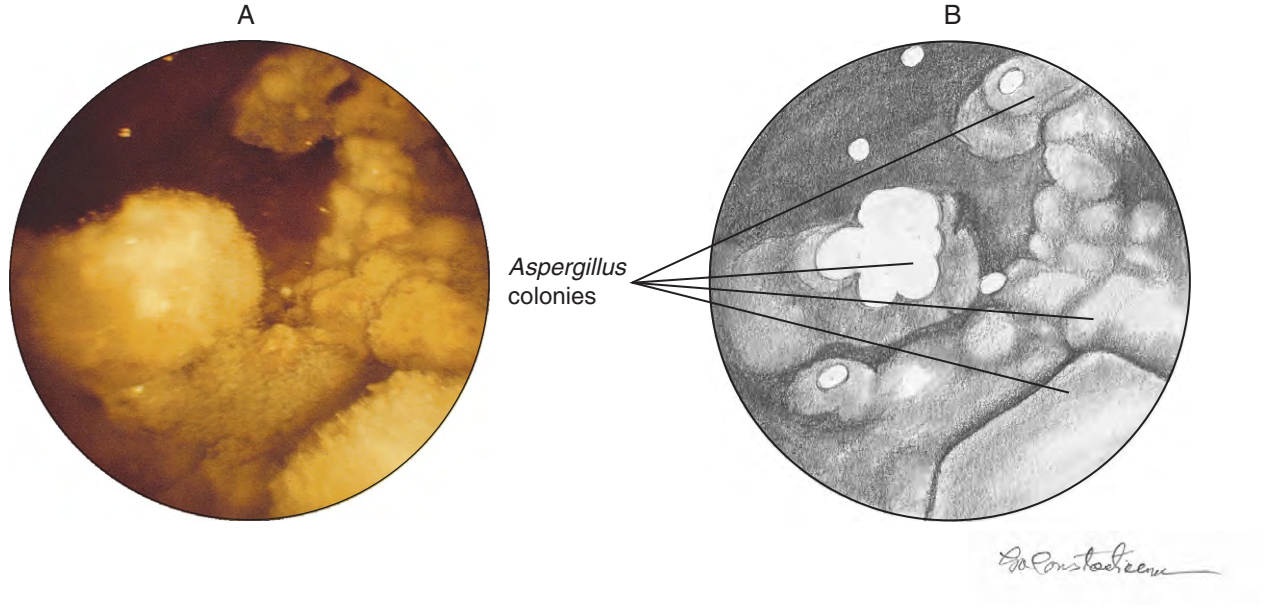



**Fig. 5–72**
Large, gray and white *Aspergillus* spp. colonies. These colonies are hard and dry.

(Fig. 5-72). These larger fungal colonies are dry and hard, and can be felt as a hard, rigid structure when contacted with the endoscope or biopsy instruments. They are usually found on the floor of the nasal cavity within a large empty space and sitting on granulation tissue or a layer of exudate. Removal of fungal colonies can be performed endoscopically with irrigation, suction, and repeated biopsies.

Fungal colonies may be found in the frontal sinuses when they cannot be seen in the nasal cavity. The appearance of the nasal cavity and progression of destructive events appear to be the same with frontal sinus involvement as with nasal cavity infections, even though colonies are not present in the nasal cavity itself. The primary indication of frontal sinus involvement is a concentration of

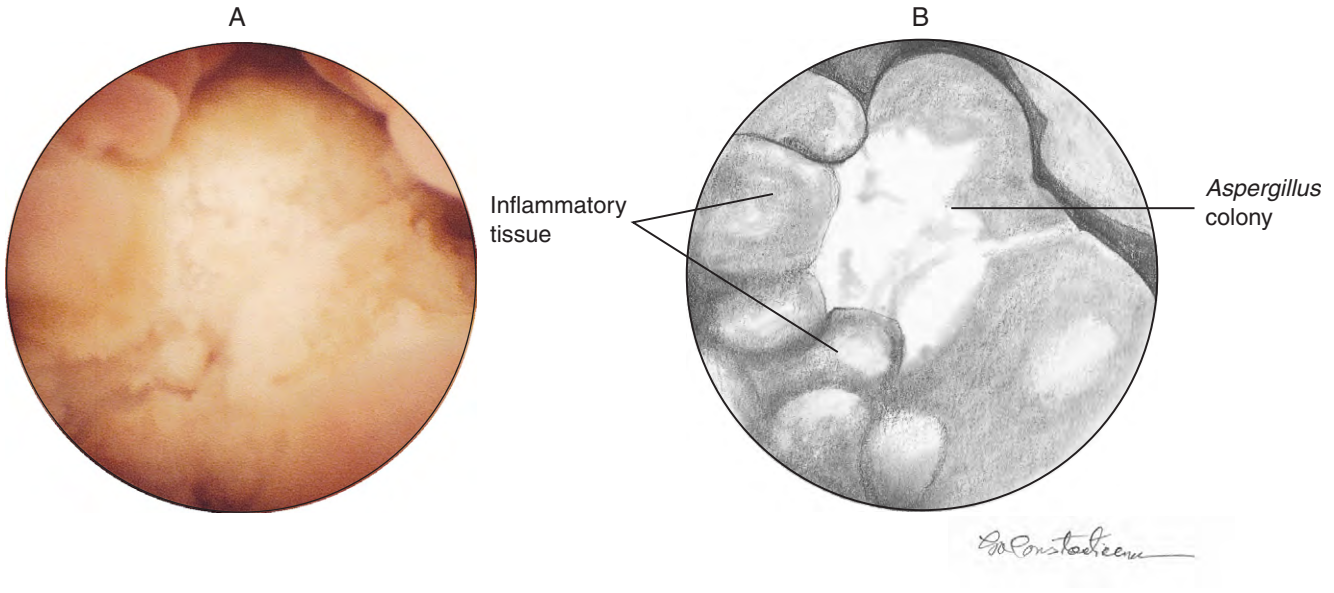



**Fig. 5-73**
A large fungal mass in the frontal sinus of a cat accessed via the nasal cavity.

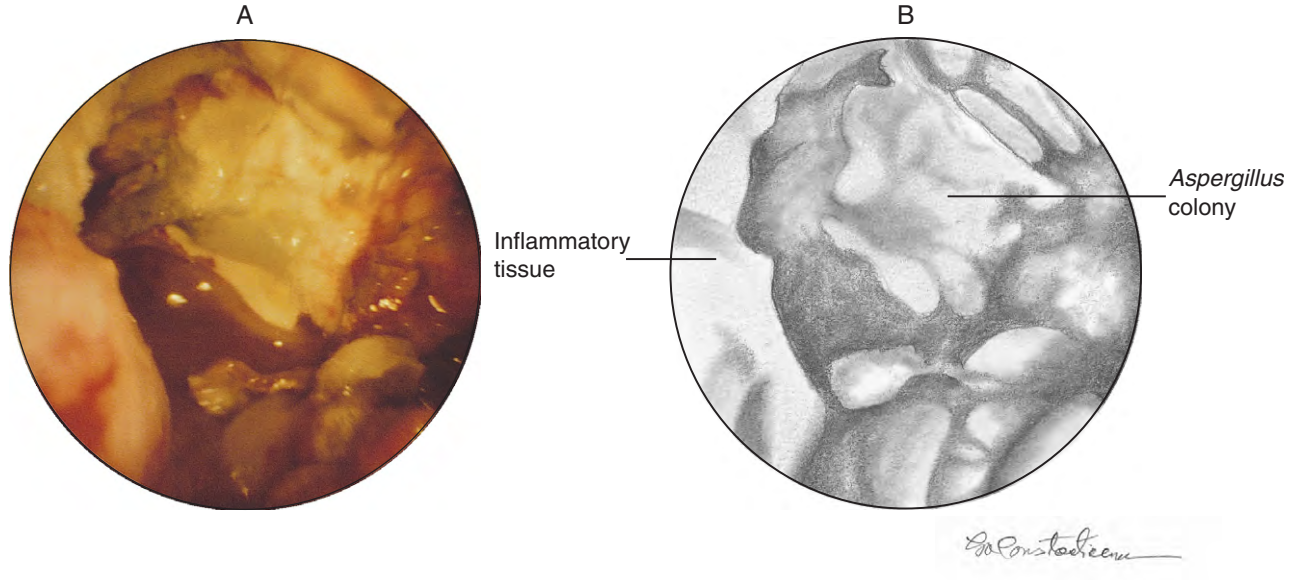



**Fig. 5-74**
A large *Aspergillus* spp. colony in the frontal sinus of a dog with signs of chronic rhinitis. The frontal sinus in this case was accessed by trephining a hole in the dorsal wall of the frontal sinus and placing the endoscope through the hole into the frontal sinus.

thick mucopurulent exudate dorsally in the caudal or caudolateral aspect of the nasal cavity. This exudate is usually unilateral and no other disease process is evident. In these cases, radiography usually shows increased density of the involved frontal sinus. Involvement may appear as generalized increased fluid density of the entire cavity or as an irregular increased density on the floor of the frontal sinus. These cases may be evaluated further by frontal sinoscopy with access via trephination of the frontal sinus or occasionally via the nasal cavity (Fig. 5-73). Fungal colonies in the frontal sinuses are generally large and easily seen with exudate under the colonies but not covering them (Fig. 5-74). There is typically a contralateral response to frontal sinus infections with thickening

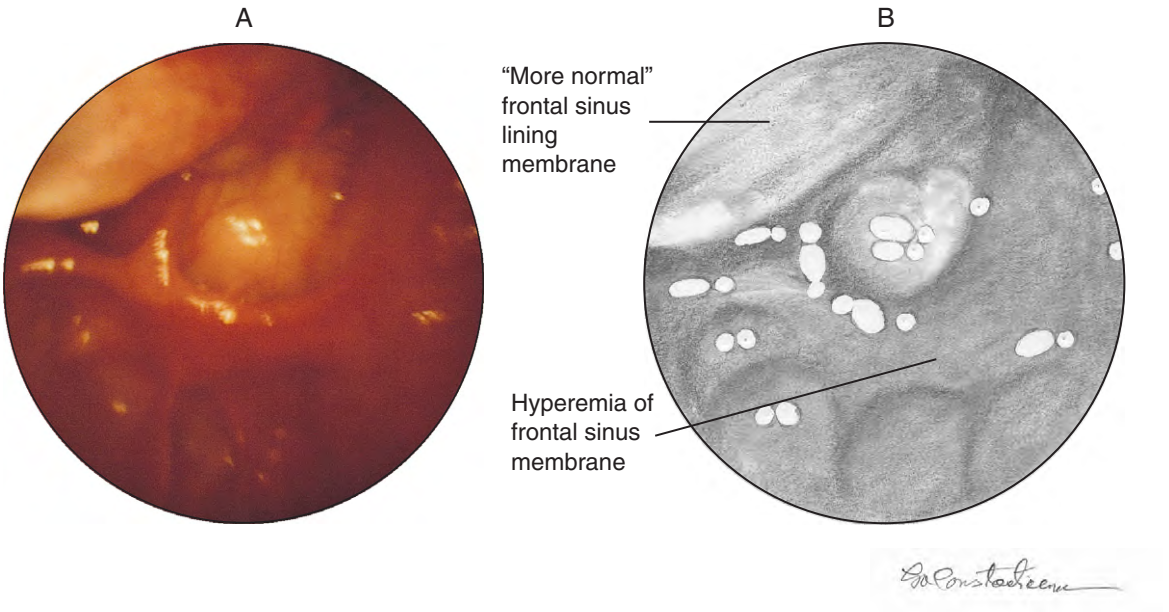



**Fig. 5–75**
The contralateral frontal sinus in a dog with frontal sinus *Aspergillus* spp. infection showing marked mucosal thickening, hyperemia, and inflammation without any fungal colonies.

and hyperemia of the mucosa, limited exudate, and no visible fungal colonies (Fig. 5-75).

Fluid irrigation may or may not be required for examination of the frontal sinus in the presence of fungal infection. If there is extensive exudate in the frontal sinus, irrigation is required. If the frontal sinus is air filled with a dry fungal mass on its floor, then irrigation may not be required. The procedure is usually started dry and irrigation is added if needed.

Frontal sinus fungal colonies can be removed endoscopically either from the nasal cavity or through the trephine hole. Irrigation, suction, repeated biopsies, and curettage are used for fungal colony removal. Frontal sinus and nasal cavity tube placement can be performed at the time of frontal sinoscopy if fungal colonies are found.

## Nasal Foreign Bodies

Foreign bodies are uncommon in dogs and cats with chronic nasal disease. Chronicity of most cases presented to a referral practice for evaluation with rhinoscopy has excluded most cases of acute nasal disease and has therefore skewed population statistics. A variety of nasal foreign bodies has been found including grass awns (Fig. 5-76), blades of grass (Fig. 5-77), sticks (Fig. 5-78), beans (Fig. 5-79), conifer needles (Fig. 5-80), pieces of bone (Fig. 5-81), metal fragments from gunshot wounds (Fig. 5-82), fracture fragments (Fig. 5-83), and mineralized amorphous material of unidentifiable origin (Fig. 5-84). Iatrogenic sources of nasal foreign bodies include orthopedic implants (Fig. 5-85) and the flap of bone elevated for exposure of the nasal cavity during dorsal rhinotomy (Fig. 5-86). When replaced, this bone frequently becomes an avascular free sequestrum (Fig. 5-87) that incites a chronic exudative inflammatory process.

Foreign bodies may enter the nasal cavity from the rostral end through the external nares, from the caudal end through the nasopharynx, and transversely through the bones surrounding the nasal cavity from the sides of the face or through the hard palate from the oral cavity. The caudal route is thought to occur with vomiting or regurgitation when there is failure of closure of the nasopharyngeal sphincter. Foreign material found in these cases may be single (Fig. 5-88) or multiple (see Fig. 5-78). Many are too large to have entered through the external nares.

The nasal exudate that occurs with foreign bodies is usually mucopurulent to purulent and is most commonly unilateral. Bilateral exudation may occur if there are bilateral foreign bodies or if a foreign body is lodged in the nasopharynx. There is usually a sufficient quantity of purulent to mucopurulent exudate to completely hide the foreign material. The presence of foreign bodies may not become apparent until irrigation has removed sufficient exudate for visualization. If areas of thick exudate are found in the absence of other defined diseases, persistent irrigation is done until the exudate is completely removed.

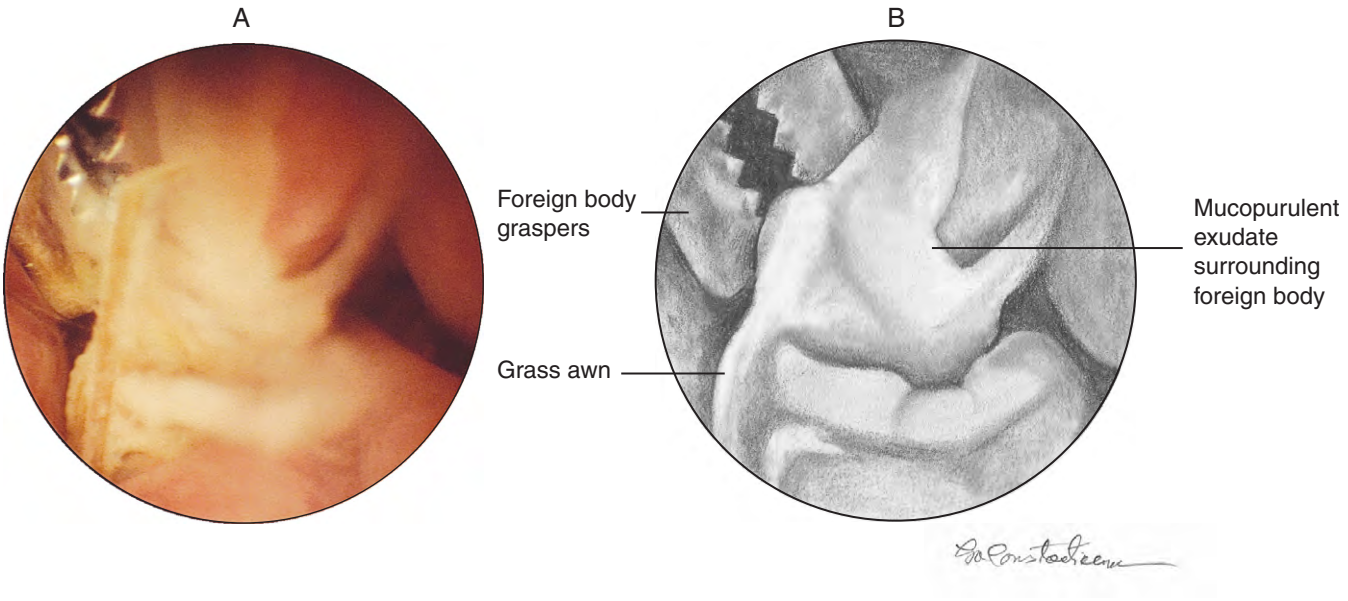



**Fig. 5-76**
Removal of a grass awn from the nasal cavity of a dog using an alligator forceps passed parallel to the telescope.

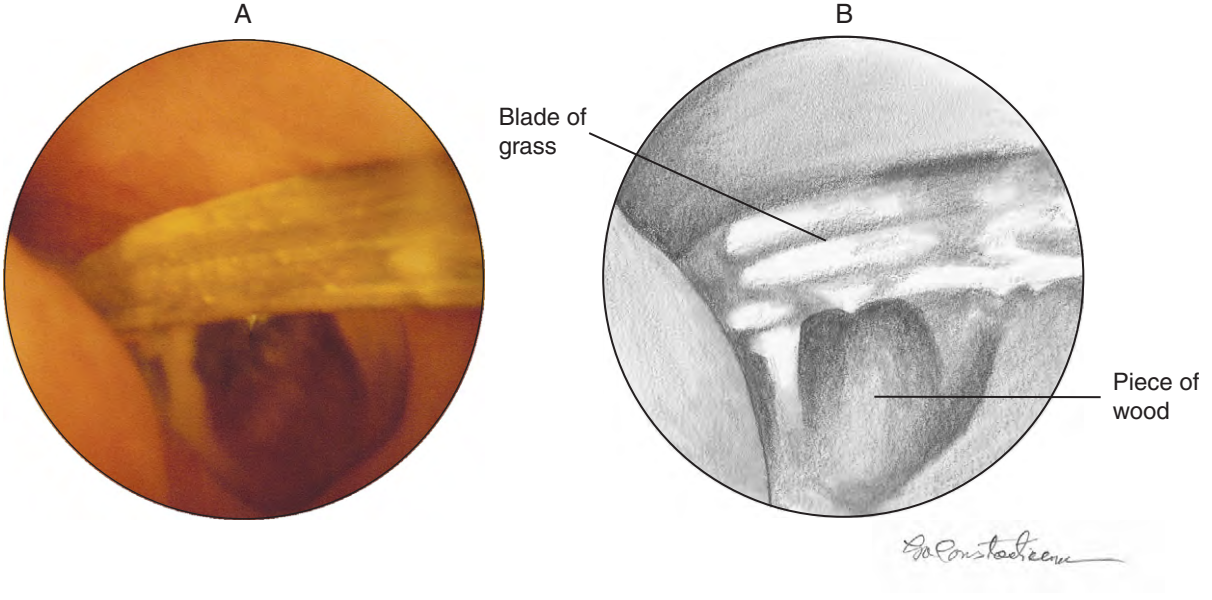



**Fig. 5-77**
Blade of grass in the nasal cavity of a 1-year-old Bull Terrier with multiple nasal foreign bodies.

Foreign bodies are removed under endoscopic visualization using foreign body removal forceps designed for endoscopic application or with alligator forceps of appropriate length. Smaller foreign bodies are removed rostrally by retraction with forceps. Larger foreign material must be pushed caudally into the nasopharynx or pharynx for removal. Large bone foreign bodies have been found in the nasopharynx that were lodged firmly in place between the bone of the hard palate and the vomer dorsoventrally or between the palatine bones laterally. Considerable force may be required for their removal. If a foreign body is pushed into the nasopharynx, rostral retraction of the soft palate may be required to locate and remove the foreign material from this area. Vigorous irrigation is done after foreign body extraction to remove residual exudate and minimize the chance for persistent infection. All foreign bodies encountered during rhinoscopy in the series of cases I have performed were removed endoscopically (excluding orthopedic implants). Surgery could potentially be required for multiple foreign bodies or those that are fixed in place and cannot be dislodged with the endoscope.




**Fig. 5-78**
A stick and other material removed from the nose of the dog in Fig. 5-77 with multiple recurrent nasal foreign bodies. This dog would get into the garbage, develop gastroenteritis with vomiting, and then develop rhinitis secondary to multiple nasal foreign bodies.

## Dental Disease

Dental disease can cause unilateral or bilateral rhinitis with unilateral or bilateral clear watery, mucoid, mucopurulent, or purulent discharge. The infection and inflammation can originate from periapical abscesses or severe gingivitis associated with bone erosion around the roots of any of the maxillary or premaxillary teeth. The most common teeth involved are the upper canine teeth, the upper fourth premolar, and upper first molar because of their size and root configurations. Involvement can, however, include the entire upper dental arcade on one or

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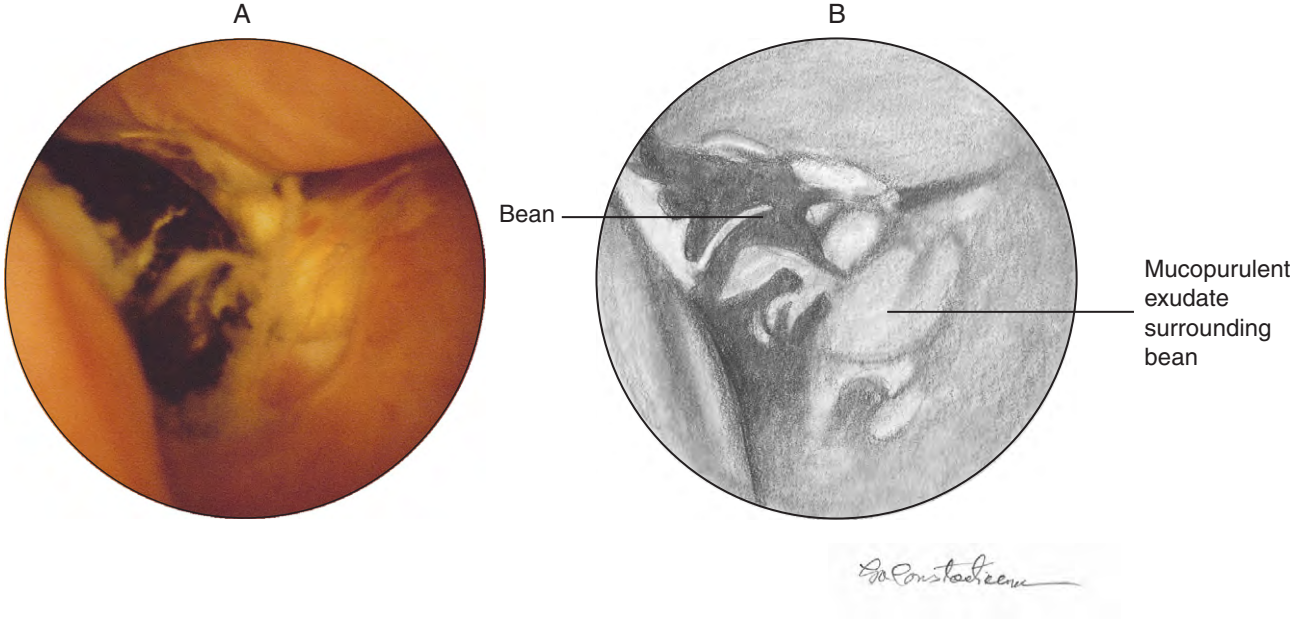



**Fig. 5-79**
A bean in the nasal cavity of the same dog as in Figs. 5-77 and 5-78. This foreign body was found at a third rhinoscopic examination 9 months after the rhinoscopy shown in Fig. 5-77. This dog was normal between episodes of nasal discharge that occurred after episodes of vomiting.

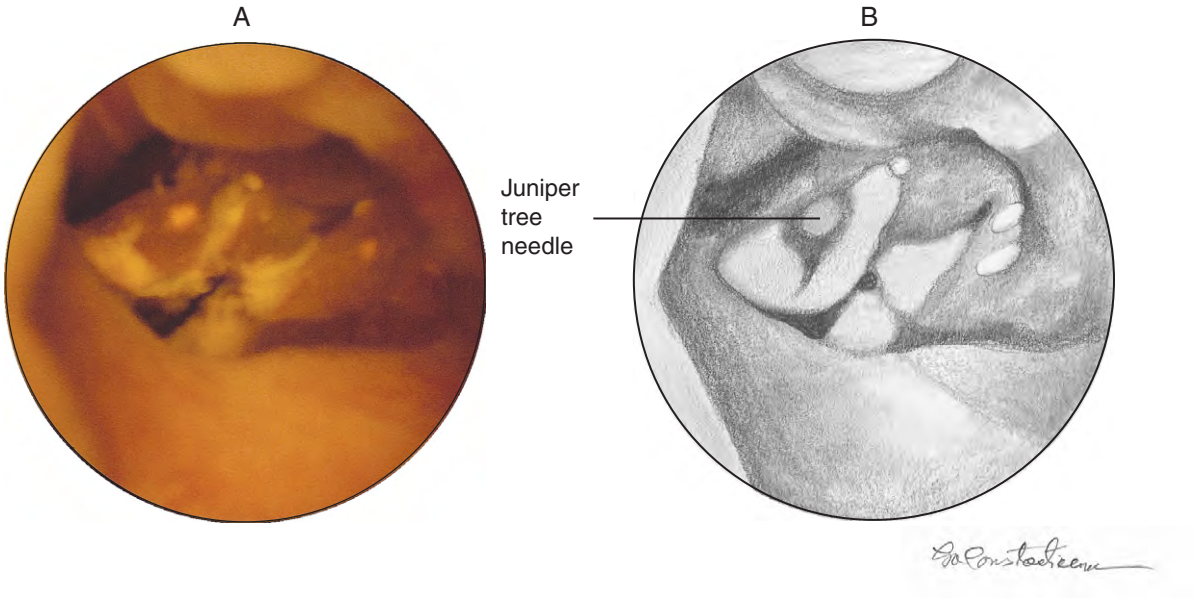



**Fig. 5-80**
A Juniper tree needle in the nose of a small dog with chronic nasal discharge and sneezing.

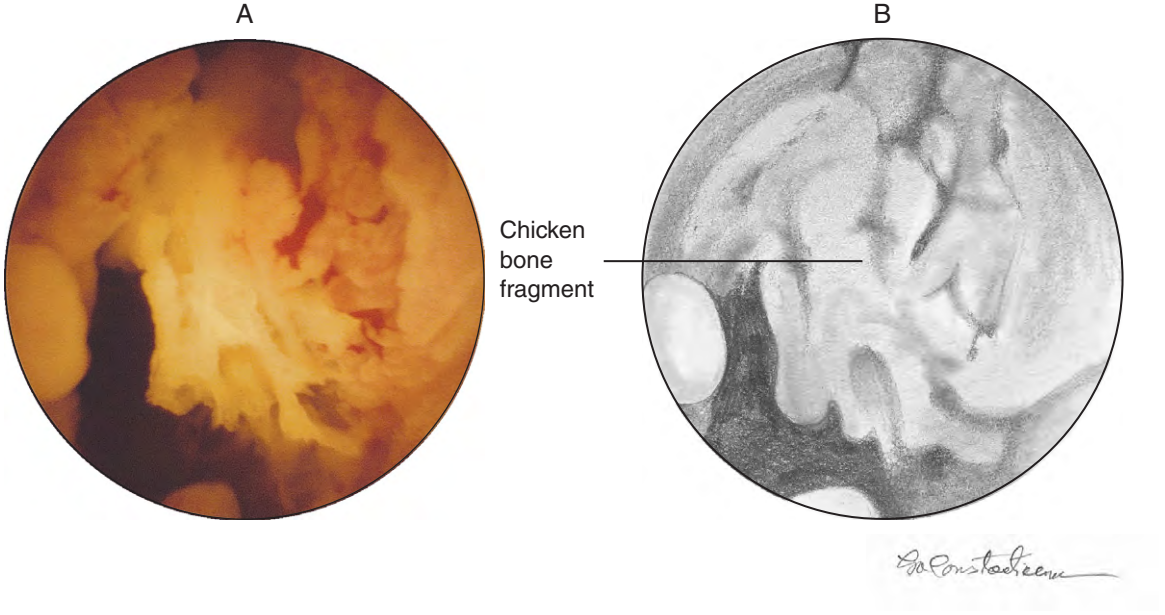



**Fig. 5-81**
A fragment of a chicken bone in the nasopharynx of a 2-year-old Poodle. This dog had an acute onset of dyspnea, reverse sneezing, wheezing, and partial nasal obstruction after eating chicken bones.

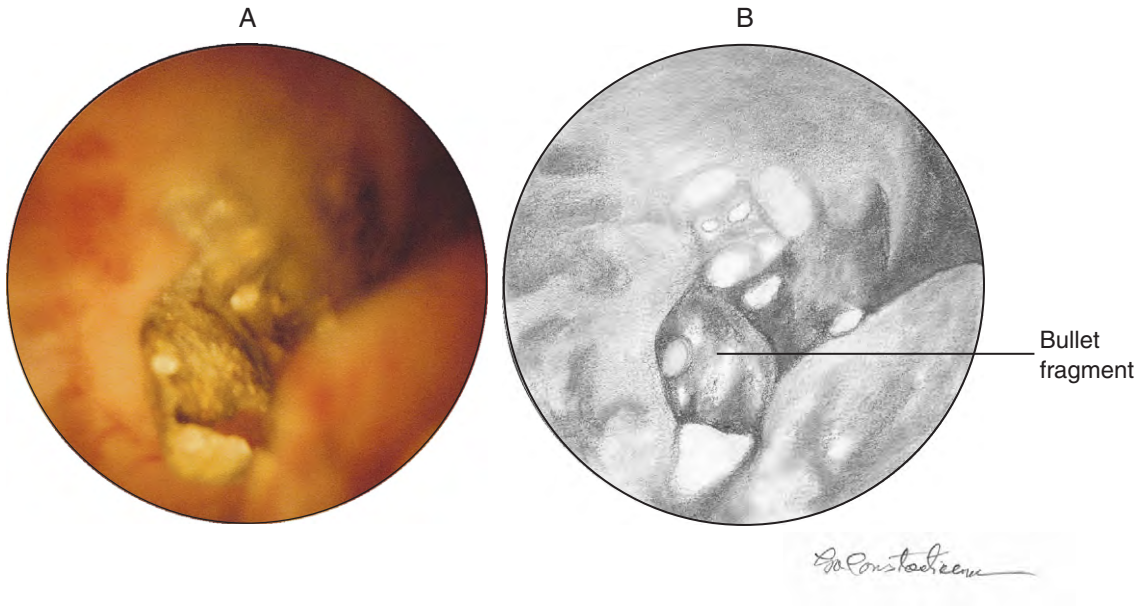



**Fig. 5-82**
A bullet fragment in the nasal cavity of a dog that had a chronic nasal discharge for 6 years since it had been shot in the face. This dog had a positive serologic titer to *Aspergillus* spp. that resolved following removal of the foreign material and without any other treatment.

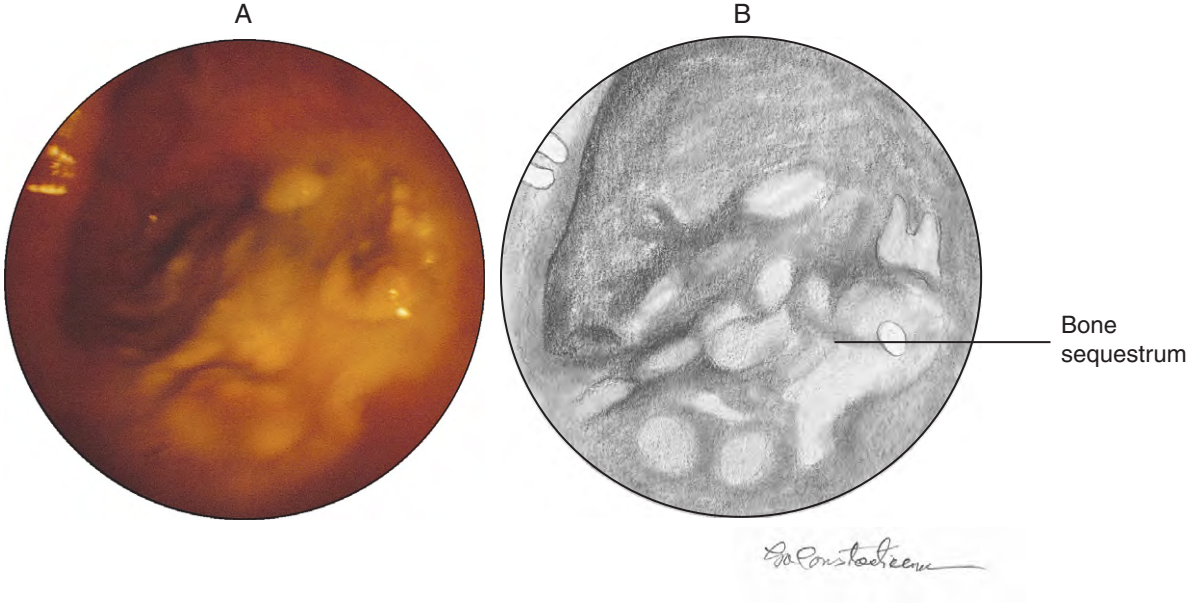



**Fig. 5-83**
A bone sequestrum on the floor of the frontal sinus of a dog with chronic nasal discharge, and a draining fistula from the frontal sinus was seen using frontal sinoscopy through the open draining fistula. This dog had been hit in the head and sustained fractures of the dorsal lamina of the frontal sinus several years before presentation for rhinoscopy.

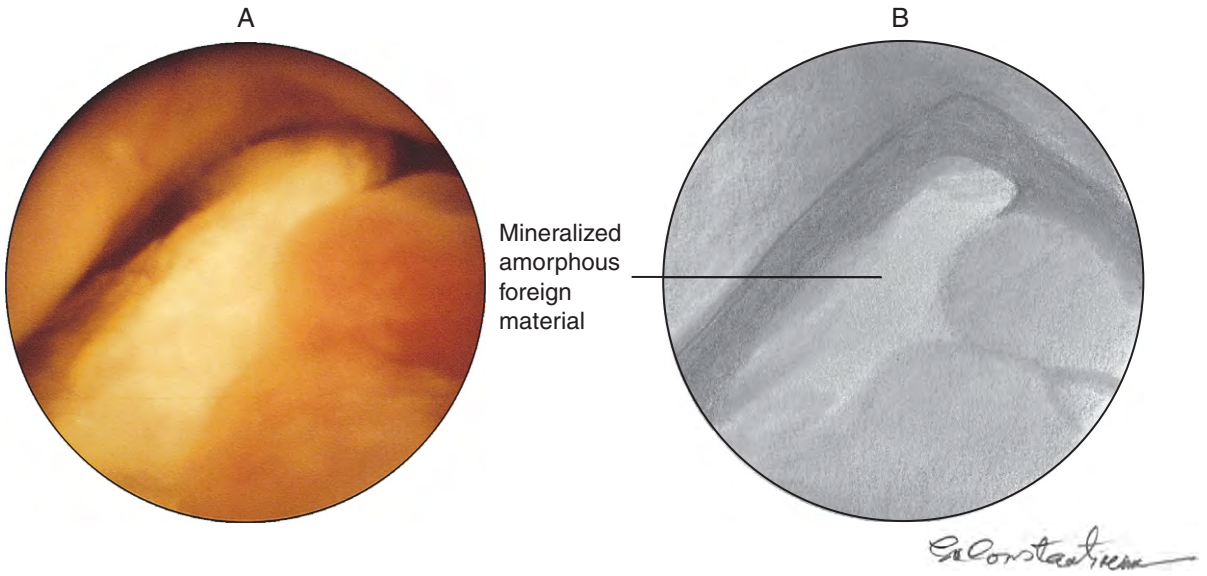



**Fig. 5-84**
A fragment of mineralized amorphous material of unidentifiable origin in a dog with severe epistaxis.

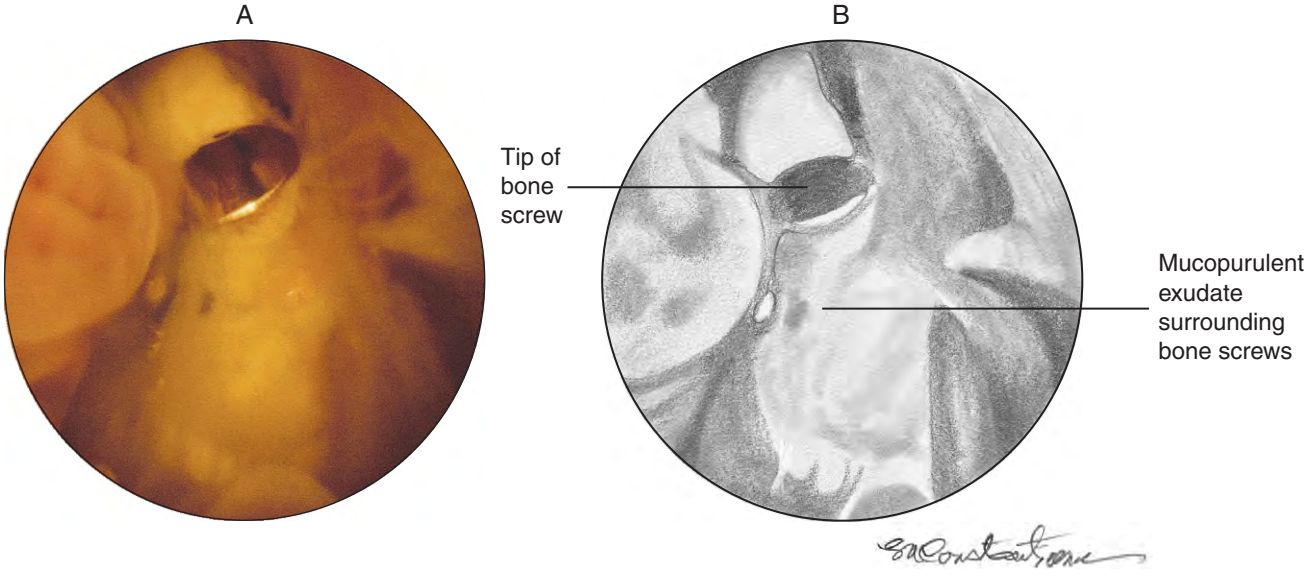



**Fig. 5-85**
A bone screw visible in the nasal cavity of a dog with a chronic nasal discharge. Maxillary fractures had been repaired with bilateral bone plates and the screws extended into the nasal cavity. Removal of the implants resolved the nasal discharge.

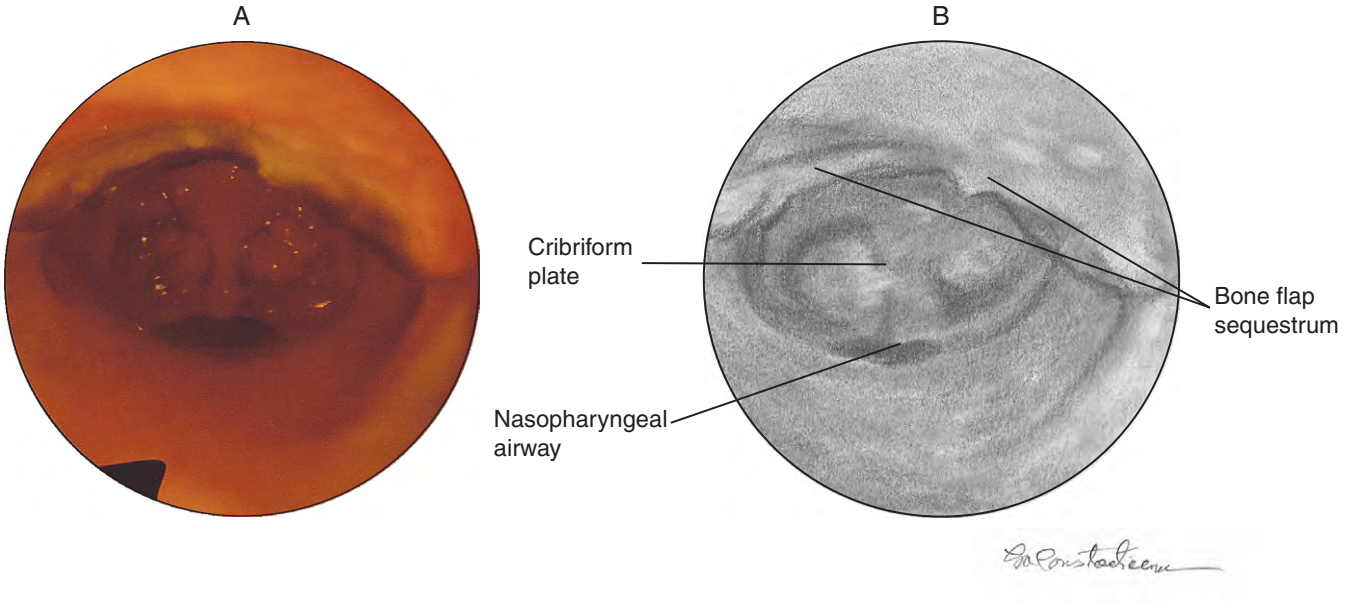



**Fig. 5-86**
Rhinoscopy performed 1 month after a total turbinectomy for a nasal adenocarcinoma. The rim of white visible across the dorsal aspect of the empty nasal cavity is the nasal bone flap that was created for access to the nasal cavity. This free flap of bone became a sequestrum.

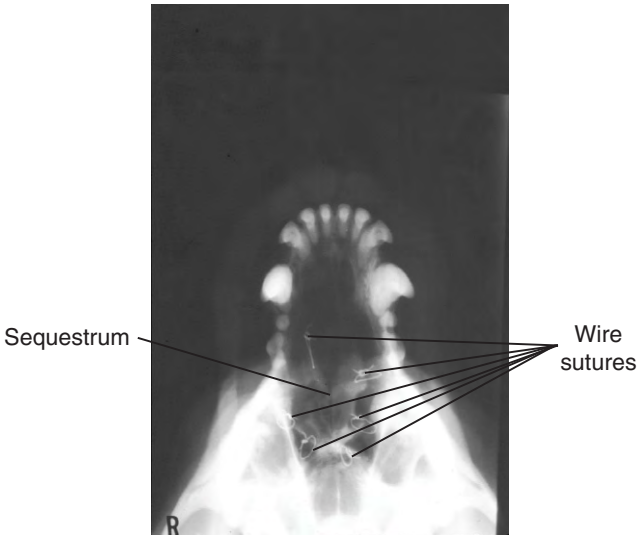



**Fig. 5-87**
An open mouth ventrodorsal radiographic projection of the nasal cavity in this dog showing the sequestrum.




**Fig. 5-88**
A single bone fragment foreign body removed from the nasopharynx of a dog. This bone fragment was too large to take out rostrally and was removed by pushing it caudally into the pharynx.

both sides. The incidence of rhinitis secondary to dental disease has decreased as improved dental care has become common in small animal practice.

Exudate in the nasal cavity of dogs with rhinitis secondary to dental disease is characteristic in close proximity to the involved teeth but is extremely variable in quantity and appearance throughout the remainder of the nasal cavity. Discharge from the external nares is usually mild, clear, and watery or mucoid even in the presence of severe dental involvement and rhinitis. Exudate in the nasal cavity, but not in close proximity to the involved area of the dental arcade, is variable in quantity and type. The appearance and amount of exudate does not seem to be related to the severity of the dental disease. The character of the exudate may be more mucoid than purulent or mucopurulent when compared with the extent of dental disease present and the amount of exudate seen with other nasal inflammatory processes. Exudate found ventrolaterally in the nasal cavity associated with areas of dental involvement is characteristic and specific to rhinitis induced by dental disease (Fig. 5-89). The exudate in the area of dental disease is white, thick flocculent material that is well delineated from the surrounding, more fluid exudate in the remainder of the nasal cavity. This material is basically the same inspissated purulent material seen in the oral cavity around tooth roots with severe periodontal disease (Fig. 5-90). When irrigated vigorously, the exudate breaks off in discrete chunks. Tissue under the areas of the exudate is inflamed, hyperemic, and ulcerated. Roots of involved teeth generally cannot be seen in the endoscopic field. In many cases, flow of irrigant can be seen in the oral cavity coming from around involved teeth. Probing around the roots of involved teeth may reveal loss of bone between the root and the nasal cavity. Direct communication between the oral and nasal cavities (Fig. 5-91) is found in many cases. Extraction of involved teeth results in resolution of nasal discharge and rhinitis. Oral nasal fistulae may result following removal of these involved teeth and surgical closure is required or rhinitis may persist.

Dental disease is always considered as a cause of nasal discharge in older, especially smaller breed, dogs that have significant dental disease. It is not ruled out in larger dogs, or in dogs without significant obvious dental disease or gingivitis. Roots of the maxillary teeth are assessed carefully on radiographs, and the teeth examined carefully under anesthesia for evidence of bone recession and periapical abscesses. Additional oblique radiographic views or dental films of the maxillary teeth may be needed before rhinoscopy is initiated if suspicious areas are found. Rhinoscopic examination is then directed at these areas. Enlargement of bone in the area of tooth roots may indicate dental disease (Fig. 5-92), but, without penetration into the nasal cavity or accumulation of exudate, these teeth are not the ones causing the rhinitis.

Bacterial culture samples are submitted when dental disease is diagnosed, but submission of fungal cultures is optional. Biopsy specimens of the involved areas of nasal mucosa are obtained and may be sent or saved for future submission if there is not an adequate response to treatment of the dental disease. Neoplasia can occur

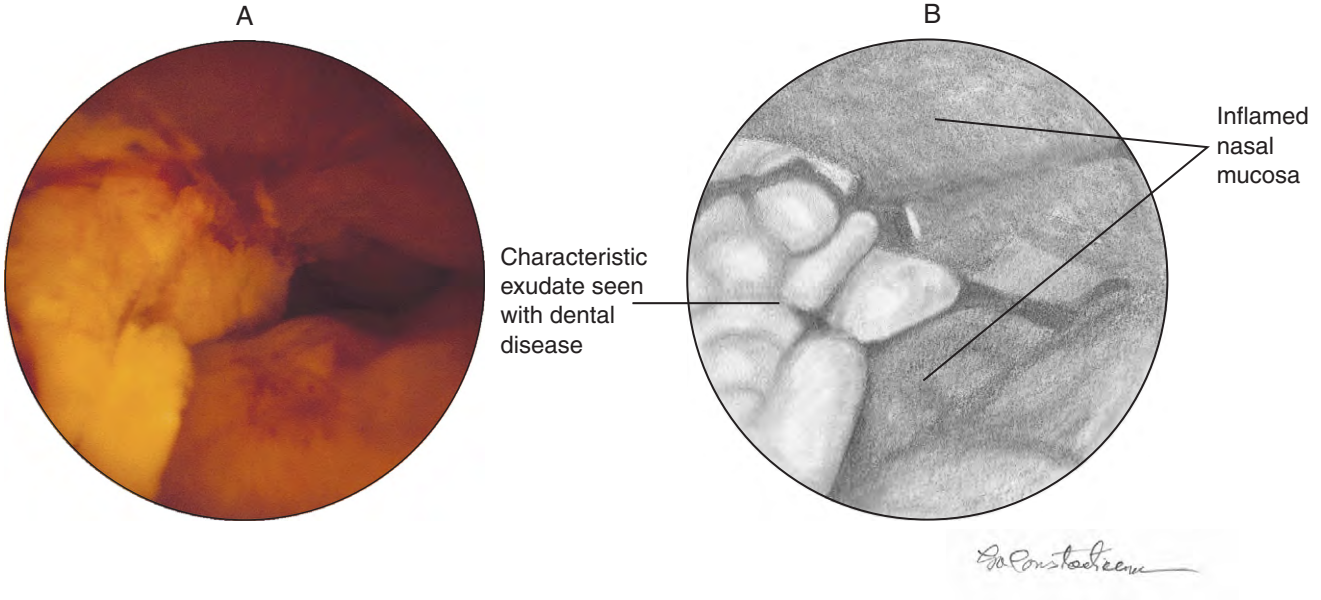



**Fig. 5-89**
Characteristic exudate adjacent to involved roots of teeth in the nasal cavity of a dog with nasal discharge and rhinitis secondary to dental disease.

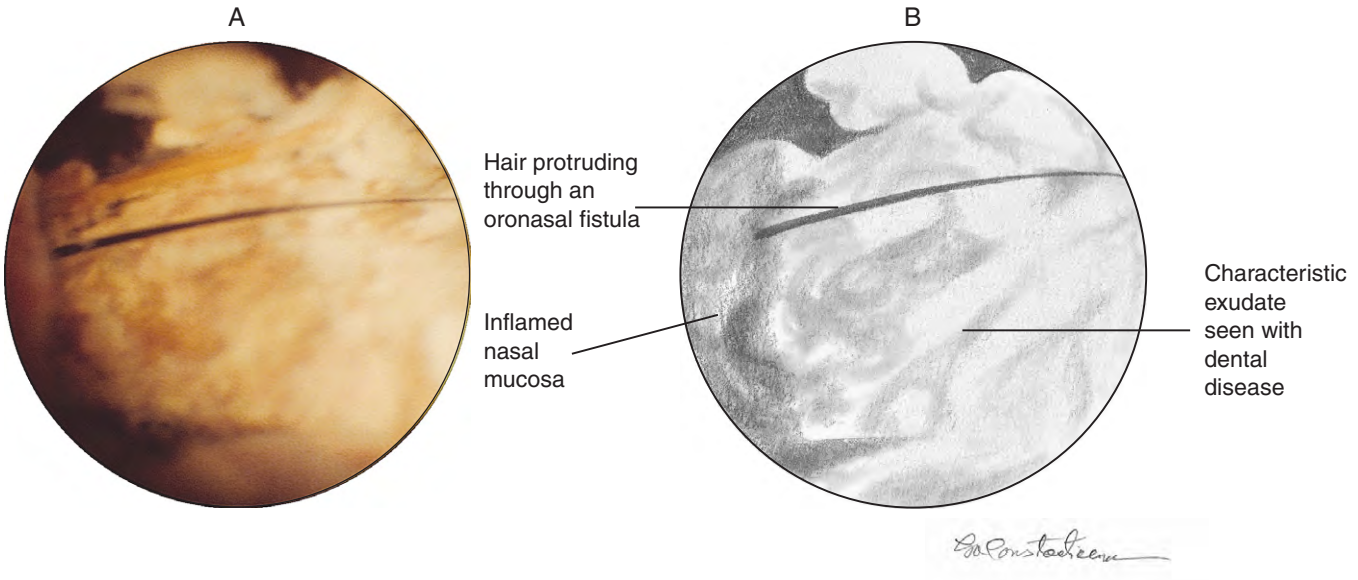



**Fig. 5-90**
Exudate and hair in the nasal cavity in a dog with rhinitis secondary to dental disease with oronasal fistulae around the upper canine teeth.

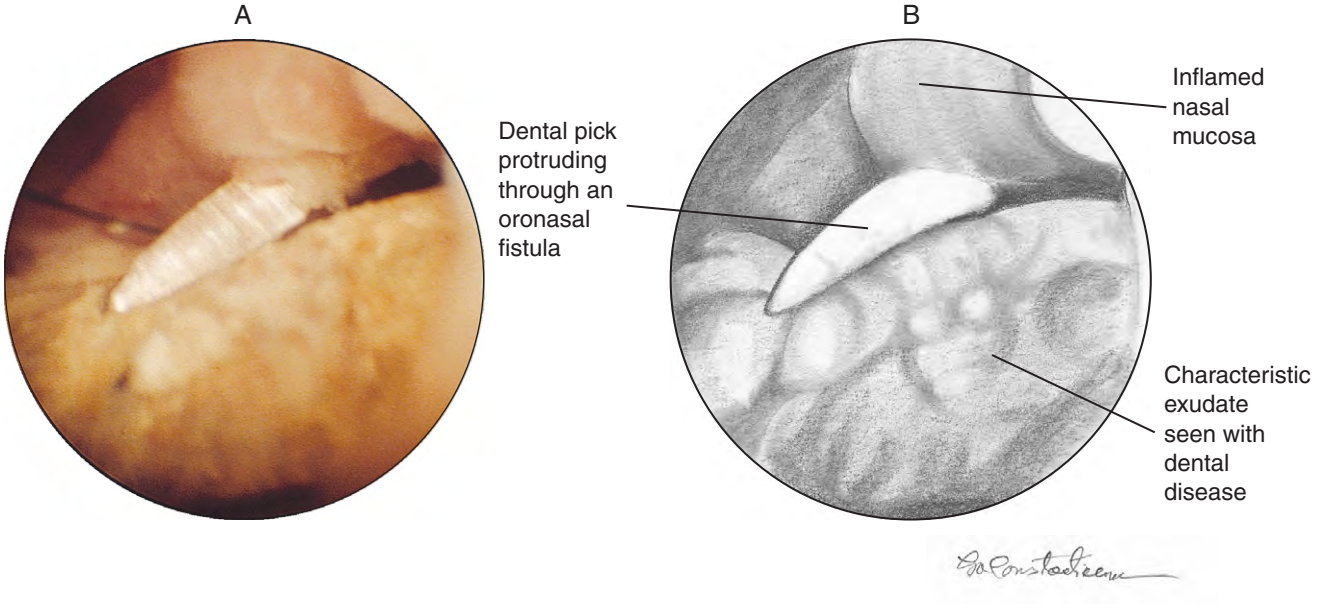



**Fig. 5-91**
A dental pick visible in the nasal cavity that is passing through an oronasal fistula in a dog with rhinitis secondary to dental disease.

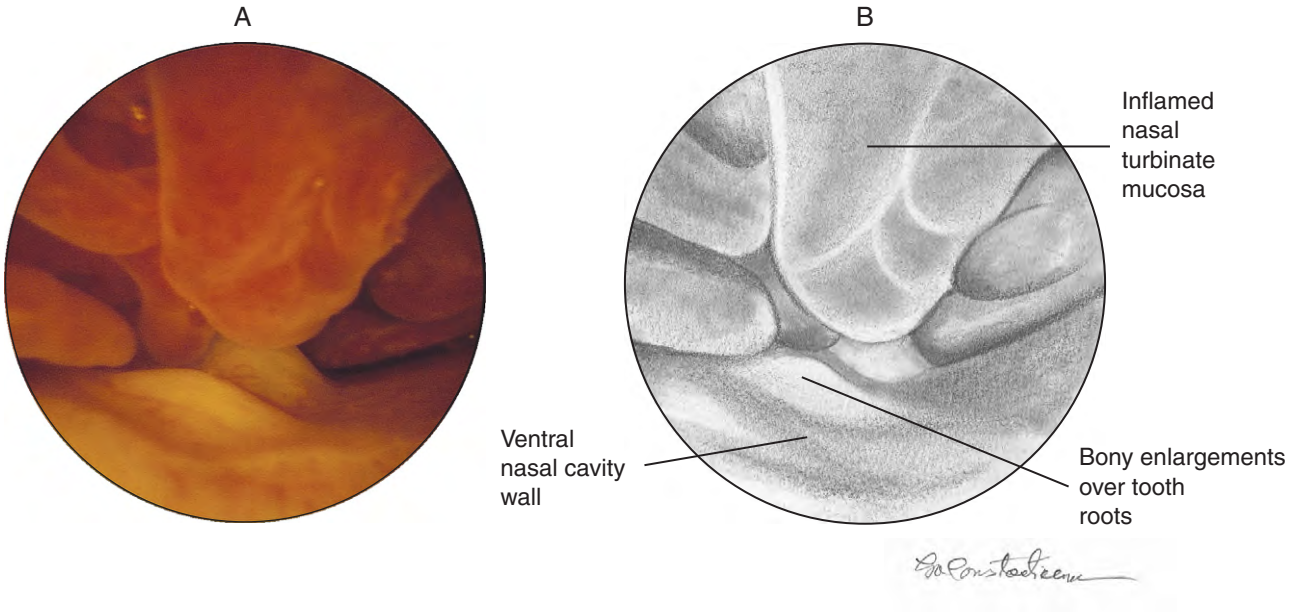



**Fig. 5-92**
Enlargements of bone over tooth roots in a dog with rhinitis resulting from dental disease. The mucosa in this case is roughened and the turbinates are mildly distorted.

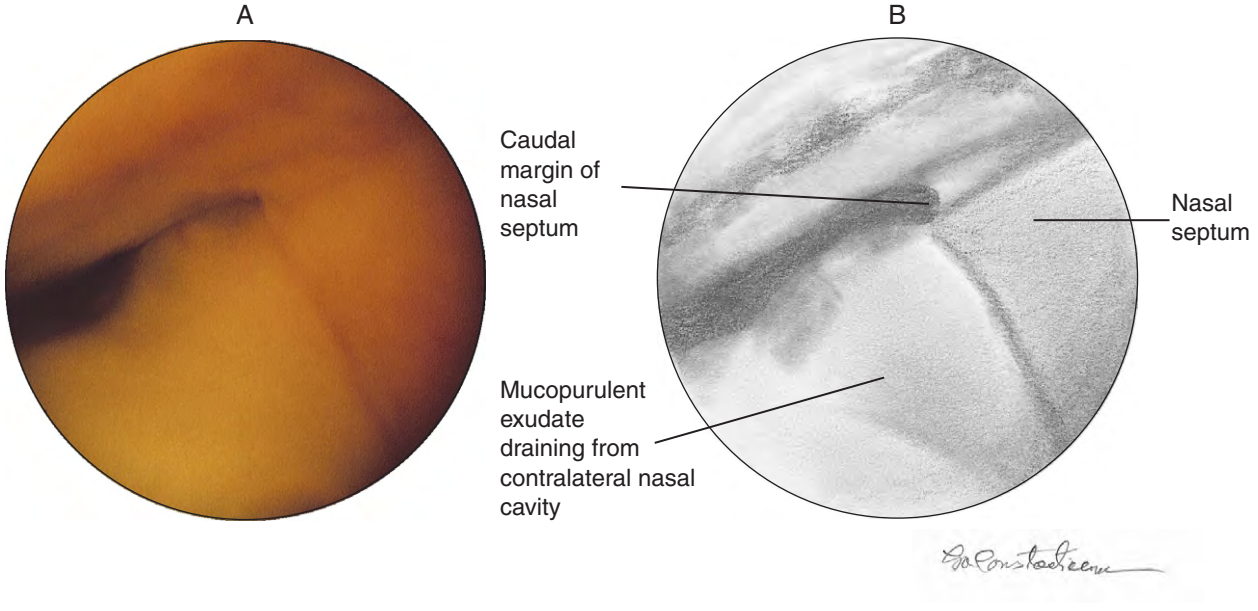



**Fig. 5-93**
The typical appearance of mucopurulent exudate in the nasal cavity of a dog with allergic rhinitis. This picture shows a strand of exudate hanging over the caudal edge of the nasal septum.

concurrently with dental disease and any suspicious tissues are submitted.

## Allergic Rhinitis

Allergies are an additional etiology for chronic rhinitis. Dogs presented with bilateral mucoid or mucopurulent nasal discharge with or without other systemic or dermatologic signs of allergies are suspect. Radiographic assessment in these cases usually reveals turbinate thickening that is bilateral and diffuse without evidence of turbinate or bone destruction. There may or may not be radiographically detectable frontal sinus involvement. Rhinoscopy reveals copious mucoid to mucopurulent nasal discharge (Fig. 5-93) that may completely fill both nasal cavities

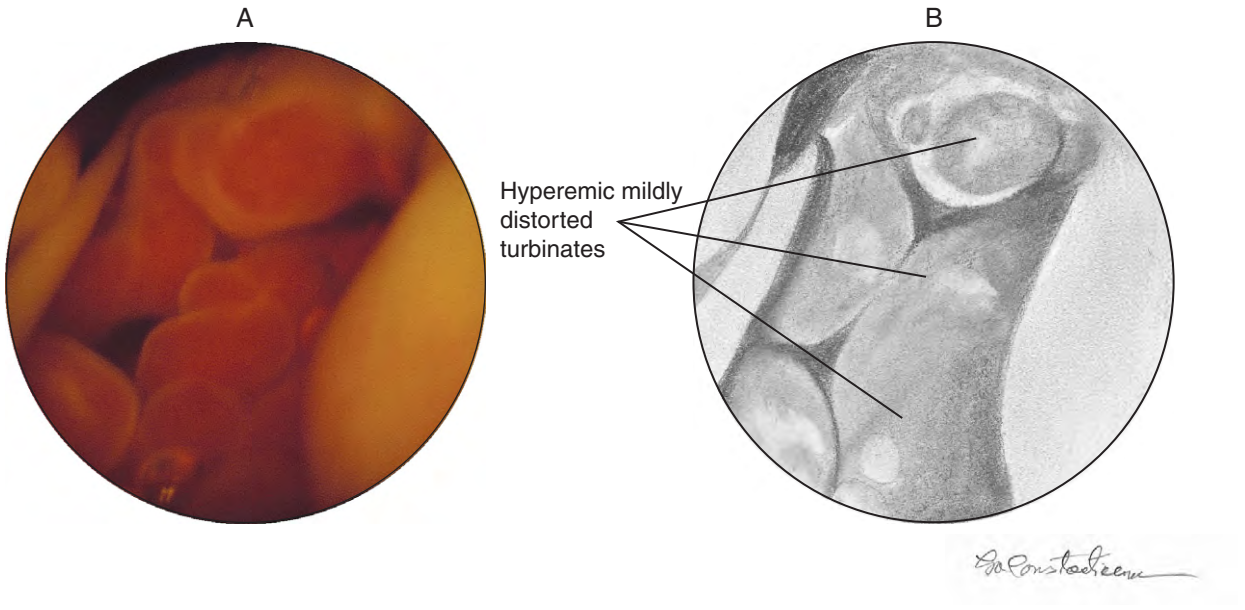



**Fig. 5-94**
Mucosal hyperemia in a dog with allergic rhinitis.

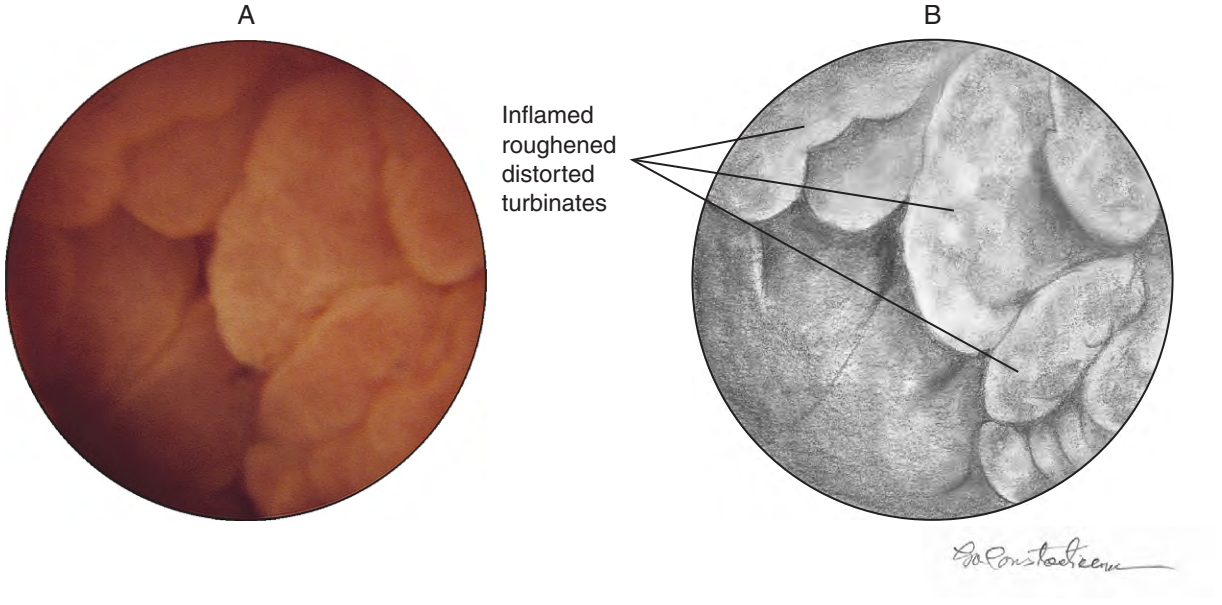



**Fig. 5-95**
Roughening of the mucosa and turbinates in a cat with allergic rhinitis.

and the nasopharynx with rostral and caudal drainage of exudate. The mucosa is usually hyperemic (Fig. 5-94) with variable roughening and friability (Fig. 5-95). The turbinates have a puffy or thickened appearance and examination may seem difficult for the size animal involved because of reduced working space. In these cases, it may be difficult to achieve adequate removal of exudate because of its quantity and tenacity. Flushing with a large syringe and saline may be required for exudate removal before examination. Turbinate distortion can occur with chronic disease (Fig. 5-96). No foreign bodies, fungal colonies, tumors, or evidence of dental disease are found in these cases. Histopathology of the nasal mucosa shows an inflammatory response with infiltrates of eosinophils, lymphocytes, plasmacytes, or combinations of these. Polyps are commonly found with

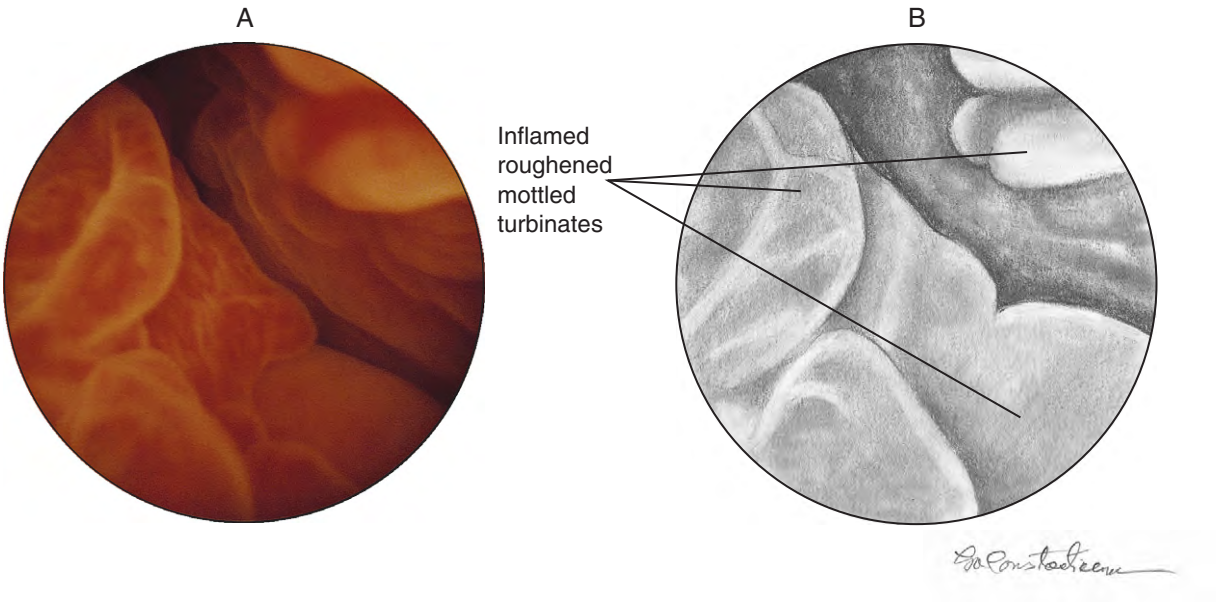



**Fig. 5-96**
Distortion of turbinates and mottled hyperemia of the nasal mucosa in a dog with allergic rhinitis.

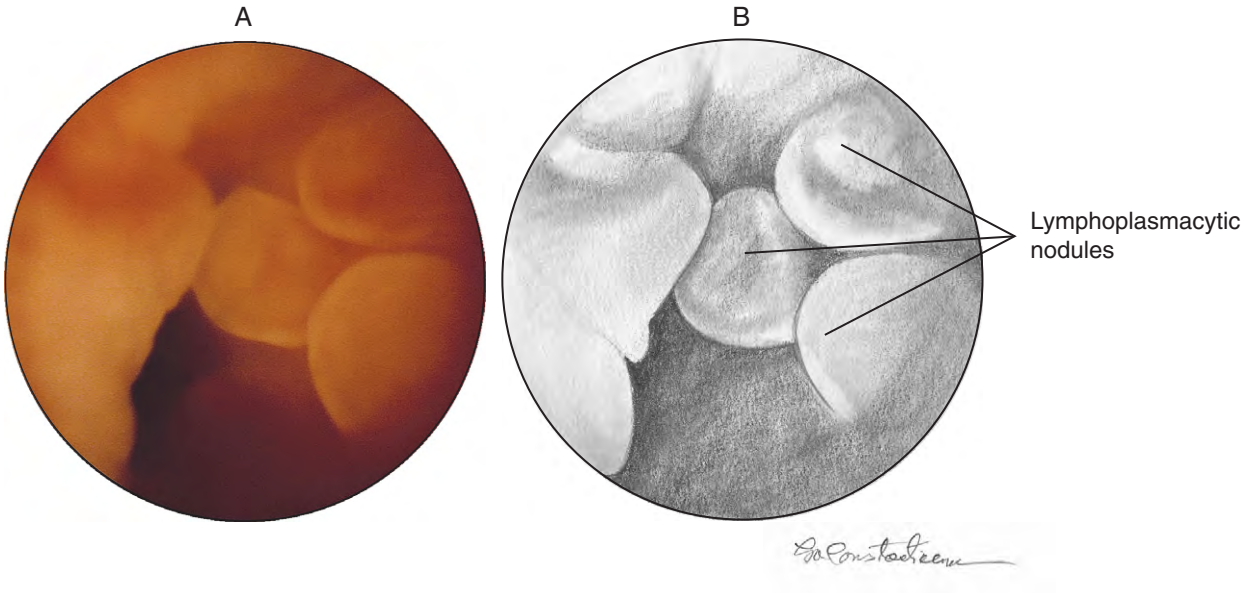



**Fig. 5-97**
Individual small, smooth, white nodules in the nasal cavity of a dog with allergic rhinitis. These are typically lymphoplasmacytic polyps that can be seen in multiple areas of the body.

allergic rhinitis. They may appear as individual small, smooth, white bumps (Figs. 5-97 and 5-98); small, roughened solitary lesions (Fig. 5-99); or sheets of contiguous inflammatory masses (Fig. 5-100). Allergy screening in these cases has consistently produced positive reactions to multiple allergen groups. Hyposensitization injections combined with environmental allergen exclusion has been encouraging in these cases.

## Bacterial Rhinitis

True bacterial rhinitis is not thought to be a final diagnosis in cases with chronic nasal disease. Acute bacterial cases may be seen as a primary entity or, with chronicity, infections may develop secondary to other diseases. Primary chronic bacterial sinusitis may occur in the dog and cat but is more likely to be secondary to other conditions such as nasal disease or feline viral upper

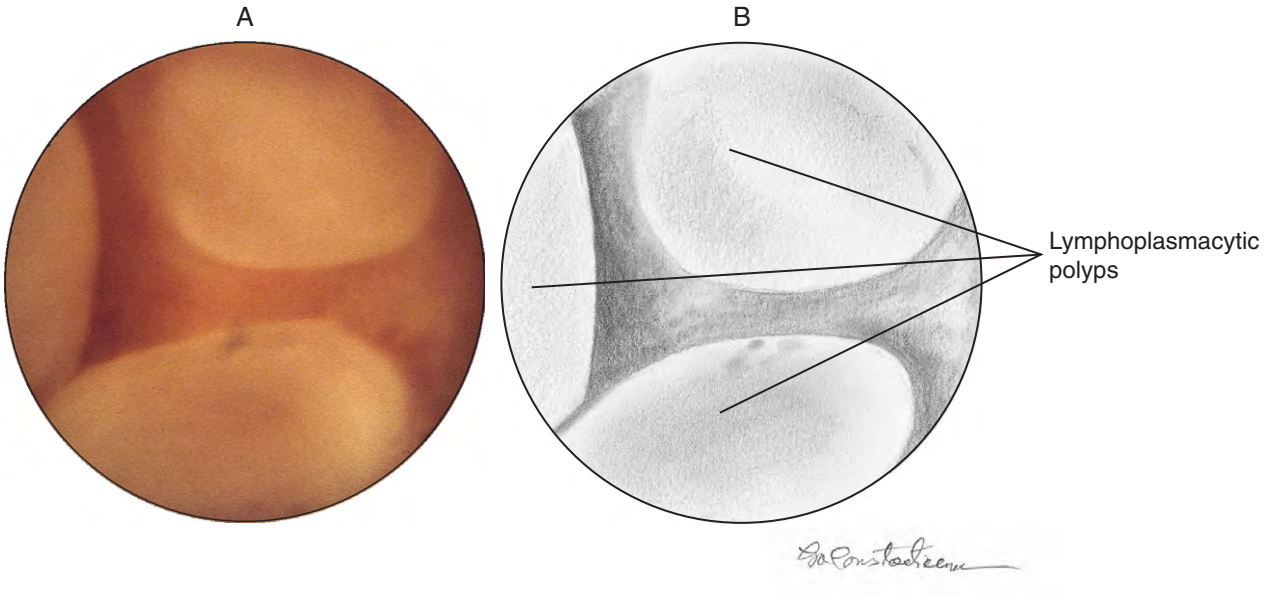



**Fig. 5-98**
Lymphoplasmacytic polyps in a cat with allergic rhinitis.

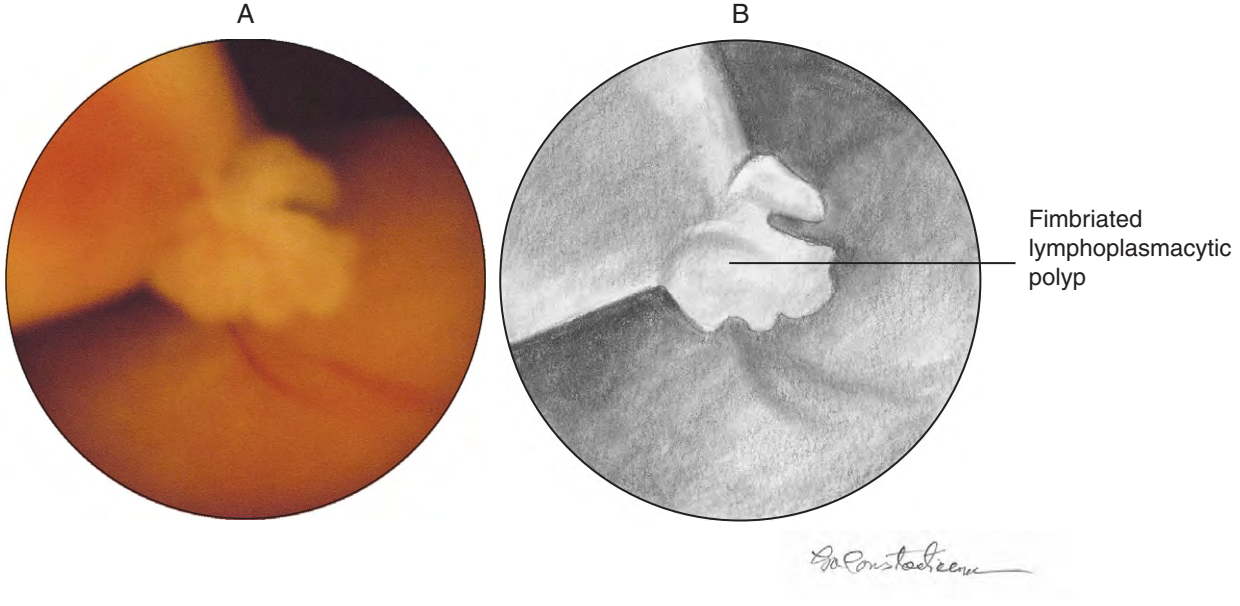



**Fig. 5-99**
A roughened fimbriated lymphoplasmacytic polyp in the nasal cavity of a dog with allergic rhinitis.

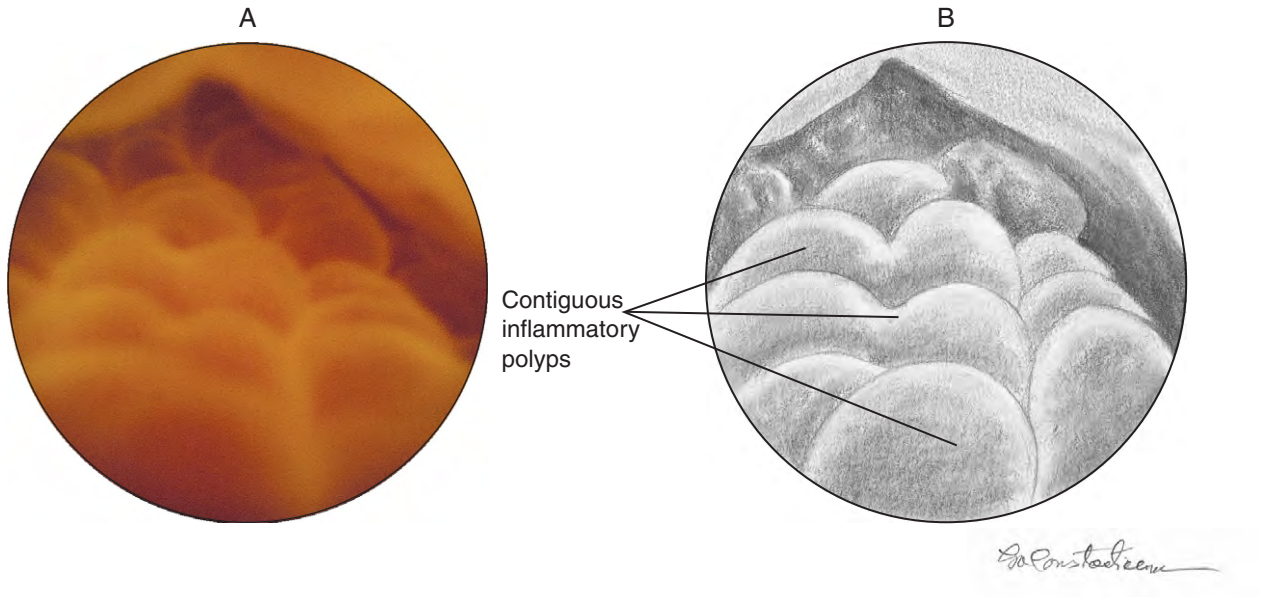



**Fig. 5-100**
Multiple contiguous inflammatory polyps forming a sheet of inflammatory tissue completely covering the nasal mucosa in a dog with severe allergic rhinitis.

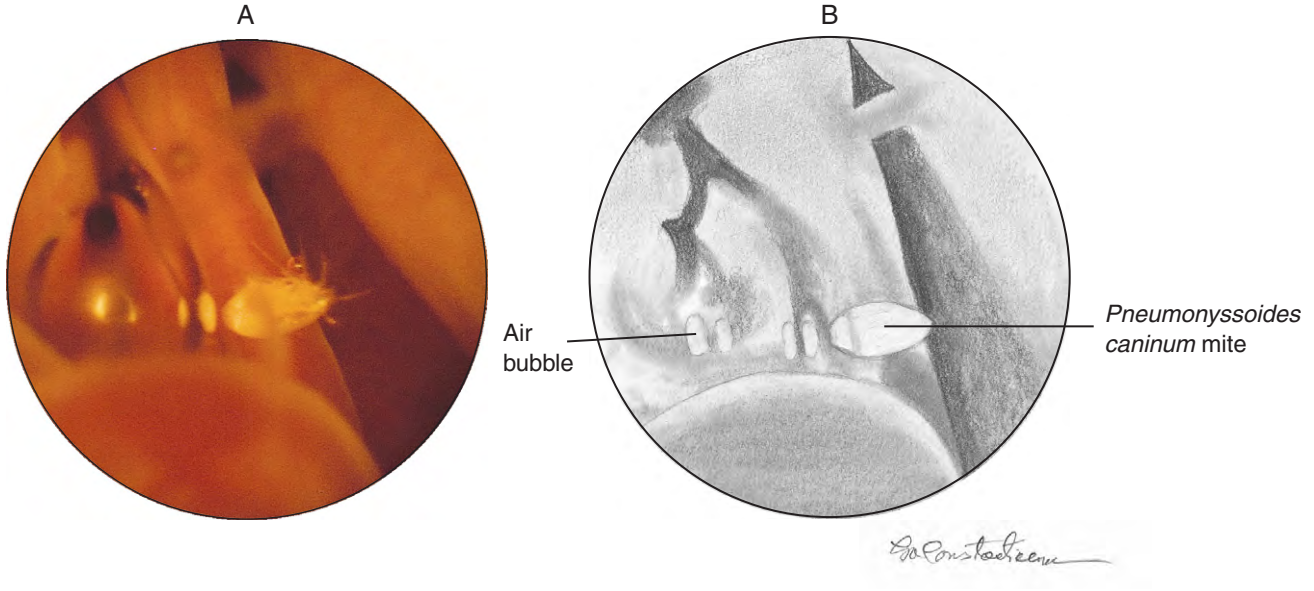



**Fig. 5-101**
A *Pneumonyssoides caninum* mite in the nasal cavity of a dog.

respiratory infections. Cases of bacterial rhinitis would be expected to respond well to antibiotic therapy and would not become part of the chronic nasal disease group that is presented for the type of nasal evaluations discussed here. Chronic bacterial sinusitis may not respond well to antibiotics until adequate debridement is achieved and adequate drainage is established or until the underlying etiology is removed. Rhinoscopy can be used therapeutically for frontal sinus irrigation and debridement.

## Parasitic Rhinitis

The nasal mite, *Pneumonyssoides caninum*, can be found in the nasal cavity in dogs. It is a small white mite that is less than 1 mm long (Fig. 5-101).

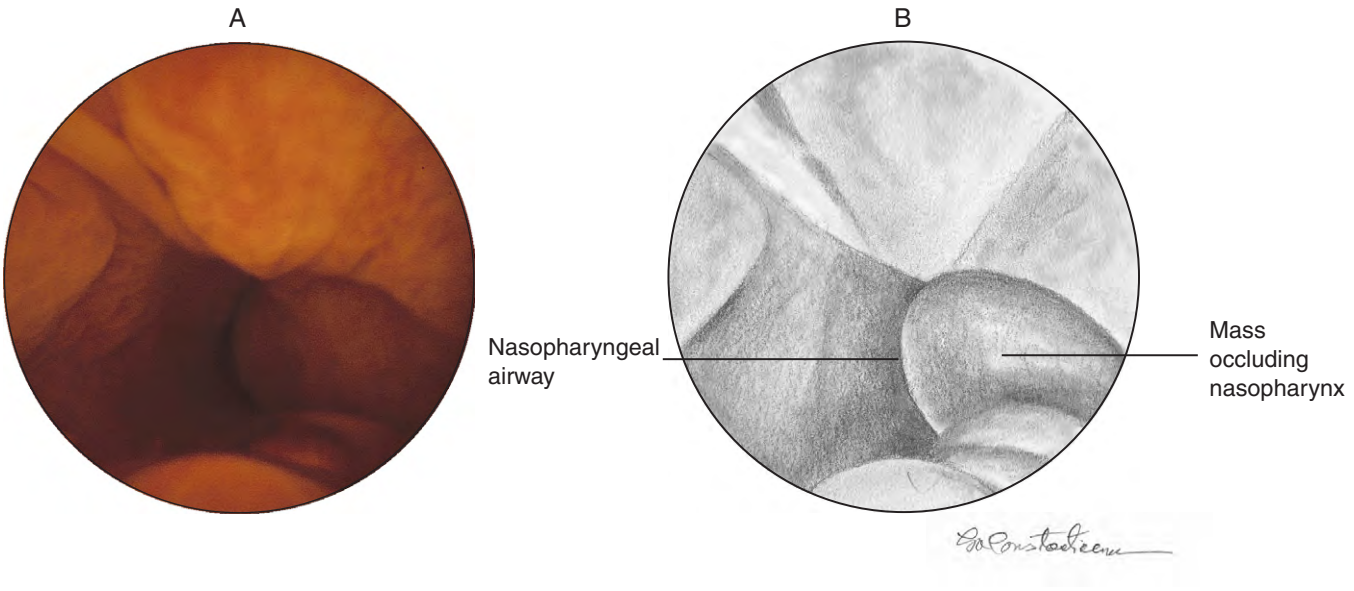



**Fig. 5-102**
Nasopharyngeal occlusion by an enlarged inflamed middle ear and bulla secondary to otitis in a Cocker Spaniel. This dog was presented for dyspnea because of the nasal airway obstruction. Ear canal ablation with bullectomy resolved the nasal airway obstruction and breathing difficulty.

## Nasal Diseases Secondary to Otitis

The most common association of nasal signs with otic disease is the nasopharyngeal polyp syndrome in cats. Signs of nasal disease secondary to otitis due to other etiologies are uncommon. Signs of dyspnea due to nasal obstruction have been seen secondary to severe otitis externa and otitis media. Soft tissue swelling and bony proliferation of the bulla and middle ear can produce sufficient enlargement to create a mass to occlude the nasopharynx (Fig. 5-102). Ear canal ablation combined with bullectomy has been performed to resolve the nasal obstruction and respiratory difficulty.

Acute onset of sneezing and reverse sneezing has been associated with ear canal foreign bodies that have penetrated the tympanic membrane. Rhinoscopy in these cases has revealed marked mucosal hyperemia and swelling of the nasopharynx adjacent to the ipsilateral eustachian tube openings (Fig. 5-103) or exudate draining from the eustachian tube (Fig. 5-104). Evaluation of the nasal cavity has revealed mild, nonspecific rhinitis or a normal nasal cavity. Removal of the foreign bodies and treatment of the otitis has resolved the nasal signs. Additional cases have been evaluated for the complaint of reverse sneezing and suggest a strong correlation between nasopharyngitis and reverse sneezing.

## Epistaxis

Epistaxis is not a diagnosis but is a sign of nasal disease and may be due to a variety of conditions that can be nasal or systemic in origin. Epistaxis, hemorrhage from the nasal cavity, should be differentiated from blood staining of a nasal discharge. True epistaxis is most commonly seen with nasal neoplasia and with systemic coagulopathies. Epistaxis is a cardinal sign of hypertension in humans but it has not been defined as such in the dog. A blood-stained discharge, whether watery, mucoid, mucopurulent, or purulent, can be seen with almost any of the conditions that produce chronic nasal discharge. Neoplasia, severe mycotic rhinitis, and foreign bodies demonstrate blood more frequently, but the finding is too variable to use as a diagnostic criterion.

## Rhinitis of Undetermined Origin

Inflammatory nasal disease of undetermined origin or where an etiology has not been established is included in this group. A large percentage of cases that were initially being included in this diagnosis category are now being diagnosed as allergic rhinitis. Cases that were being placed in this category show similar findings to those that are now being included in the allergy group and have clinical signs, radiographic appearance, rhinoscopic findings, and histopathology similar to allergic rhinitis. Addition of allergy testing as part of the workup protocol has established a strong correlation with cases and findings previously included in this group and positive allergy results. Final determination of this separation and classification has not been completed, and pathologic differentiation and the meaning of the different classifications of inflammatory reactions remain to be established.

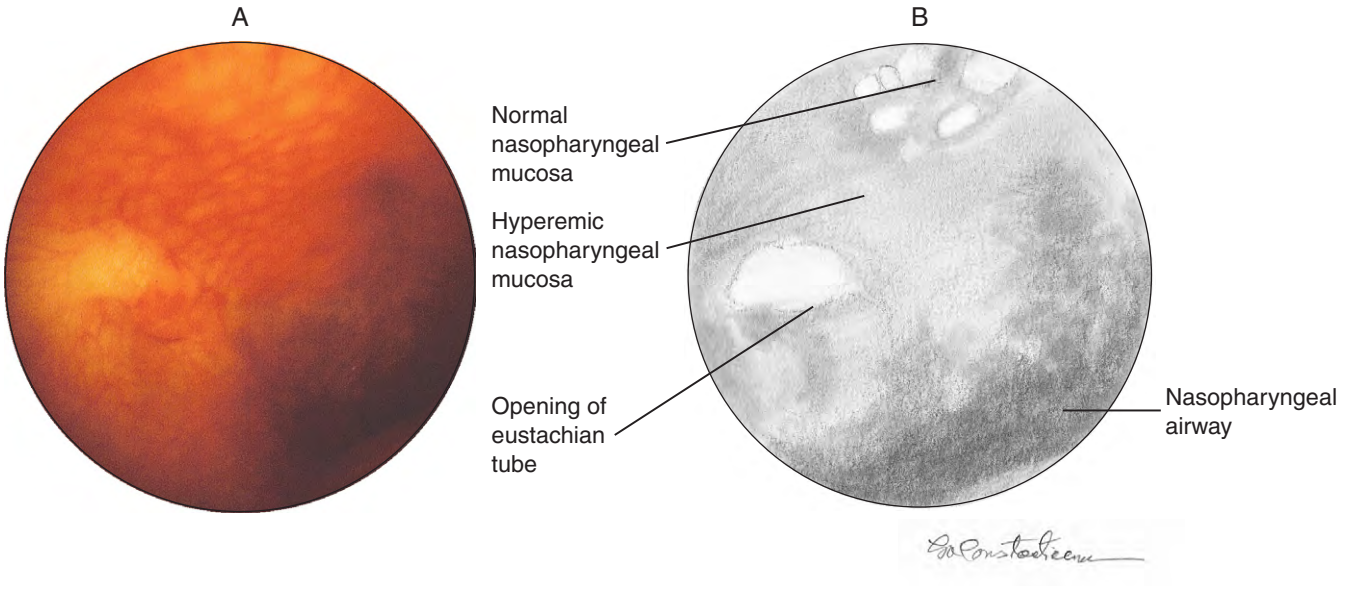



**Fig. 5-103**
Nasopharyngitis secondary to an otic foreign body that had penetrated the tympanic membrane in a dog that presented for reverse sneezing.

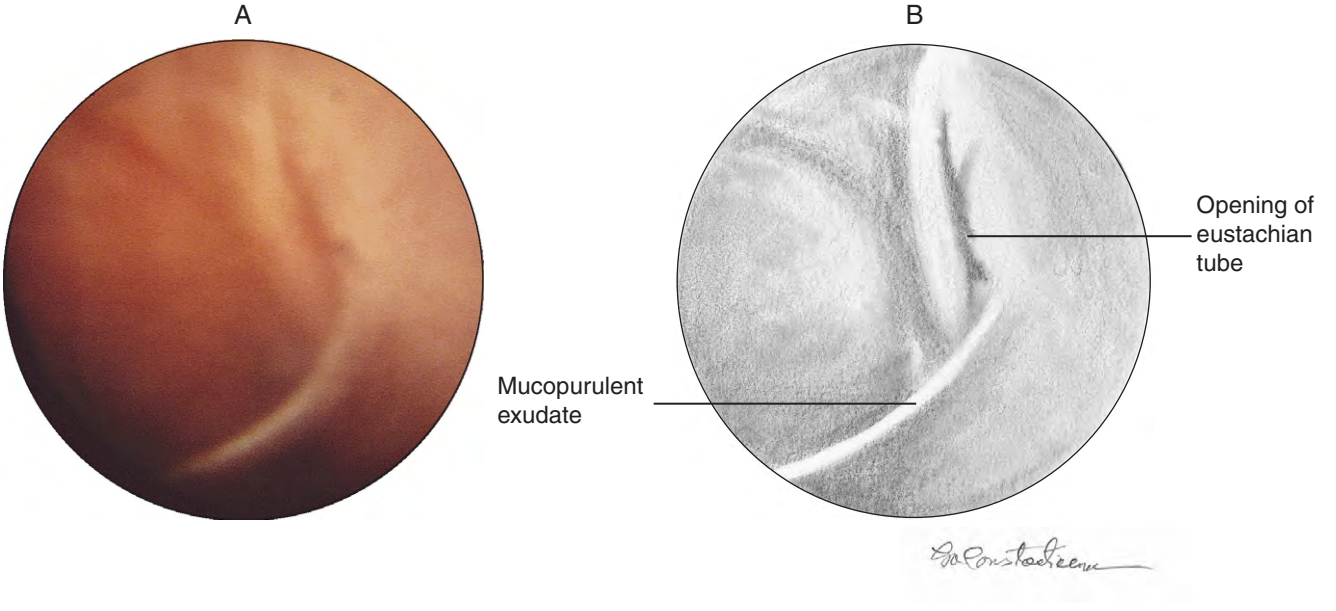



**Fig. 5-104**
Exudate coming from the eustachian tube of a dog with otitis media and reverse sneezing.

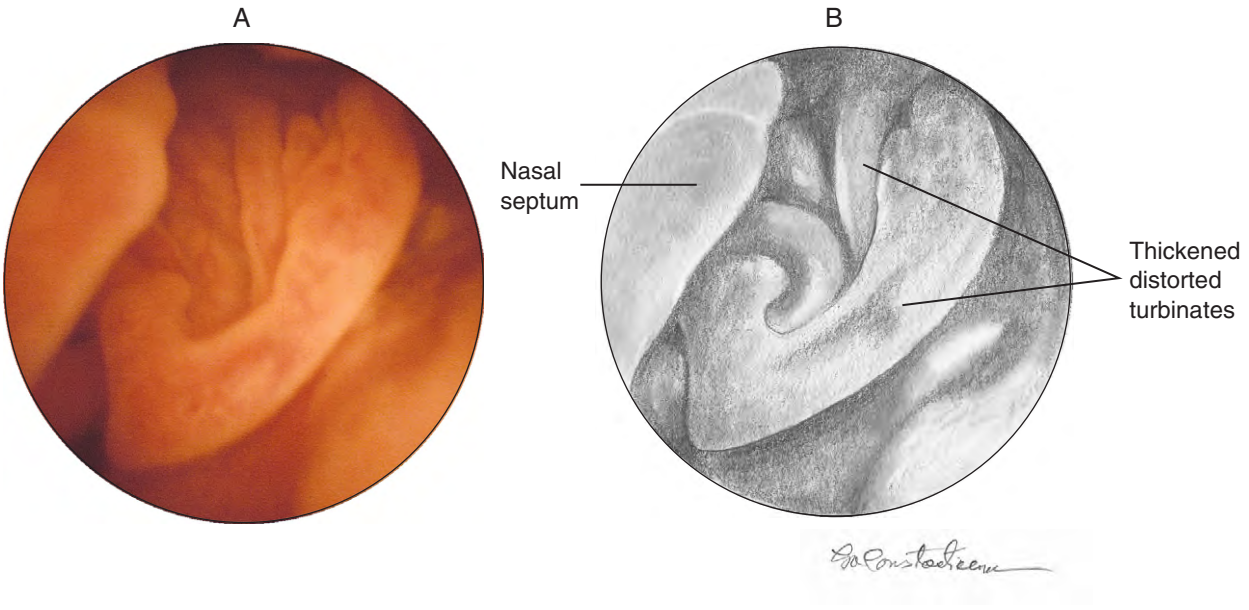



**Fig. 5-105**
Roughened mottled mucosa with turbinate thickening and distortion in a dog with suppurative rhinitis of undetermined origin.

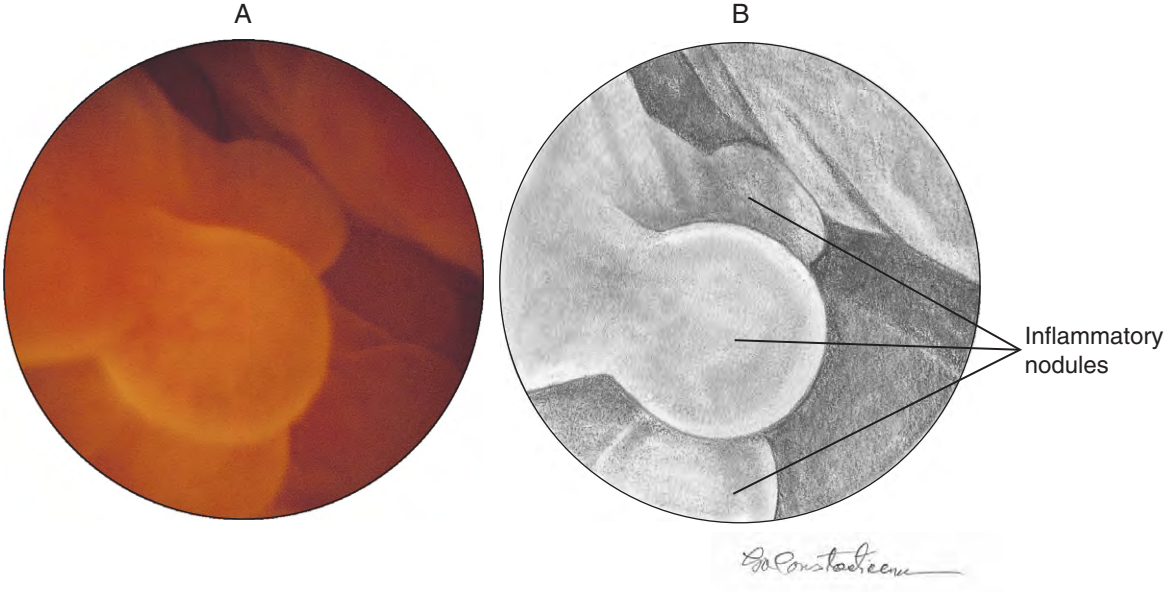



**Fig. 5-106**
Multiple small, smooth individual polyps in a dog with idiopathic rhinitis.

Amyloid deposition has been found in nasal tissues but has not been linked to a specific disease process or etiology.

Large quantities of mucoid to mucopurulent nasal discharge are commonly present that may be difficult to remove with irrigation because of its quantity and tenacity. Before examination, forced irrigation with a syringe and saline may be required for exudate removal. The mucosa is usually roughened, hyperemic, or mottled, with puffy, thickened, and sometimes distorted turbinates (Fig. 5-105). Examination may seem difficult as a result of reduced working space. Inflammatory infiltrates with eosinophils, lymphocytes, plasmacytes, neutrophils, or combinations of these are found on biopsy of these cases. Inflammatory polyps and masses are frequently seen and may be individual small, smooth, white lumps (Fig. 5-106),

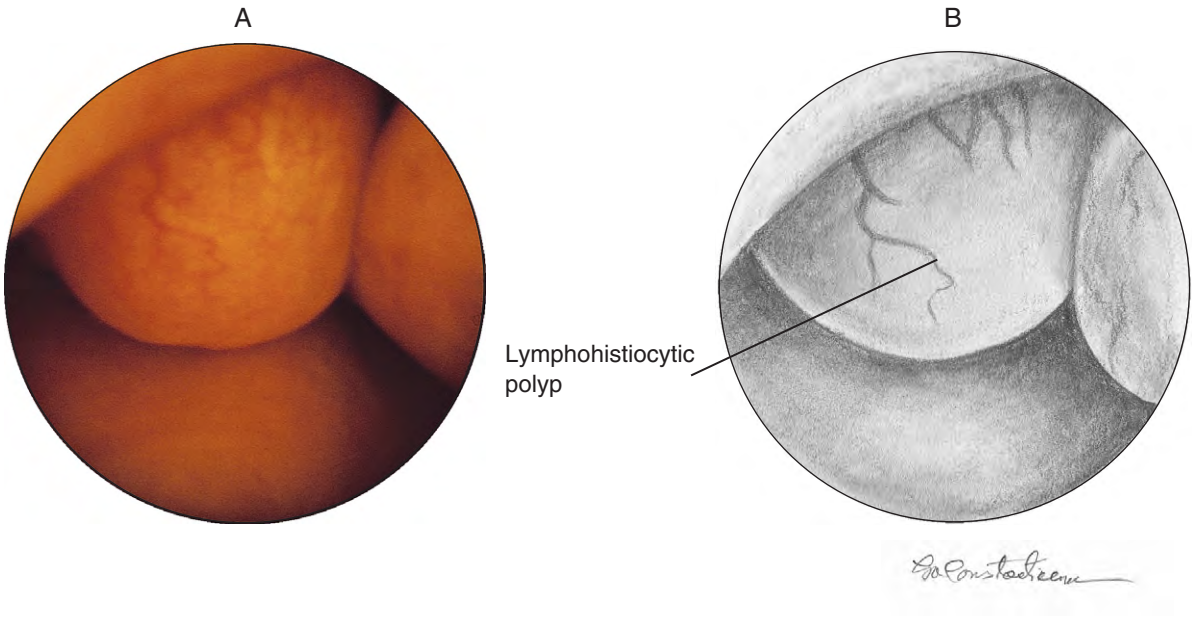



**Fig. 5-107**
A large, smooth lymphohistiocytic polyp in a dog with rhinitis of undetermined origin.

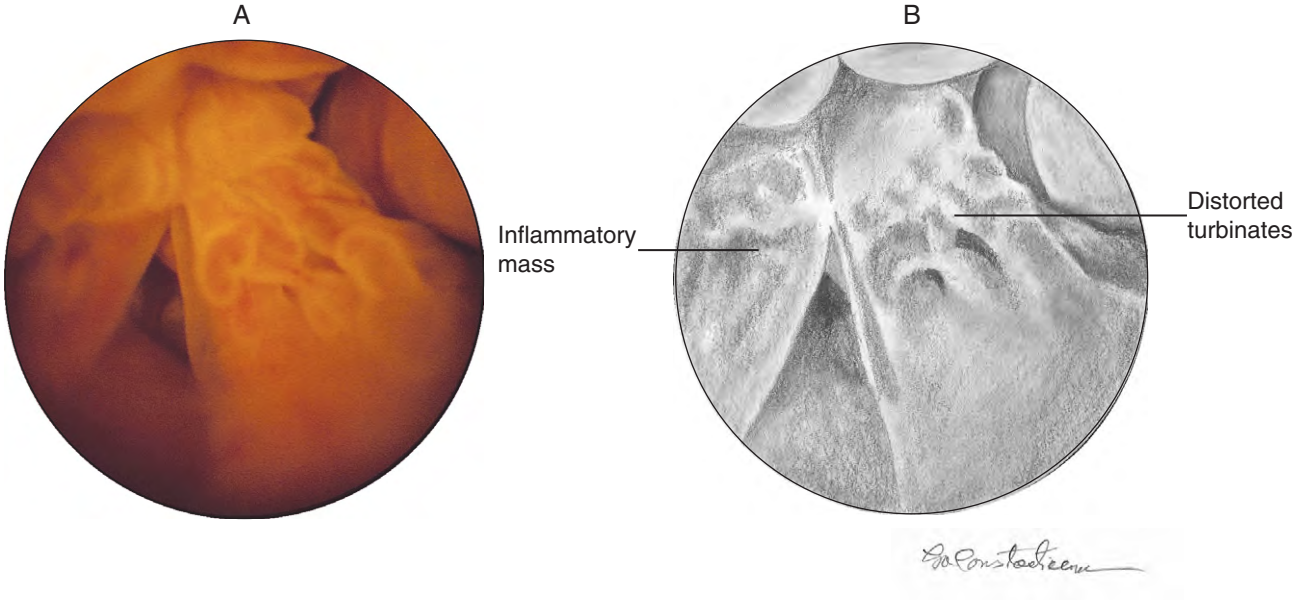



**Fig. 5-108**
Inflammatory mass and turbinate distortion and loss of cartilage support in a dog with rhinitis of undetermined origin.

larger solitary lesions (Fig. 5-107), irregular masses (Fig. 5-108), or tumor-like masses of inflammatory tissue (Fig. 5-109). Extensive turbinate destruction can occur with (Fig. 5-110) or without (Fig. 5-111) inflammatory mass formation. Markedly enlarged blood vessels have also been found in cases with rhinitis of undetermined origin (Fig. 5-112). Foreign bodies, fungal colonies, tumors, and evidence of dental disease are not found in these cases.

An additional consideration in these cases is that the underlying cause has not been found. Further diagnostic evaluations with CT, MRI, or surgical exploration may be indicated. An approach that has been recommended and used in some of these cases is reexamination in 4 to

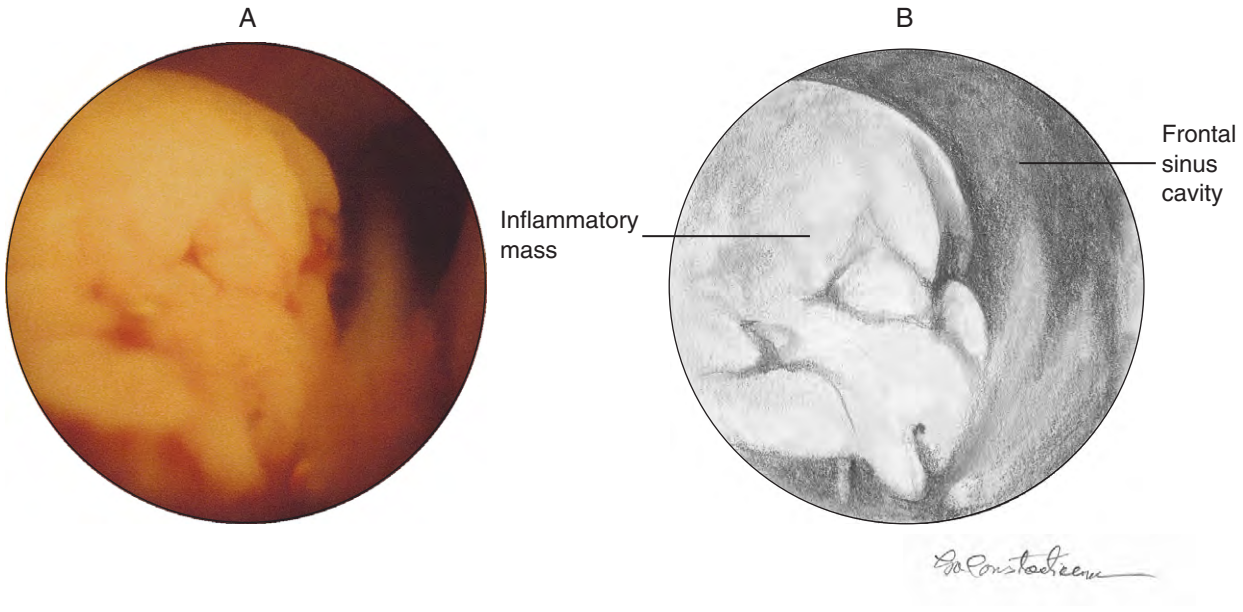



**Fig. 5-109**
An inflammatory mass in the frontal sinus of a cat with rhinitis of undetermined origin.

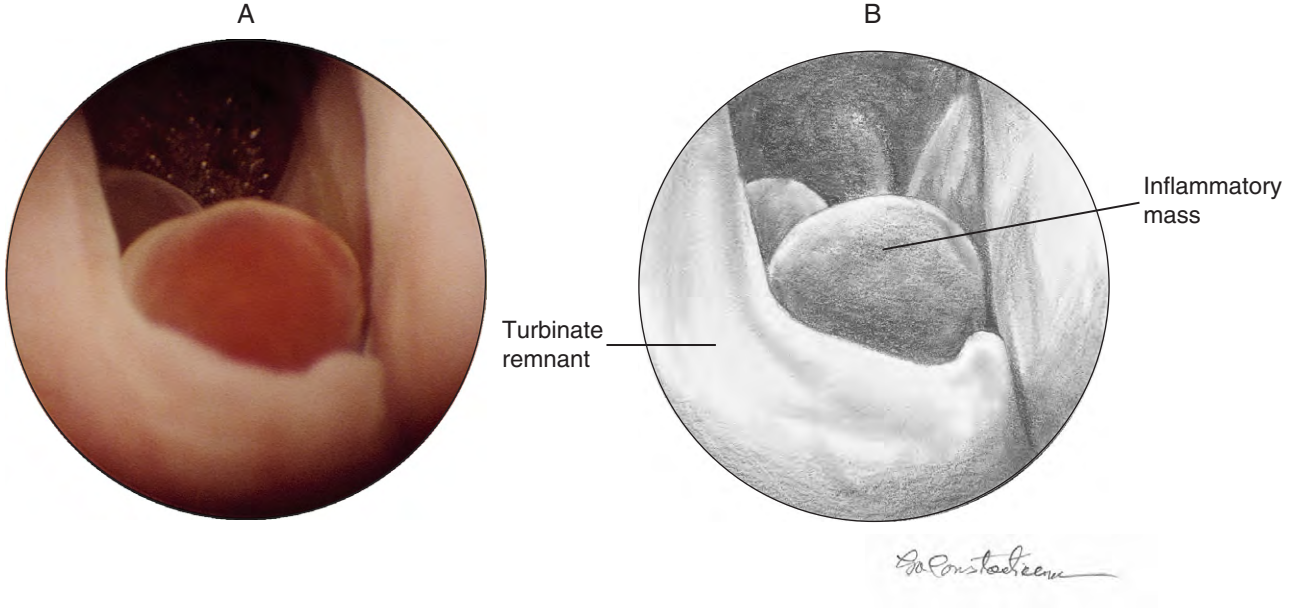



**Fig. 5-110**
A hyperemic inflammatory tissue mass in the nasal cavity of a dog with extensive turbinate destruction from suppurative rhinitis of undetermined origin.

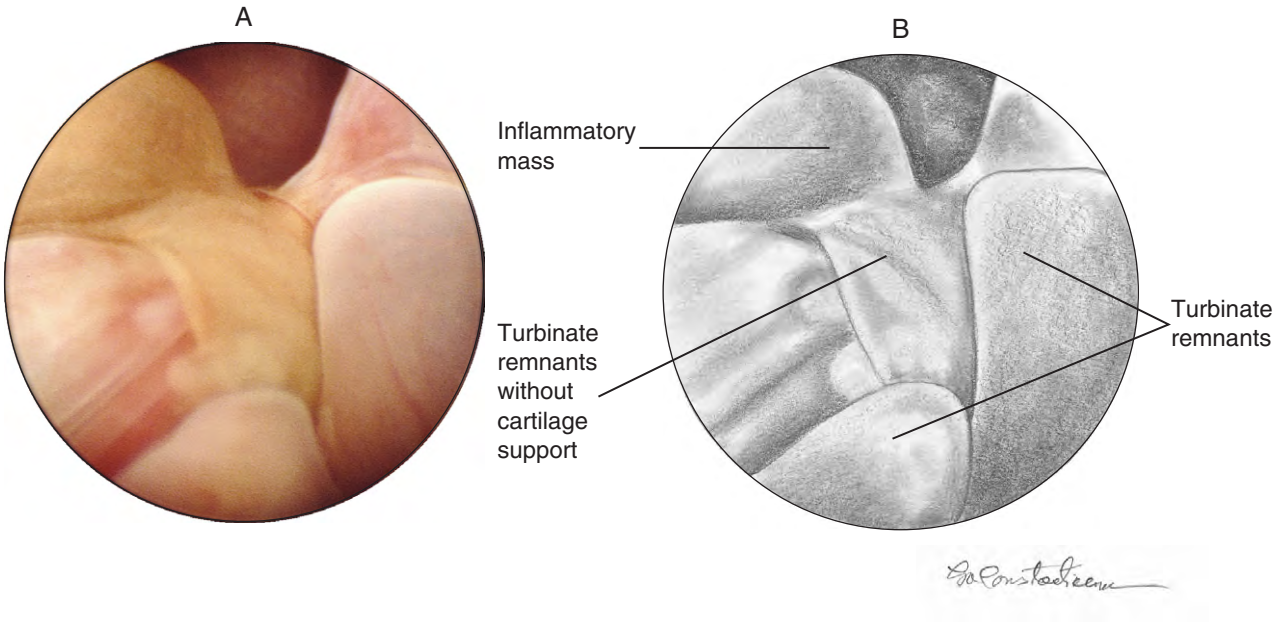



**Fig. 5–111**
An irregular inflammatory mass with marked turbinate destruction and distortion in a dog with rhinitis of undetermined origin.

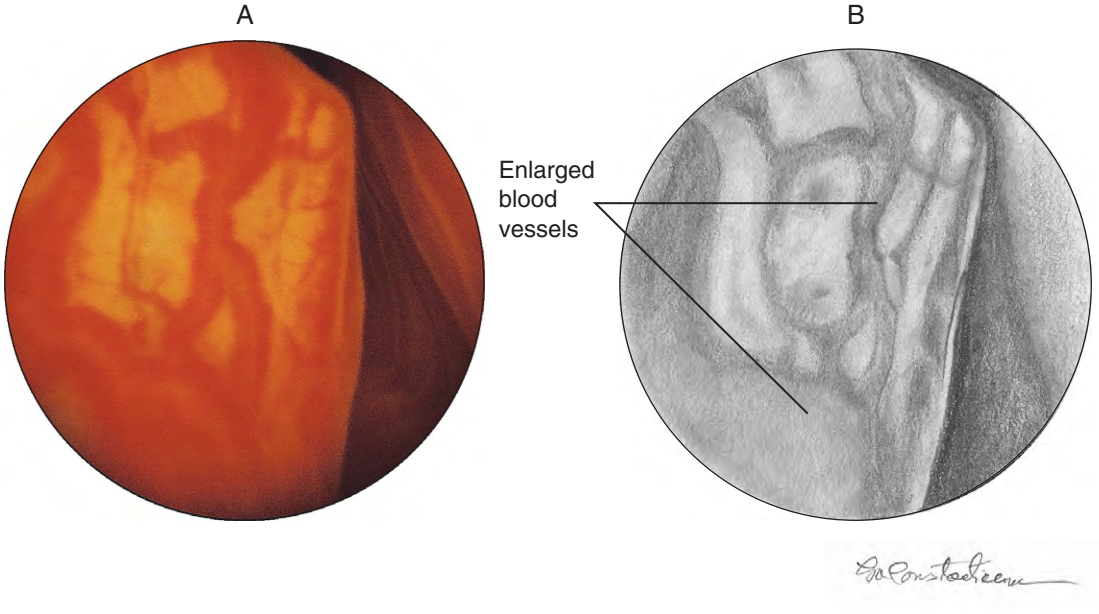



**Fig. 5–112**
Enlarged blood vessels in a dog with rhinitis of undetermined origin.

6 months. With progressive disease the etiology may become obvious with time.

### Reexaminations

Repeat examinations of the nasal cavity may be required. Indications for multiple rhinoscopic examinations of the nasal cavity include recurrent or repeat nasal foreign bodies, monitoring treatment and progression or resolution of diseases, debriding the nasal cavity with mycotic rhinitis, tumor debulking, and in unresolved cases of idiopathic rhinitis.

## CONCLUSION

Rhinoscopy is a highly effective diagnostic tool with minimal morbidity and mortality. Its use is recommended in evaluation of a variety of nasal conditions to establish a diagnosis and minimize the need for surgical explorations.

## REFERENCES

1. Hunt GB and others: Nasopharyngeal disorders of dogs and cats: a review and retrospective study, *Compend Cont Educ Pract Vet* 24:184-200, 2002.
2. Lent SEF, Hawkins EC: Evaluation of rhinoscopy and rhinoscopy assisted mucosal biopsy in diagnosis of nasal disease in dogs: 119 cases (1985-1989), *J Am Vet Med Assoc* 102:1425-1429, 1992.
3. Tasker S and others: Aetiology and diagnosis of persistent nasal disease in the dog: a retrospective study of 42 cases, *J Small Anim Pract* 40:473-478, 1999.
4. Willard MD, Radlinsky MA: Endoscopic examination of the choanae in dogs and cats: 118 cases (1988-1998), *J Am Vet Med Assoc* 215:1301-1305, 1999.
5. Thayer GW: Infections of the respiratory system. In Greens CE, editor: *Clinical microbiology and infectious diseases of the dog and cat,* Philadelphia, 1984, WB Saunders.

## SUGGESTED READING

Davidson AP and others: Diseases of the nose and nasal sinuses. In Ettinger SJ, Feldman EC, editors: *Textbook of veterinary internal medicine,* ed 5, Philadelphia, 2000, WB Saunders.

Forrest LJ: The cranial and nasal cavities: canine and feline. In Thrall DE, editor: *Textbook of veterinary diagnostic radiology,* ed 4, Philadelphia, 2002, WB Saunders.

Noone KE: Rhinoscopy, pharyngoscopy, and laryngoscopy, *Vet Clin North Am Small Anim Pract* 31:671-689, 2001.

Patrid PA, McKiernan BC: Endoscopy of the upper respiratory tract of the dog and cat. In Tams TR, editor: *Small animal endoscopy,* ed 2, St Louis, 1999, Mosby.

Willard MD: Respiratory tract endoscopy. In Fossum TW, editor: *Small animal surgery,* ed 2, St Louis, 2002, Mosby.

# 6 Bronchoscopy

*Brendan C. McKiernan*

Bronchoscopy has been an integral part of respiratory practice in veterinary medicine since at least the early 1970s. Performed by experienced veterinarians, bronchoscopy is invaluable in the diagnosis of a variety of respiratory disorders. In addition to its application in diagnostics, bronchoscopy has been used therapeutically and to determine a patient's overall prognosis.

## EQUIPMENT

Both rigid and flexible endoscopes are used for bronchoscopy. Rigid bronchoscopes have been used in human medicine since the early 1900s. Following the introduction of the flexible fiberscope by Ikeda in 1967, the use of flexible endoscopes increased significantly and they are now the most commonly used instruments for both veterinary and human bronchoscopy.

Flexible endoscopes have many advantages over rigid endoscopes, including versatility (one scope is often used for a variety of endoscopic procedures) and improved maneuverability, which increases viewing area within the tracheobronchial tree. When compared with rigid endoscopes, disadvantages include increased initial cost, greater repair costs, decreased image quality (noted primarily with endoscopic photography), decreased durability (the greater flexibility can lead to more optical bundle breakage), and less suction and instrumentation capability (the biopsy channel size is generally smaller). Despite these limitations, the versatility, maneuverability, and increased viewing area have made flexible endoscopes the preferred bronchoscopic instrument.

Species differences (e.g., in the length and diameter of an animal's airway) result in certain limitations for using a given endoscope as a "veterinary bronchoscope." I use two sizes of bronchoscopes: 5 mm and 3.7 mm diameter. These two endoscopes allow for the bronchoscopic evaluation in patients weighing from approximately 2 or 3 kg to more than 75 kg and have enough versatility to be used in other endoscopic procedures, such as rhinoscopy and cystoscopy. A major limitation for bronchoscopy in large dogs is the limited length (55 cm) of human bronchoscopes. One bronchoscope (5 mm wide and 85 cm long) has been made specifically for use in veterinary medicine (Canine Bronchoscope, model 60001 VL1, Karl Storz Veterinary Endoscopy America, Goleta, Calif); it is sufficient to use in all but the largest dogs. In those giant breed animals, a pediatric gastroscope can be successfully used as a bronchoscope. Good quality used endoscopes are often available from local hospitals or endoscopic support and sales companies.

### Care and Cleaning

Flexible endoscopes are delicate, expensive instruments and must be handled and cared for with the utmost attention. Improper handling (e.g., forceful insertion or bending of the scope; forceful forceps insertion) or improper cleaning (e.g., some instruments can be totally immersed, whereas others need to be sterilized by gas) may result in instrument damage and expensive repair costs. Equipment sterility is often hampered by humidity; *Pseudomonas*, which favors damp environments, is a common contaminant of respiratory equipment. Flexible endoscopes must be hung up for storage because leaving them in a closed case may prevent them from completely drying out inside (Fig. 6-1). Ethylene oxide, steam, and cold soaking techniques have been successfully used to sterilize endoscopes and biopsy equipment. It is wise to ensure that all users understand the manufacturer's approved use, care, and cleaning recommendations for these instruments.

## INDICATIONS AND CONTRAINDICATIONS OF BRONCHOSCOPY

Bronchoscopy may be used for diagnostic, therapeutic, and prognostic purposes.[1-3] Diagnostic bronchoscopy is used to obtain visual information concerning the airways (e.g., compression, dynamic collapse, and dilation) as well as to

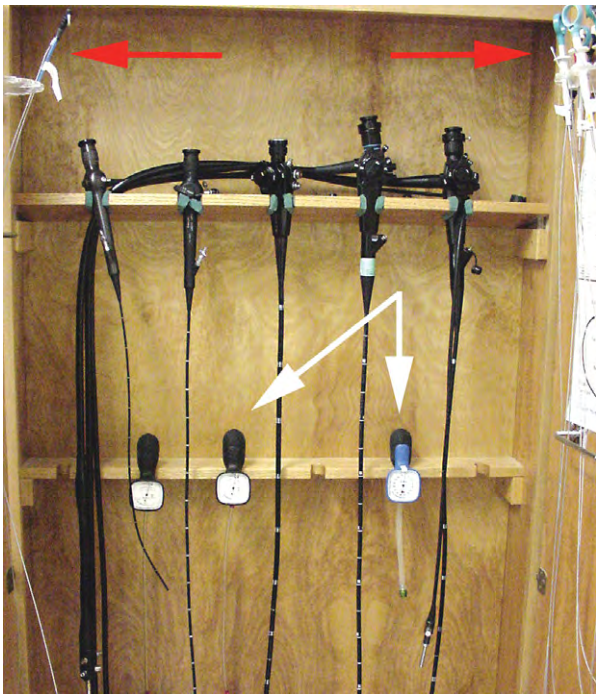


**Fig. 6-1**
Flexible endoscopes (3.7- and 5-mm bronchoscopes and three 7.9-mm gastroduodenoscopes) hang in a storage cabinet for security and to allow them to dry fully after cleaning. Note the pressure testers (*white arrows*) for ensuring there are no leaks before each use and a variety of biopsy forceps (*red arrows*).

obtain samples (cytology, culture, and occasionally biopsy) to help establish a specific etiologic diagnosis.[4] Bronchoscopy is useful therapeutically, especially in the removal of airway foreign bodies.[5] It is also helpful in determining prognosis when nonreversible anatomic or mucosal changes are recognized in the airways.

Other than the risks associated with anesthesia required for the procedure, there are no established absolute contraindications to bronchoscopy in veterinary medicine. The clinician must weigh any risks presented by the patient (e.g., anesthesia, bleeding, hypoxemia, arrhythmias) against the benefit of the procedure. Roudebush[3] summarized the clinical indications and the potential contraindications for bronchoscopy, a modification of which is outlined in Table 6-1.

## ANESTHESIA FOR BRONCHOSCOPY

Insertion of an endoscope into an animal's airway results in the stimulation of protective reflexes, which may include sneezing, head shaking, paroxysmal coughing, and airway constriction. General anesthesia is necessary to control these reflexes during bronchoscopy, to prevent airway trauma, and to protect the endoscope.

Except in severely compromised patients, the information obtained from bronchoscopy (which aids in establishing a definitive diagnosis and an accurate long-term prognosis) overrides concerns about the requirement for general anesthesia. The availability of newer, short-acting or reversible injectable anesthetics has allowed bronchoscopy to be performed safely in almost all patients. This form of anesthesia is particularly beneficial because it not only provides adequate anesthesia for the procedure but also allows for relatively rapid patient recovery, which is an important factor in geriatric or compromised patients.

A variety of satisfactory anesthetic protocols are used for bronchoscopy. Selection of a particular protocol is based on the preanesthetic evaluation of the patient's condition, the bronchoscopic purpose at hand (a routine diagnostic vs. a prolonged foreign body removal procedure), as well as the veterinarian's familiarity with the anesthetic agent. Patient movement must be controlled because it not only makes bronchoscopy more difficult, but excessive movement can also lead to patient or equipment trauma. The ideal anesthetic provides good patient restraint, has minimal cardiorespiratory effects, is either reversible or of short duration, and allows for a smooth recovery period. Propofol is an ideal anesthetic agent for bronchoscopy and is the anesthetic I choose for both dogs and cats. Patients are premedicated with an anticholinergic (atropine or glycopyrrolate) and a mild sedative (acepromazine, butorphanol) before inducing anesthesia with propofol. Other alternatives include short-acting barbiturates, ketamine-diazepam combination, and reversible narcotic agents (e.g., oxymorphone).

In large and giant breed dogs, gas anesthetics (e.g., isoflurane or sevoflurane) can be used while the bronchoscope is passed through an anesthetic T-piece connected to the endotracheal tube (Fig. 6-2). There are risks with this form of anesthesia; care must be taken to ensure that air trapping does not occur as the result of the endoscope being placed inside the endotracheal tube. Too large an endoscope relative to the size of the endotracheal tube can significantly increase the resistance to air flow in and especially out of the lungs. Potential barotrauma to the lungs (resulting in pneumothorax) can result from insufflation of anesthetic gas while not allowing an adequate volume of gas to be exhaled.

All cats and many dogs are too small to allow the bronchoscope to be passed through an endotracheal tube; therefore, injectable anesthesia is used in these patients. I prefer to use injectable anesthesia in *all* small animals. Oxygen administration before induction is recommended (by face mask) because hypoxemia is a common finding in many of these patients. Although flexible endoscopes do not allow for assisted ventilation, a bias flow of oxygen (1 to 2 L/min) through the biopsy channel of the endoscope when it is not actively being used for biopsy or lavage purposes improves patient oxygenation. Alternatively,

*Table* **6-1** Indications, Contraindications, and Potential Complications of Bronchoscopy in Dogs and Cats

| | |
|---|---|
| **Indications** | **Diagnostically**<br>• Chronic coughing<br>• Chronic parenchymal disease (alveolar, interstitial)<br>• Evaluation of suspected dynamic airway caliber disorders (tracheobronchial collapse, tracheobronchial malacia)<br>• Documentation of fixed airway caliber changes (compression, bronchiectasis)<br>• Persistent halitosis<br>• Hemoptysis<br>• Confirmation of suspected foreign body, lobe torsion, or tumor prior to surgery<br>**Therapeutically**<br>• Foreign body removal—primary application<br>• Removal of excess secretions, mucous plugs<br>• Assisting with a difficult intubation |
| **Contraindications** | **Absolute**<br>• Proven bleeding tendency<br>• Severe hypoxemia<br>• Cardiac failure or unstable arrhythmias<br>**Relative**<br>• Resting expiratory effort (abdominal push)—increased risk of exertional airway collapse with excitement or during anesthetic recovery with the development of hypoxemia subsequently<br>• Pulmonary hypertension—concern for significant hypoxemia<br>• Uremia—risk of bleeding<br>• Poor cardiopulmonary reserve—increased risk of arrhythmias |
| **Potential Complications** | • Excessive reflex stimulation (laryngospasm, bronchospasm, and coughing)<br>• Hypoxemia (from the anesthetic, the procedure, or a bronchoalveolar lavage)<br>• Hemorrhage—due to increased mucosal friability, secondary to biopsy<br>• Barotrauma—most commonly encountered in smaller patients during oxygen insufflation due to air trapping<br>• Miscellaneous—cardiac arrhythmias, fever, radiographic infiltrates |

*Adapted from Roudebush P:* Vet Clin North Am Small Anim Pract *20:1297-1314, 1990.*

oxygen may be delivered via a separate catheter passed alongside the bronchoscope and into the lower trachea (a 3- to 8-French urinary catheter works well for this purpose) (Figs. 6-3 and 6-4). All bronchoscopy cases are intubated upon completion of the procedure to provide oxygen during the anesthesia recovery.

## MONITORING AND POSITIONING THE PATIENT FOR BRONCHOSCOPY

Routine electrocardiographic and oxymetry monitoring is recommended during anesthetic induction, during the bronchoscopic procedure, and for a period of time while the patient is recovering. Many of the patients in whom bronchoscopy is being performed are older and may have chronic cardiopulmonary disease (e.g., valvular insufficiency, small airway obstruction, hypoxemia). In human medicine, significant decreases in $Pa_{O_2}$ have been reported during bronchoscopy.[4] Although the magnitude and frequency of this problem has not been assessed in veterinary medicine, if similar changes occur significant hypoxemia could possibly to develop. The combined cardiopulmonary effects of general anesthesia, mucosal stimulation, and any induced hypoxemia could easily result in cardiac arrhythmias in these patients.

Sternal recumbency is the preferred position when performing bronchoscopy in cats and dogs. Not only is this position easier to maintain and more familiar to veterinarians, but it also avoids any possible gravitational influences on the airways, as well as on cardiorespiratory function. To avoid confusion, endoscopic photographs and training manuals are studied with the animal's position clearly understood.

## BRONCHOSCOPIC TRAINING

A good bronchoscopist is able to maneuver the scope easily (e.g., for efficient viewing of the tracheobronchial tree and collection of specimens) with minimal risk to the patient due to unnecessarily prolonged anesthetic times or mucosal trauma.

The bronchoscopist needs to have a good understanding of normal bronchial lung anatomy as well as mucosal and dynamic airway changes to be able to diagnose abnormalities and diseases. The differentiation (recognition) between what is normal and what is abnormal is subjective. Experience and practice greatly improve the ability to detect lesions at an early stage of disease. Canine endobronchial anatomy differs from human anatomy; terminology proposed in 1986[6] has proven to be a reliable and useful aid or "map" for use during clinical bronchoscopy (Fig. 6-5). Bronchoscopic training models can be prepared from lungs collected from cadavers. The use of dried lung models[7] and a good understanding of normal endobronchial anatomy ensures that beginners have the opportunity to safely develop the manual dexterity and anatomic recognition skills that are critical to becoming a competent bronchoscopist. A thorough knowledge of anatomy is also helpful in correlating radiographic lesions to endoscopic findings (and vice versa), in localizing lesions, and in recording the location (in writing) of lesions, biopsies, or photographs for future comparison and reference. Endoscopy short courses are available through some veterinary schools and at various national continuing education meetings. Some form of specialized training is essential before bronchoscopy is used as a routine diagnostic tool.

Bronchoscopic findings and visual changes in the respiratory mucosa are difficult to describe or depict through line drawings or black and white photography. When beginning to learn bronchoscopy, one should first review normal canine endobronchial anatomy and consult texts and color photographs of endoscopic findings from healthy and diseased animals.[1,2,4,8-10]

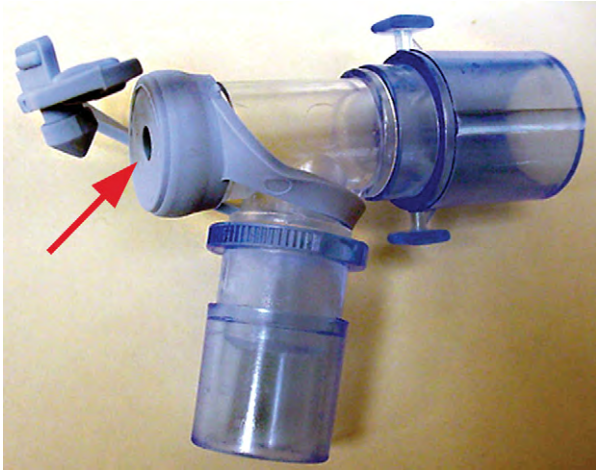


**Fig. 6-2**
An anesthesia T-adapter attaches to the endotracheal tube and allows for the passage of a small bronchoscope through a port (*arrow*) and down the lumen of the endotracheal tube in large breed dogs.

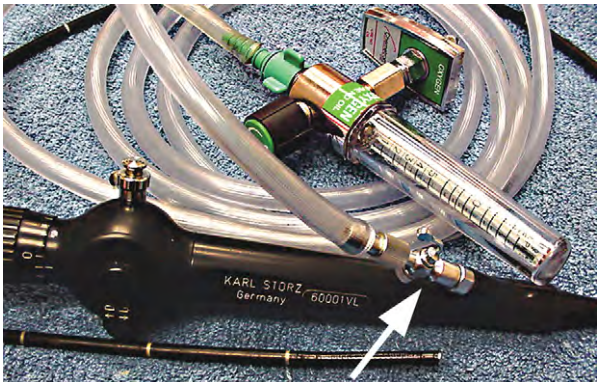



**Fig. 6-3**
Oxygen supplementation is provided during bronchoscopy by connecting to the biopsy channel of the bronchoscope (*arrow*) when it is not being used.

## BRONCHOSCOPIC PROCEDURE

All necessary bronchoscopic supplies and equipment are made ready before starting the procedure to minimize anesthetic time and maximize the benefits to the patient. Mouth gags, an oxygen delivery system, endotracheal tubes, biopsy forceps, preloaded lavage syringes, cytology slides, and other equipment are laid out for easy access (Fig. 6-6). The bronchoscope is clean and ready for use; anesthetic monitoring equipment is turned on and ready, while any image capture equipment is calibrated and white balanced before induction. As the animal is being induced, the set-up is finalized by connecting any monitoring equipment and ensuring proper positioning (my preference is sternal) for the procedure. Dental mouth gags are placed as soon as they are tolerated to protect the endoscope during the procedure. Topical anesthetic (1% to 2% lidocaine) may be applied or sprayed onto the pharyngeal and laryngeal mucosa if desired. Supplemental oxygen is administered as previously described.

A systematic examination of both the upper and lower airways is performed during bronchoscopy, starting at the oropharynx and larynx, and noting any changes in the anatomy as well as any intrinsic function or motion of

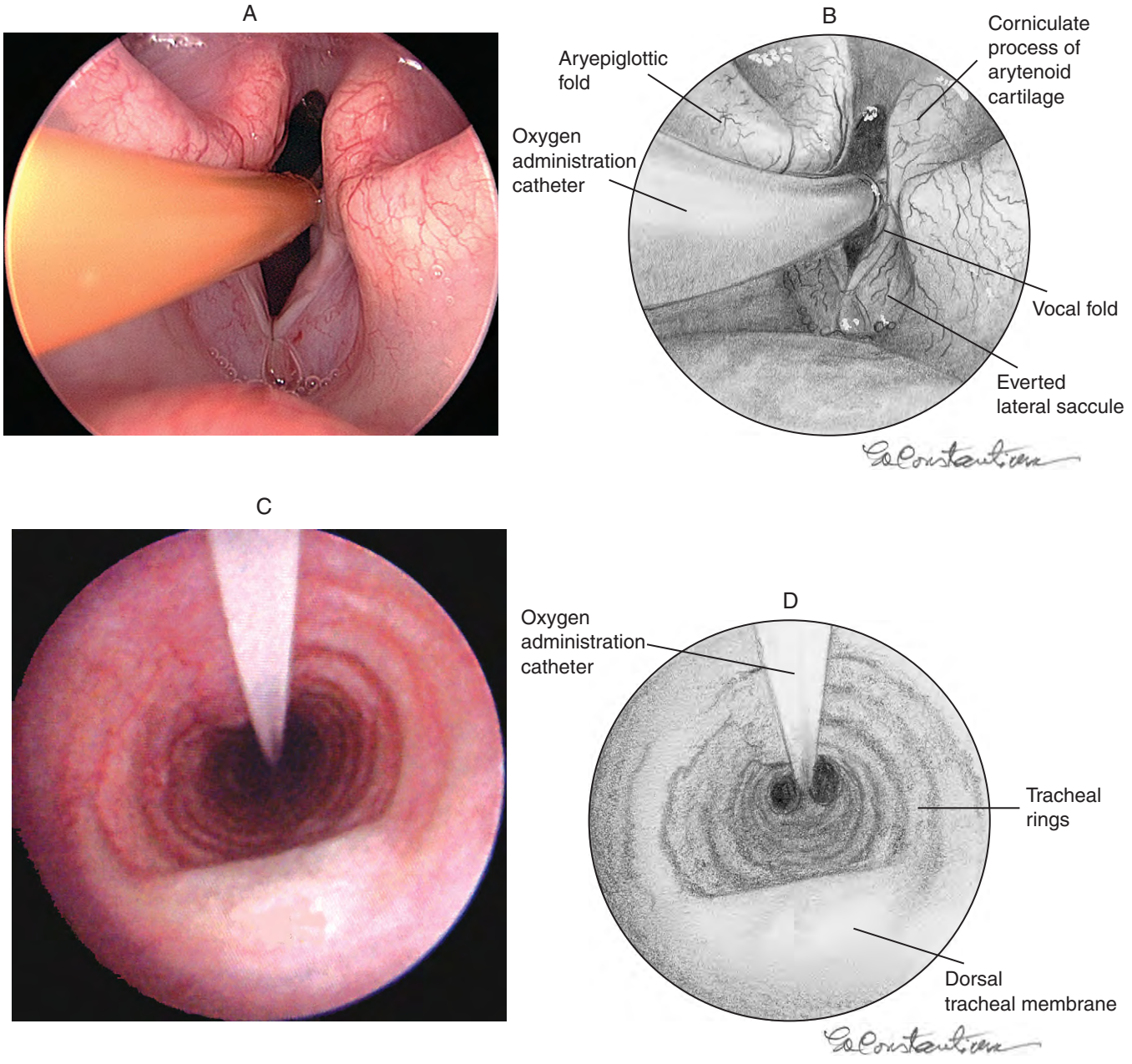



**Fig. 6-4**
A & B, Oxygen supplementation is provided during bronchoscopy by passing a separate catheter through the larynx and into the trachea. The lateral saccules in this dog are edematous and partially everted. C & D, Oxygen supplementation is provided during bronchoscopy by passing a separate catheter into the trachea.

the larynx. Miller and colleagues[12] found significant increases in glottic size following the administration of intravenous doxapram hydrochloride (Dopram-V, Ft. Dodge Animal Health, Ft. Dodge, Iowa), which is recommended for all detailed laryngeal evaluations. With use of injectable anesthetics, the upper airway is evaluated in every case and patients are not intubated until the procedure has been completed. Based on this experience, nearly one third of all bronchoscopy cases have some degree of laryngeal abnormalities upon close examination and many of these would be missed if the animal had been intubated for the procedure.

## NORMAL AND ABNORMAL BRONCHOSCOPIC FINDINGS

After the larynx is evaluated (and using the endobronchial map; see Fig. 6-5), the bronchoscope is inserted




**Fig. 6-5**
Artist's representation of the canine tracheobronchial tree using the endobronchial nomenclature proposed by Amis and McKiernan in 1986. The system uses a system of numbers and letters to identify the principal, lobar, segmental, and subsegmental bronchi by their order of origination and their dorsal and ventral anatomic orientation. *R* (the first R in each sequence), right; *L,* left; *B,* bronchus; *P,* principal; *V,* ventral; *D,* dorsal; *C,* caudal; *R* (the R appearing after a number), rostral. Numbers indicate origination order, and lowercase letters indicate origination order of subsegmental bronchi but without anatomic orientation. *(From Amis T, McKiernan BC:* Am J Vet Res *47: 2649-2657, 1986.)*

down the cervical trachea and into the intrathoracic trachea, noting any abnormalities in shape, dynamic caliber changes (collapse), and mucosal disorders (secretions, erythema, edema, masses or other lesions). The carina is evaluated for abnormalities (widening, compression, mucosal infiltration) before sequentially evaluating all the lobar and as many segmental or subsegmental bronchi as possible (the latter varies with both patient and endoscope size). It is also recommended to visualize around the end of the soft palate into the nasopharynx after bronchoscopy is completed if time and anesthetic depth allow.

As the endoscope is passed through the glottic lumen (Fig. 6-7), C-shaped cartilaginous rings are normally visible beneath the tracheal submucosal capillary network (Fig. 6-8). When this capillary bed is *not* clearly visible (Fig. 6-9), it implies that there is some degree of either mucosal edema or cellular infiltration present. The shape of the trachea is noted, with healthy dogs and cats of most breeds having a nearly circular shaped cervical and intrathoracic trachea (Fig. 6-10). Brachycephalic breeds commonly suffer from tracheal hypoplasia (often affecting the entire length of their trachea), which is detected by noting overlapping ends of the tracheal rings, a misshapen and narrowed tracheal lumen, and often excess secretions foamed into a froth in the trachea (Figs. 6-11 and 6-12). Segmental hypoplasia is also encountered, most often in toy breed dogs near the thoracic inlet. Dorsoventral (or occasionally lateral) flattening of the trachea is common in toy breed dogs (Fig. 6-13); the location, length of involved segment, and severity (grade 1 to 4) are noted.

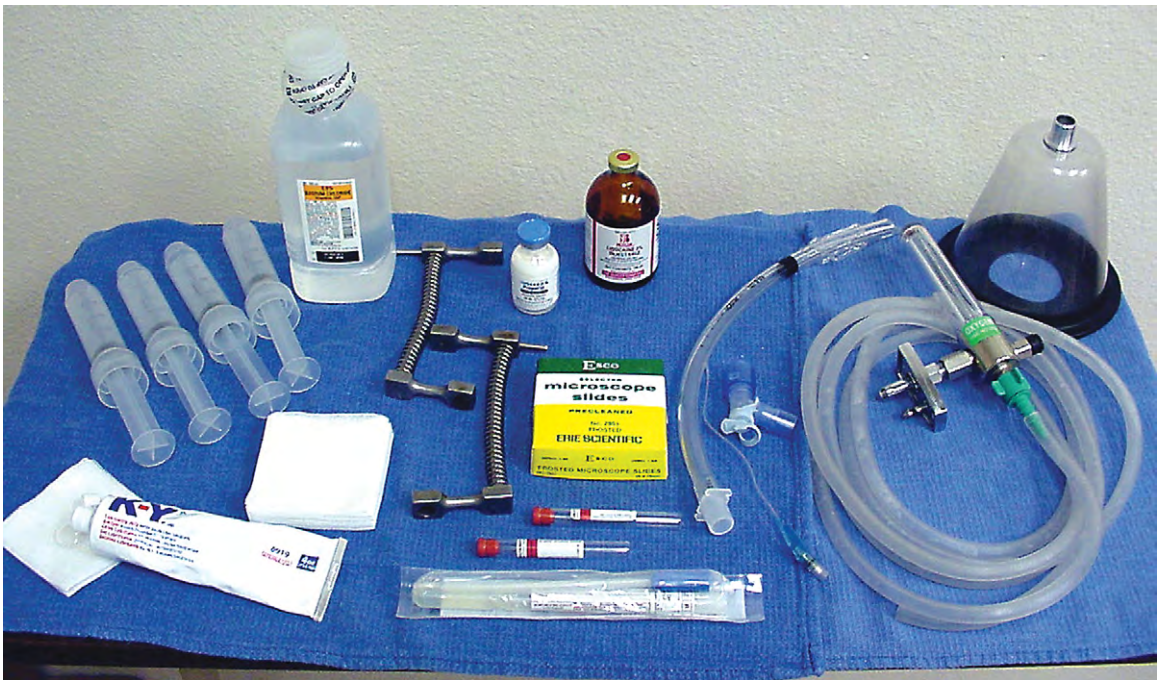



**Fig. 6-6**
All necessary equipment is set out ahead of time in preparation for the bronchoscopic procedure. Items shown include sterile NaCl and preloaded syringes for bronchoalveolar lavage (BAL), lidocaine and propofol, mouth gags, oxygen for supplementation, an endotracheal tube with an anesthesia T-port, a facemask for administering oxygen during recovery, lubricant for the endoscope, and material for processing the BAL sample (microscopic slides, tubes for collecting fluid, and culture media).

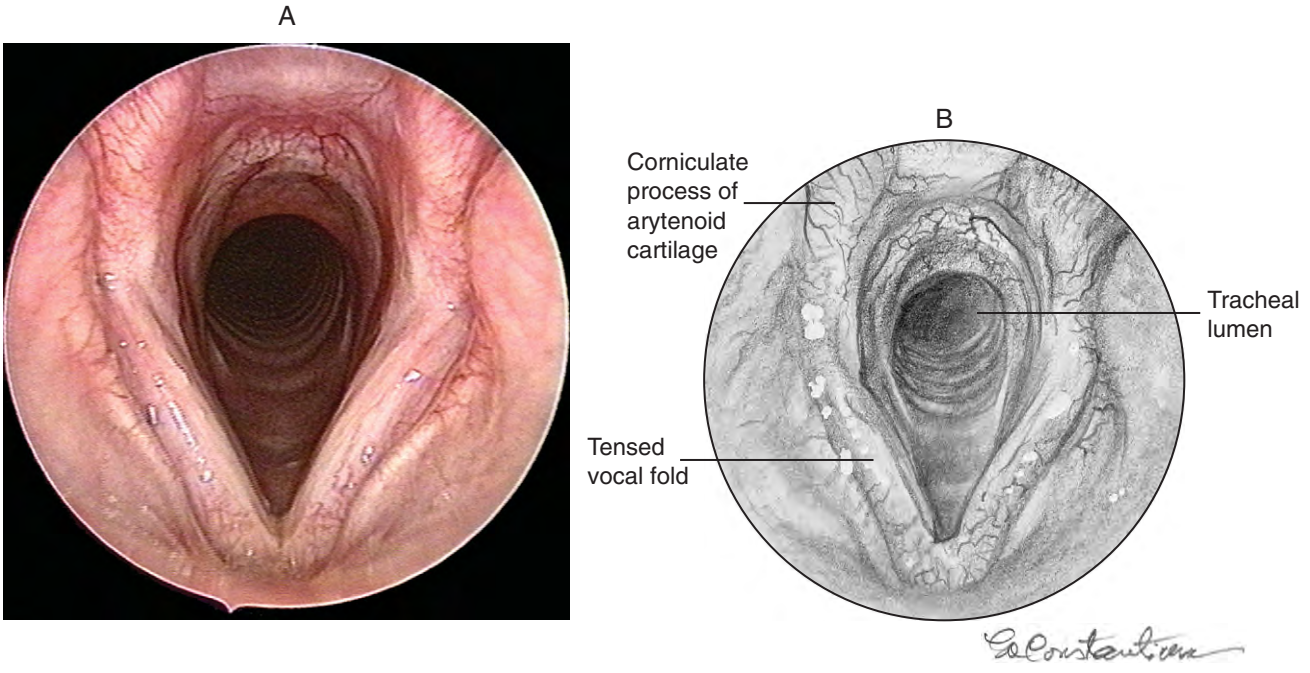



**Fig. 6-7**
Appearance of the normal canine larynx and glottic lumen following Dopram administration. Note that the vocal cords are taut, the arytenoids are fully and equally abducted, and the submucosal capillary network is readily visible, implying no mucosal edema or infiltration.

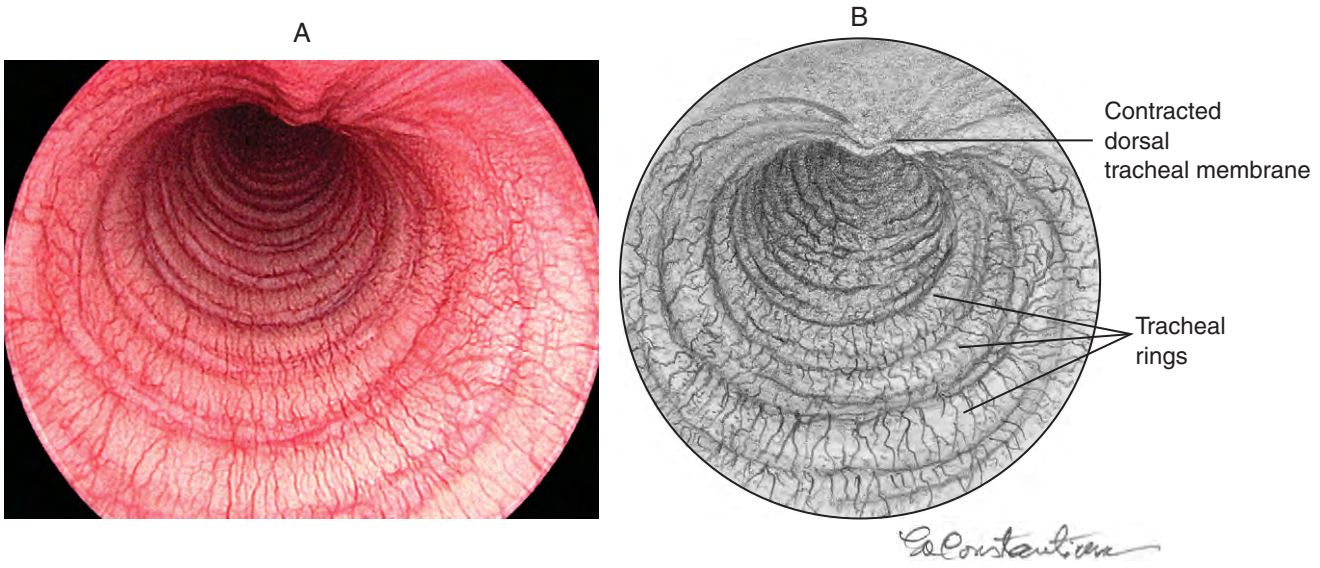



**Fig. 6-8**
C-shaped cartilaginous rings visible beneath the tracheal submucosal capillary network in a normal dog.

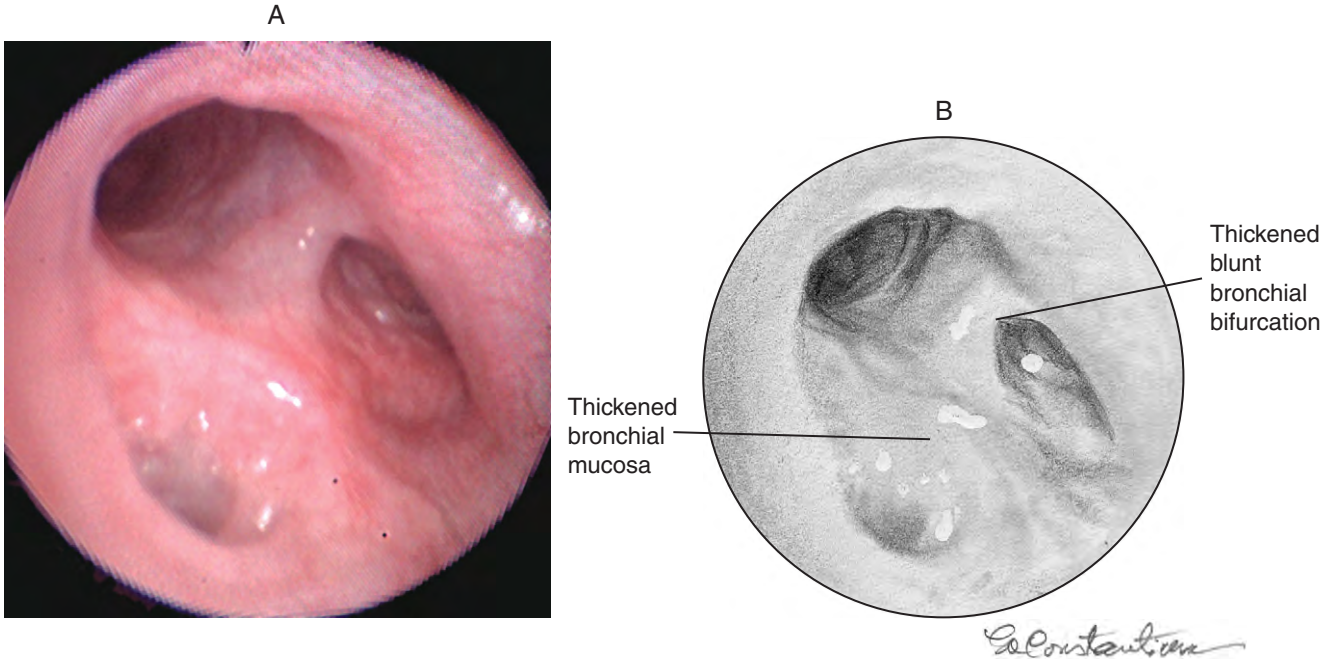



**Fig. 6-9**
The presence of either edema, as shown by the glistening appearance in this dog, or cellular infiltration into the tracheobronchial mucosa, which obscures the normal submucosal capillary detail. Compare these findings with the readily visible capillary network in the dog shown in Figs. 6-8 and 6-10.

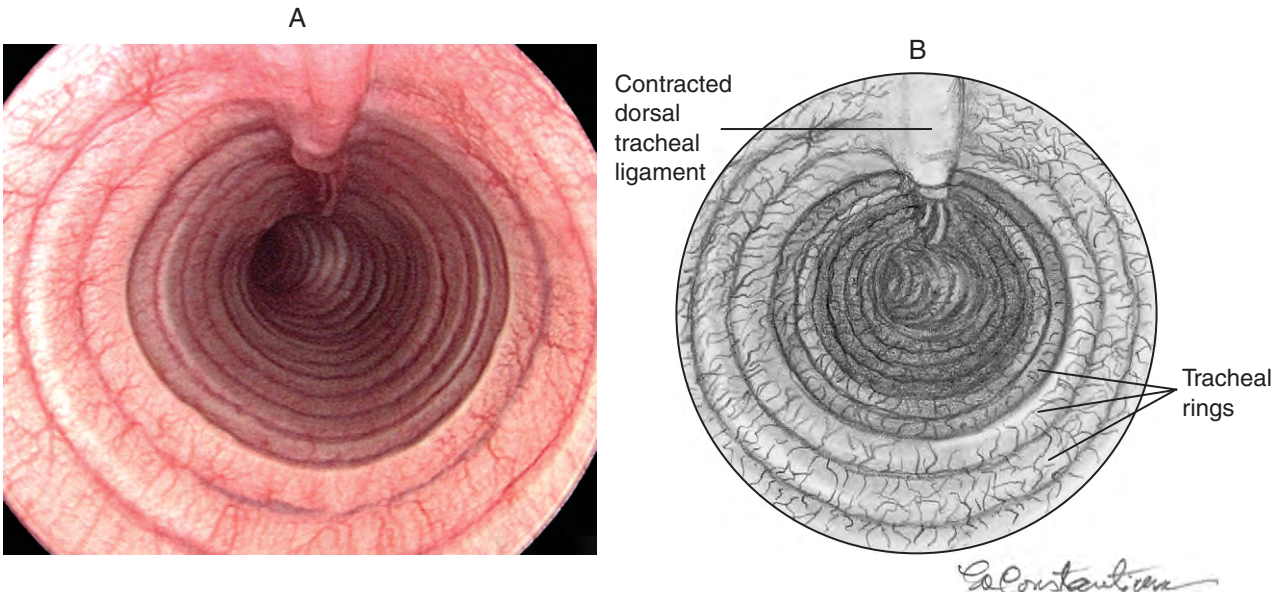



**Fig. 6-10**
Normal circular shape of the tracheal rings in a dog. Note the contracted tracheal ligament dorsally.

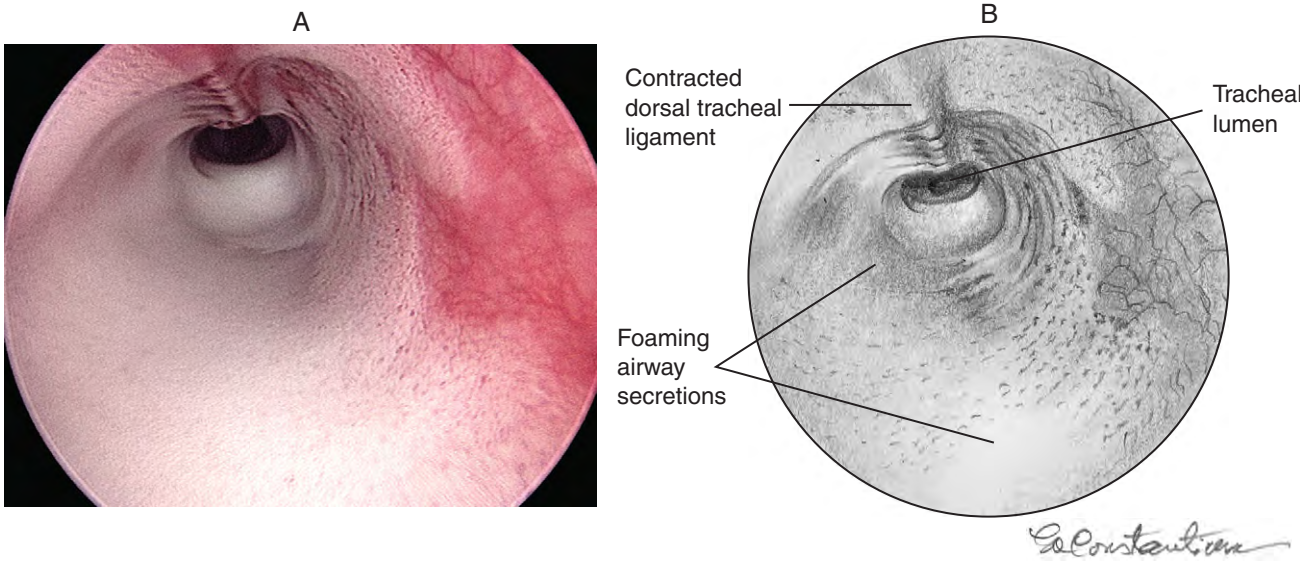



**Fig. 6-11**
Appearance of severe foaming of airway secretions that are commonly encountered in brachycephalic dogs.

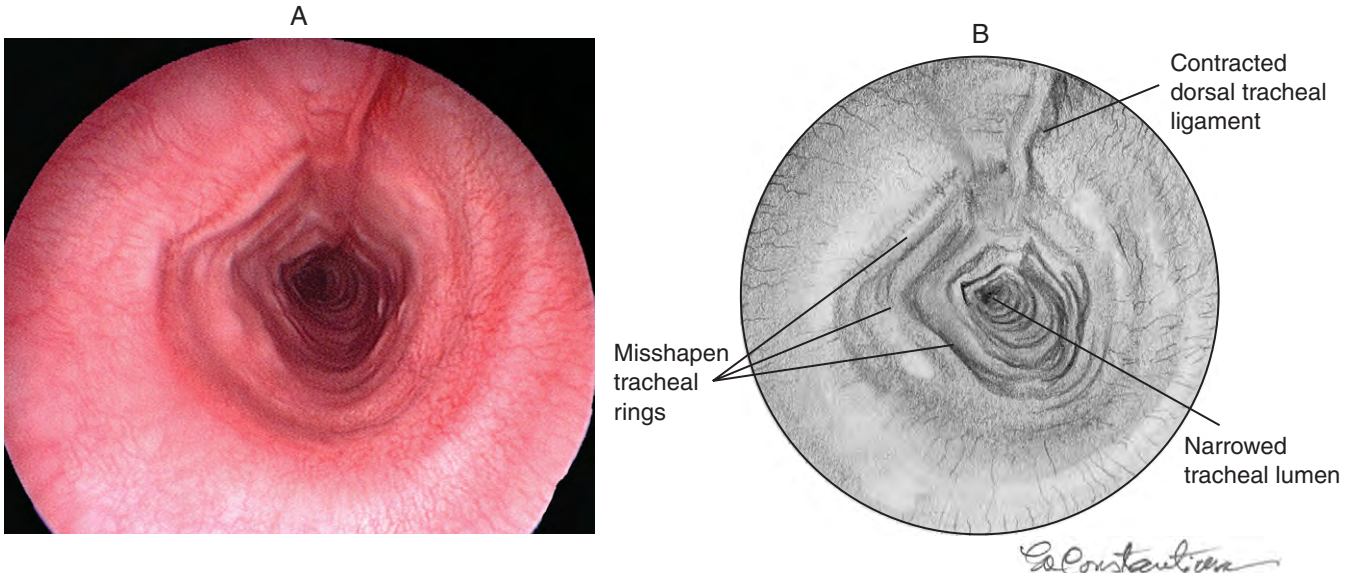



**Fig. 6-12**
Misshapen and narrowed tracheal lumen seen with tracheal hypoplasia in brachycephalic dogs.

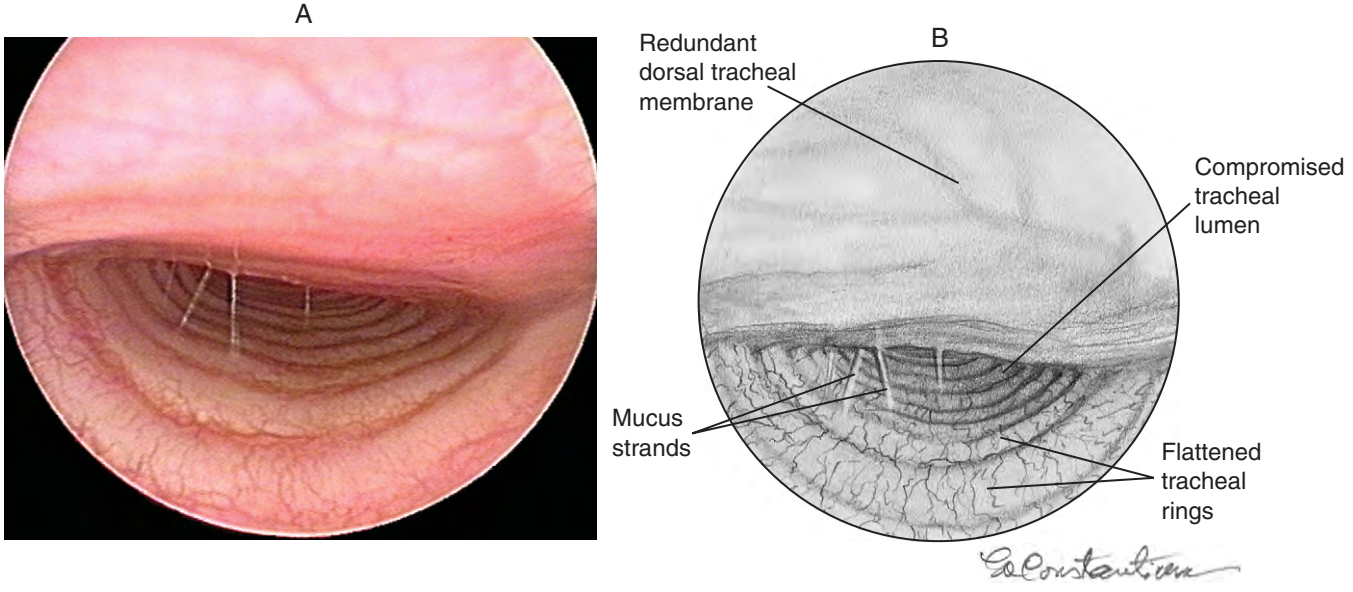



**Fig. 6-13**
Dorsoventral tracheal flattening of a grade 2-3/4 tracheal collapse in a 6-year-old Chihuahua.

The normal canine and feline airway has a monopodial branching system and there is a gentle, smooth tapering of the airways into the periphery (Fig. 6-14). Changes in the tracheobronchial tree may be focal or generalized, and include those of shape and size of the airway lumen, such as an intraluminal stricture, intraluminal tumor, external compression (tumor or lymphadenopathy), bronchiectasis, or dynamic collapse (Figs. 6-15 to 6-18).

The dorsal tracheal membrane is viewed as a longitudinal strip of muscle joining the ends of the C-shaped rings. Normally the tracheal membrane is stretched relatively tightly so that there is little, if any, redundancy (visible protrusion or collapse into the airway) in the normal animal. In my experience, a small dynamic caliber change may be noted during respirations but the airways do not completely collapse in the healthy animal, even

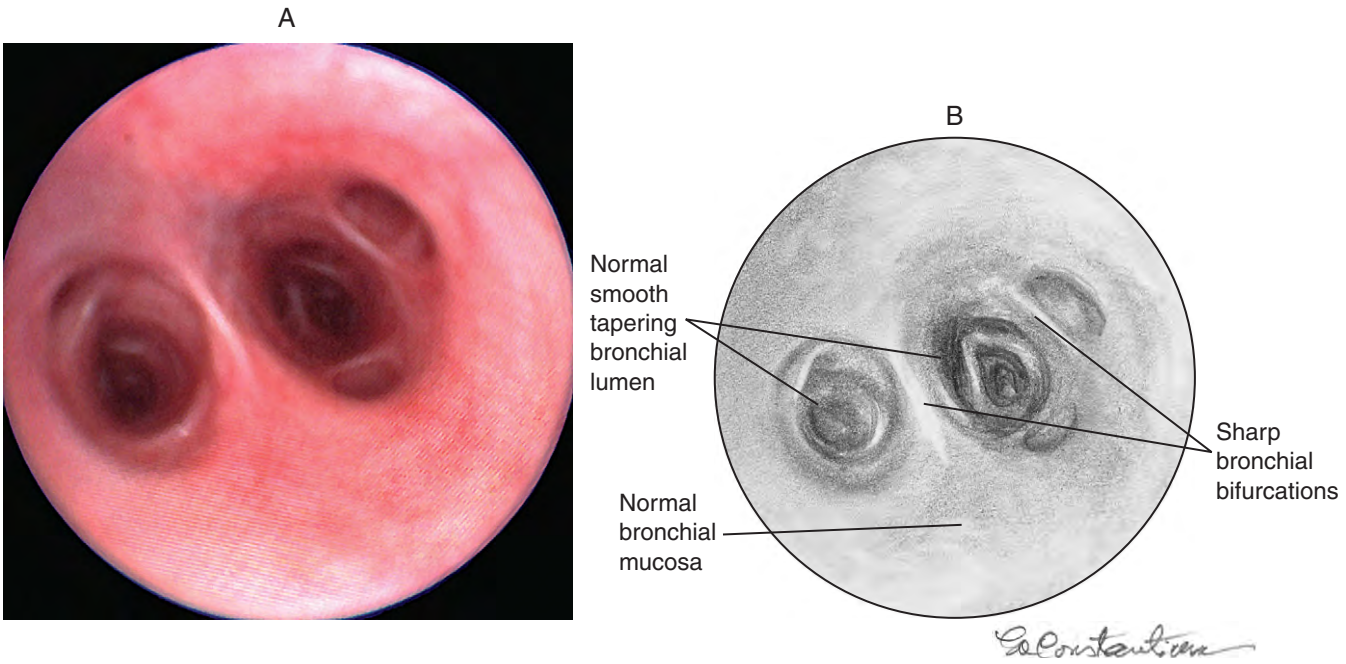



**Fig. 6-14**
Appearance of the distal airway in a normal dog. Note the smooth and gentle tapering of the airway lumen as it extends into the periphery and the sharp bifurcations (spurs) made when the parent bronchus divides into daughter bronchi.

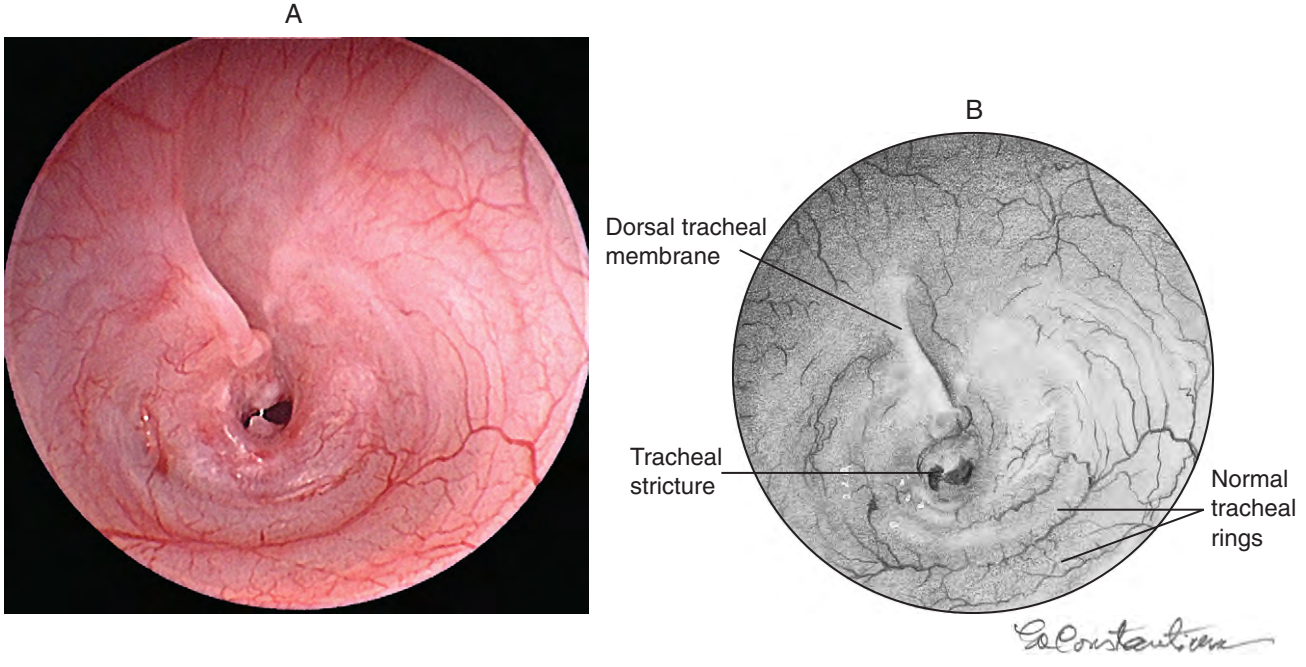



**Fig. 6-15**
Tracheal stricture causing altered airway caliber in a dog.

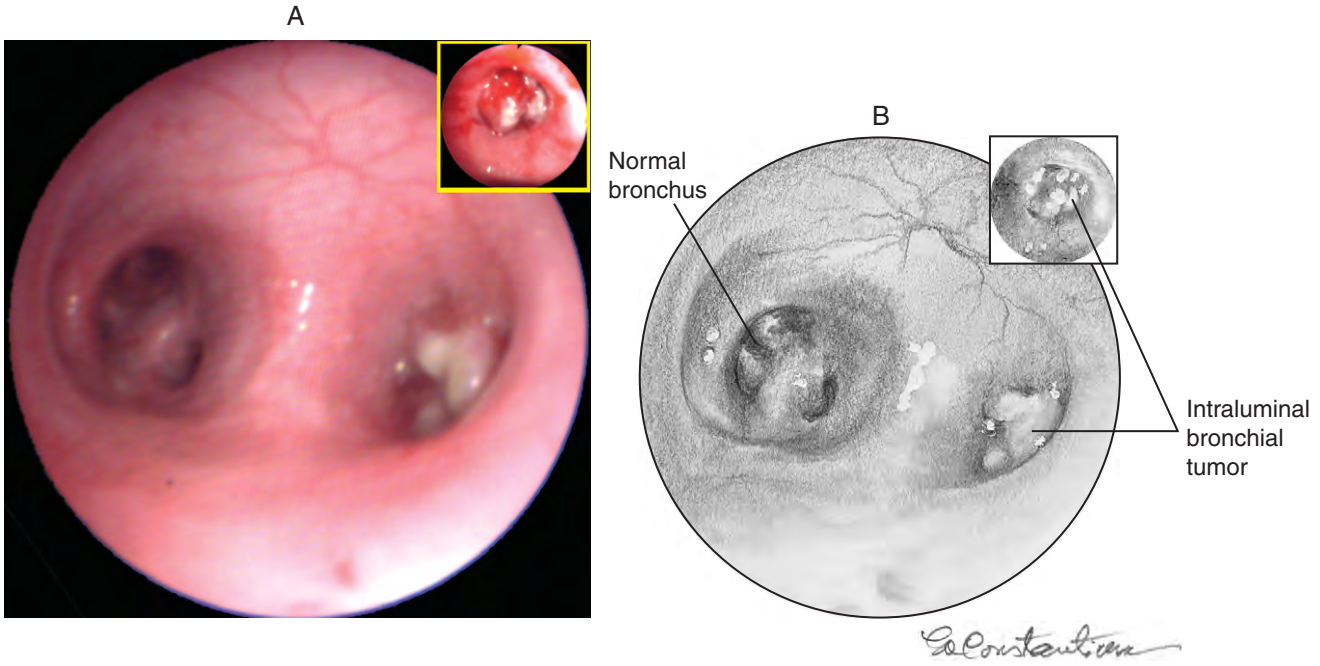



**Fig. 6-16**
An intraluminal tumor obstructing the left principal bronchus, altering the airway caliber in a dog. *Inset*: Close-up after a biopsy sample was obtained.

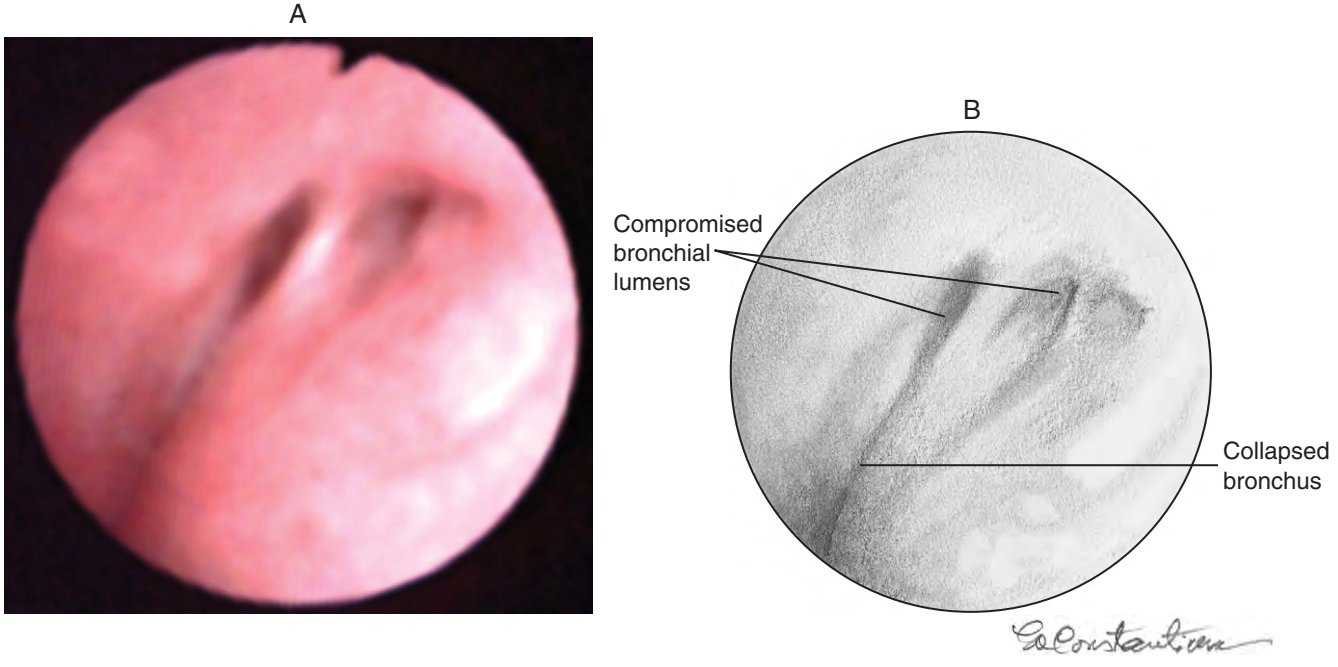



**Fig. 6-17**
Structural, fixed collapse of the left principal bronchus causing altered airway caliber in a dog.

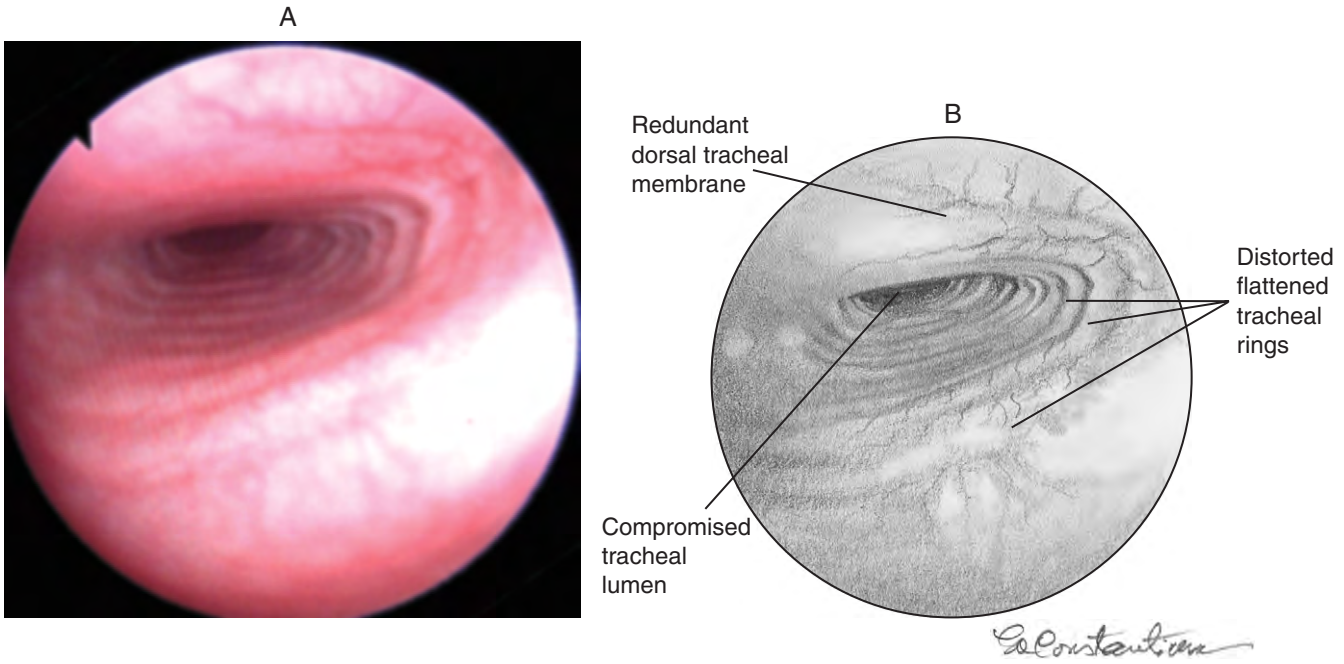



**Fig. 6-18**
Dynamic tracheal collapse of the cervical trachea causing altered airway caliber in a dog.

during a forceful expiratory maneuver (e.g., coughing). Excessive airway narrowing is commonly observed in animals with tracheal collapse, bronchiectasis, and tracheobronchial malacia—conditions in which the structural integrity of the cartilaginous support of the airways has been altered (Fig. 6-19).

The healthy tracheobronchial mucosa appears as a smooth, light pink surface with a rich supply of submucosal capillaries usually visible in the submucosa (Fig. 6-20). Note that the mucosa appears too white because of light reflection when the scope is too close to the surface. The normal mucosa has a slight glistening appearance resulting from the presence of a thin layer of fluid (the "sol") on the surface. Excessive fluid accumulation *within* the mucosa (edema) is readily apparent because it imparts a gelatinous appearance to the epithelial surface (Fig. 6-21). Generalized mucosal hyperemia (due to inflammatory changes, increased vascularity) is a common finding in chronic respiratory diseases. Because animals undergo bronchoscopy due to disease concerns, care must be taken when interpreting the appearance of the tracheobronchial mucosa so that hyperemia is not accepted as normal. Small polypoid mucosal nodules (Fig. 6-22) are commonly encountered in cases of chronic bronchitis in dogs. These are not to be mistaken for neoplastic nodules; biopsy of these nodules usually reveals ingrowth of fibrous tissue (fibroblasts) formed during normal reparative processes following damage to the airway basement membrane.

Small accumulations of mucus (clear to white or slightly opaque) may be observed on the mucosa in healthy animals, often stranding across the lumen or sometimes pushed up in front of the bronchoscope during the procedure. Larger accumulations and secretions of unusual color are abnormal and typically are associated with chronic airway irritation, infection (bacterial, parasitic, or fungal), allergies, and trauma (Figs. 6-23 and 6-24). Inspissated secretions are commonly encountered in bronchiectatic regions in dogs and cats, appearing as caseated, chunky material (Figs. 6-25 and 6-26).

Mucosal surface trauma may be detected during endoscopy and may be the result of forceful or rough endoscope insertion, or it may be due to suction, brushings, or biopsy procedures. When increased mucosal friability or hemorrhage is present on initial examination (Fig. 6-27), it may be associated with external trauma (lung contusion, bite wounds), parasitic infection (e.g., *Paragonimus*, *Oslerus*) (Fig. 6-28), foreign body (Fig. 6-29), or mucosal trauma induced from chronic coughing or airway narrowing from external compression (e.g., hilar lymphadenopathy) (Fig. 6-30). Mucosal changes are less commonly caused by primary lung tumors in dogs in that they typically develop in the periphery and impinge on the airway *without* evidence of mucosal invasion, which is more typical of human lung cancer (Figs. 6-31 and 6-32).

The carina is the name given to the bifurcation of the trachea into the left and right mainstem or principal bronchi (Fig. 6-33). This bifurcation forms a relatively sharp V in

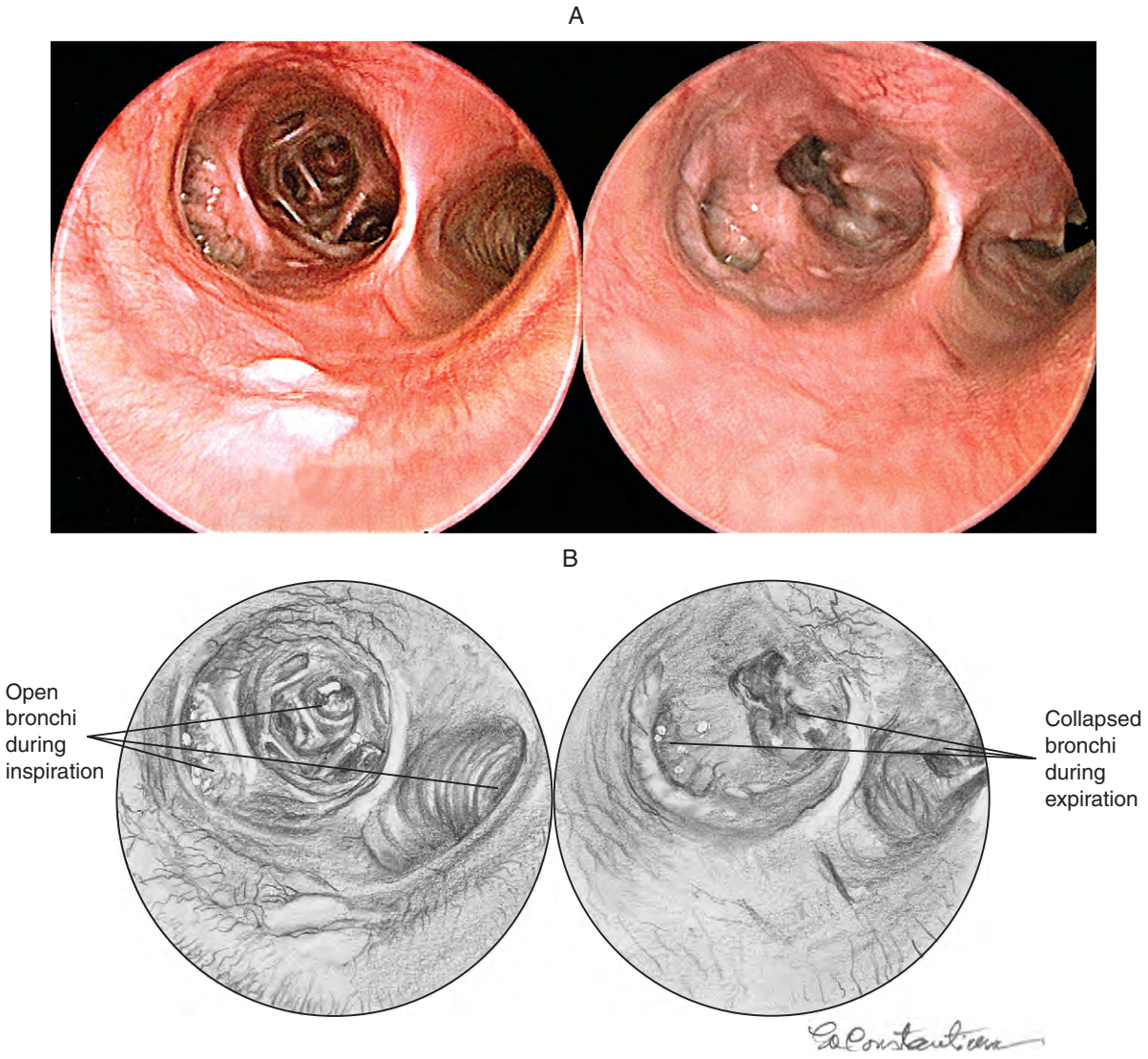



**Fig. 6-19**
Significant large airway collapse commonly seen as a result of pressure changes associated with normal inspiration and expiration in a dog with tracheobronchial malacia.

the normal dog and cat (Fig. 6-34), with no evidence of either principal bronchial compression (e.g., from hilar lymphadenopathy) or bronchial collapse. The carina may appear to be widened (taking on more of a U shape) as the result of hilar lymph node enlargement secondary to systemic fungal diseases (histoplasmosis, blastomycosis, coccidioidomycosis) and tumors (lymphosarcoma, primary lung tumors). These diseases frequently invade these nodes and can lead to mainstem bronchial compression (Fig. 6-35) and respiratory distress, especially following exertion.

Airway bifurcations *distal* to the carina share the common name of a *spur* and normally these form a V, sharply delineating the bronchial divisions. With chronic airway inflammation or mucosal edema, these spurs become widened and appear more U-shaped (Figs. 6-36 and 6-37), typically with some loss in the detail of the submucosal vessels.

## SAMPLE PROCUREMENT AND HANDLING

With practice and experience, the endoscopist is able to traverse the tracheobronchial tree quickly and recognize both the overt and the subtle changes of respiratory disease. Although the lung (bronchial epithelium) appears to respond to irritation in limited ways, grossly visible changes may not be pathognomonic for any specific disease.[13] Samples from the airways are therefore used to establish an etiologic or specific diagnosis.

Whether or not abnormalities are noted, samples are obtained for culture and cytology, and sometimes for

*Text continued on p. 224.*

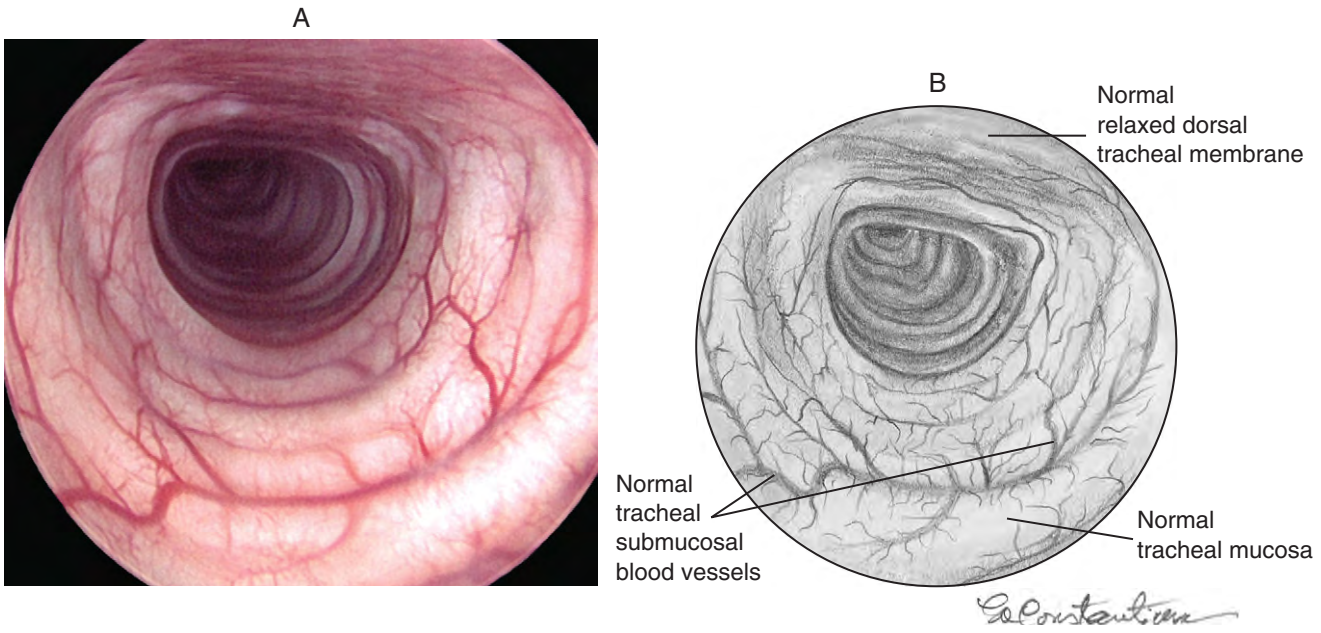



**Fig. 6-20**
Healthy tracheobronchial mucosa in a dog. Note the smooth, light pink surface with a rich supply of submucosal blood vessels.

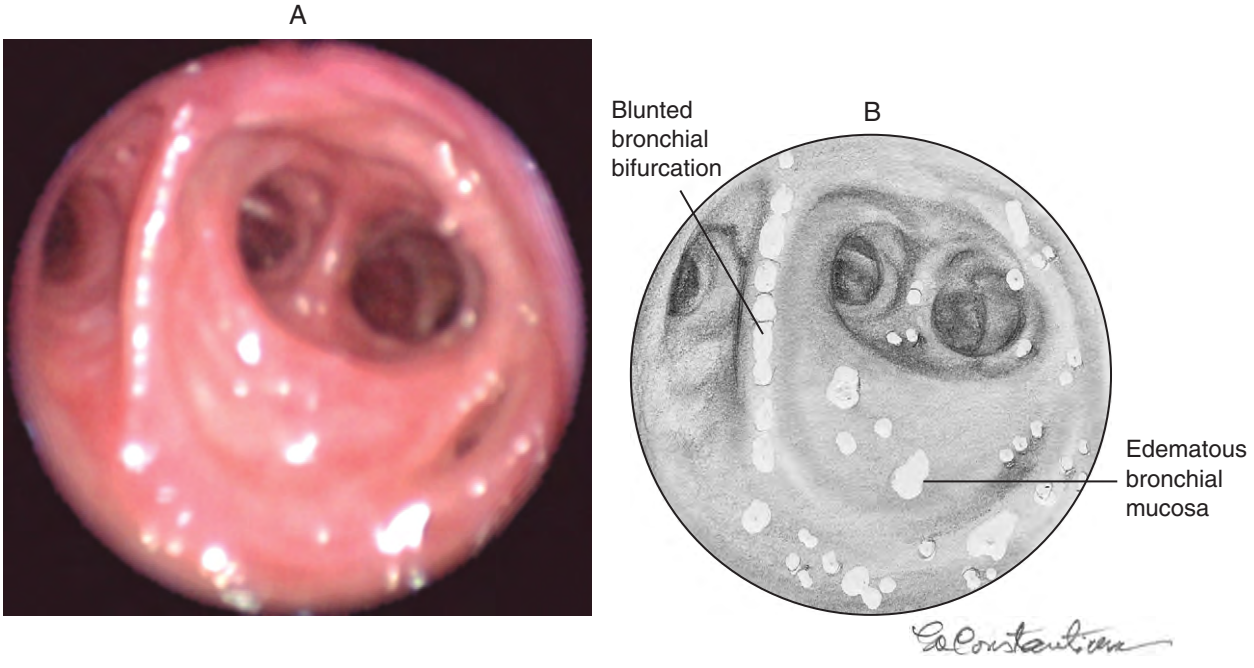



**Fig. 6-21**
Mucosal edema identified by its gelatinous appearance on the epithelial surface of the airways in a dog with bronchiectasis.

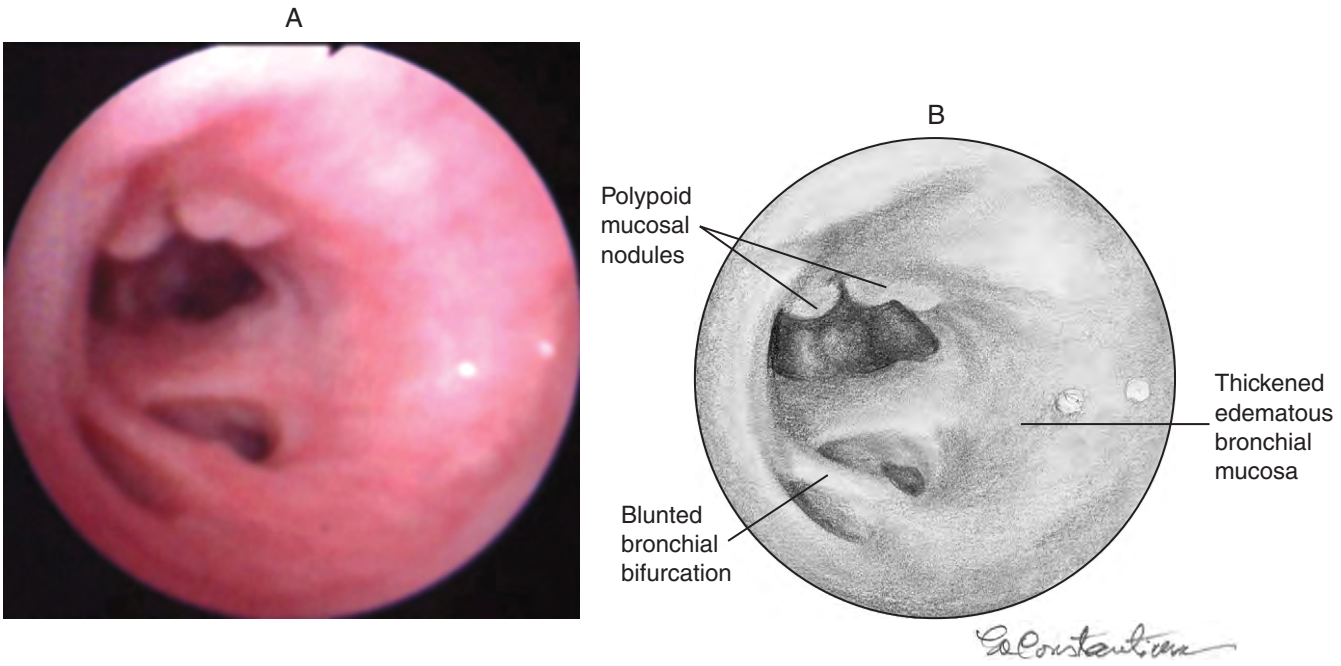



**Fig. 6-22**
Polypoid mucosal nodules are commonly encountered in cases of chronic bronchitis in dogs.

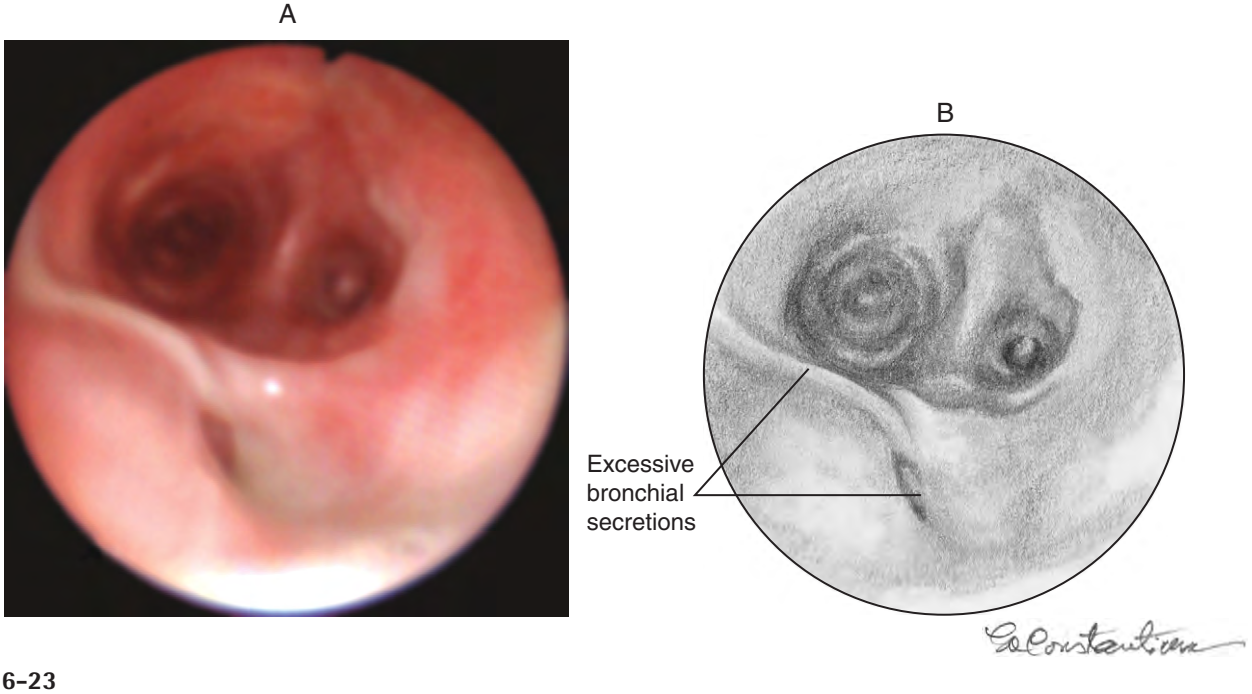



**Fig. 6-23**
Excess secretions associated with bacterial pneumonia.

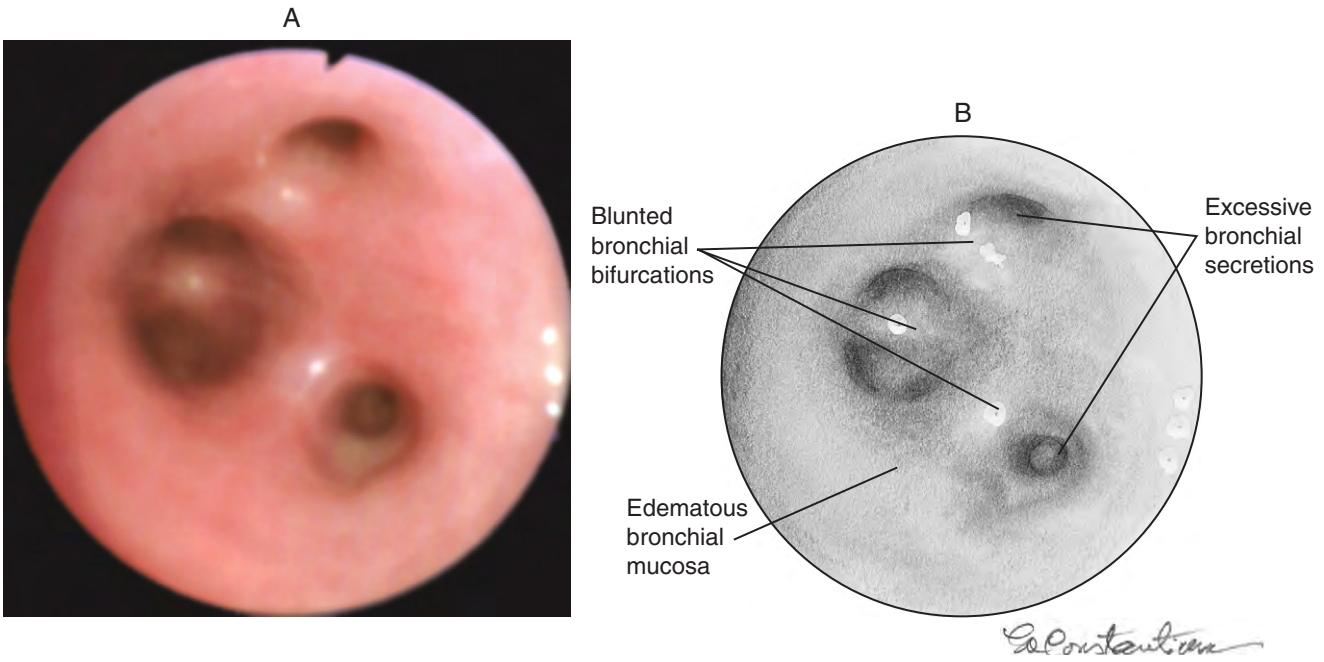



**Fig. 6-24**
Appearance of excess secretions in allergic lung disease. Note the slightly yellowish color of the secretions. The large numbers of eosinophils present in the secretions cause this color change.

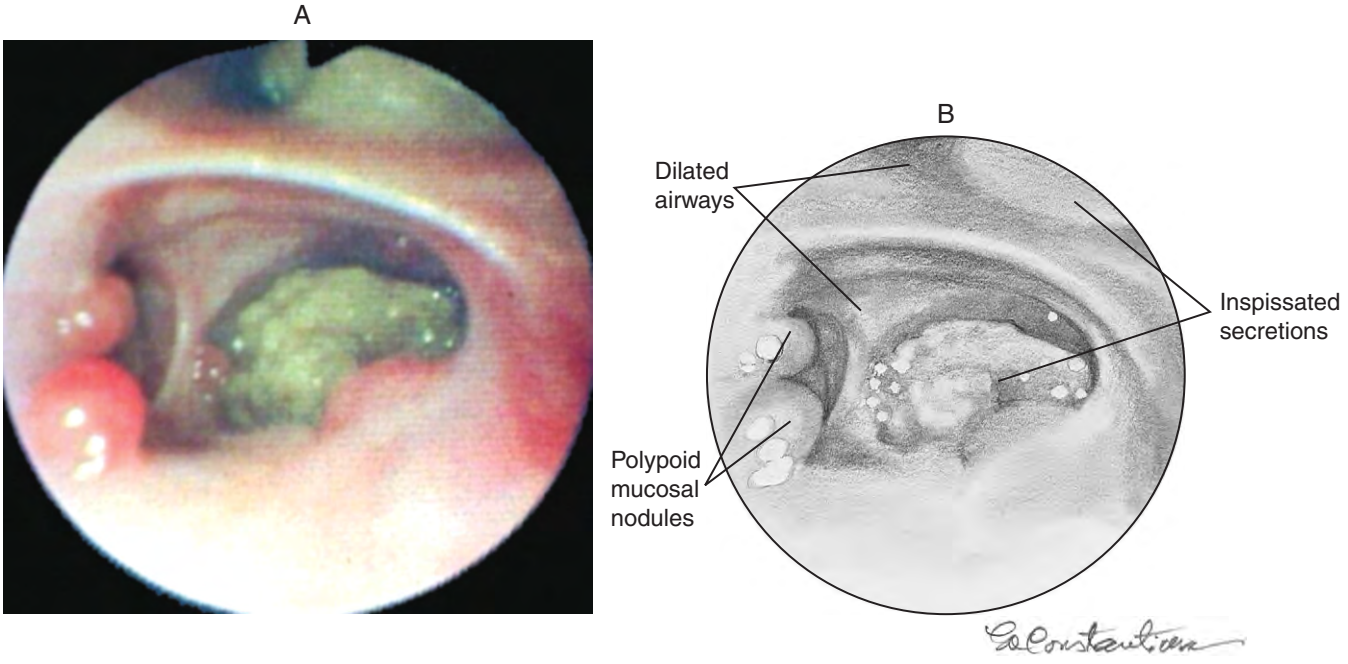



**Fig. 6-25**
The endobronchial appearance of bronchiectasis in a dog.

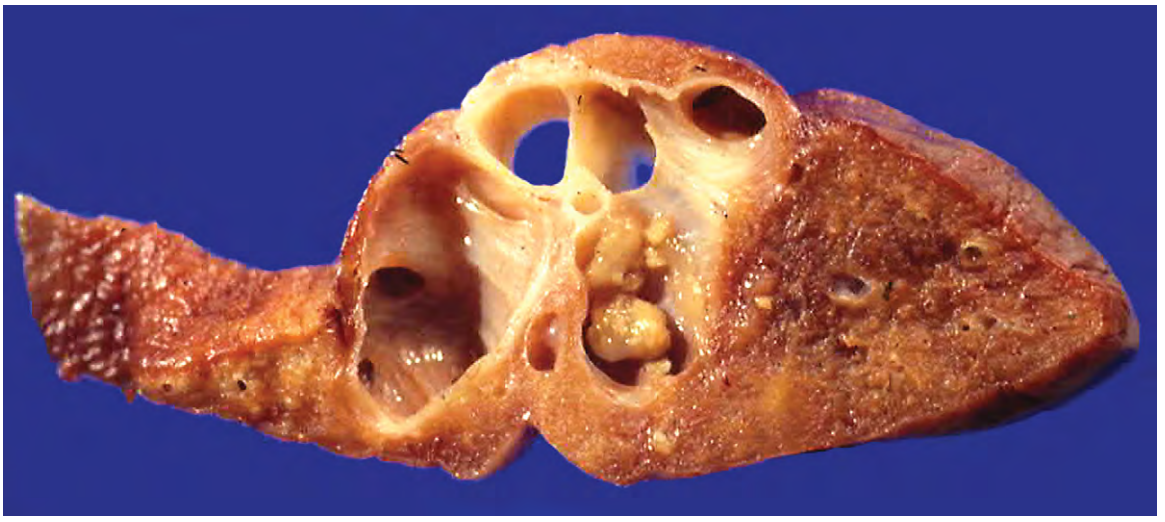


**Fig. 6-26**
The gross lung specimen following lobectomy of the lung shown in Fig. 6-25. Note the severely dilated airways and thick, inspissated accumulations of secretions.

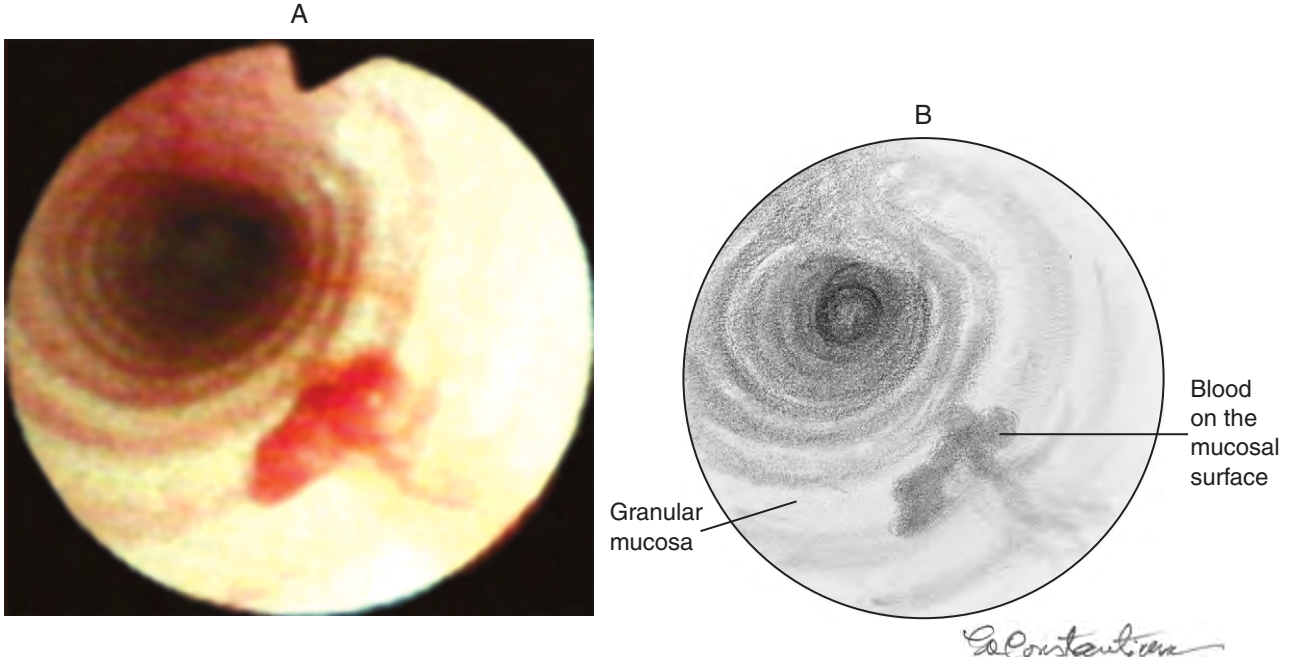



**Fig. 6-27**
Mucosal irregularity (the granular appearance) and blood on the mucosal surface in a case of chronic bronchitis.

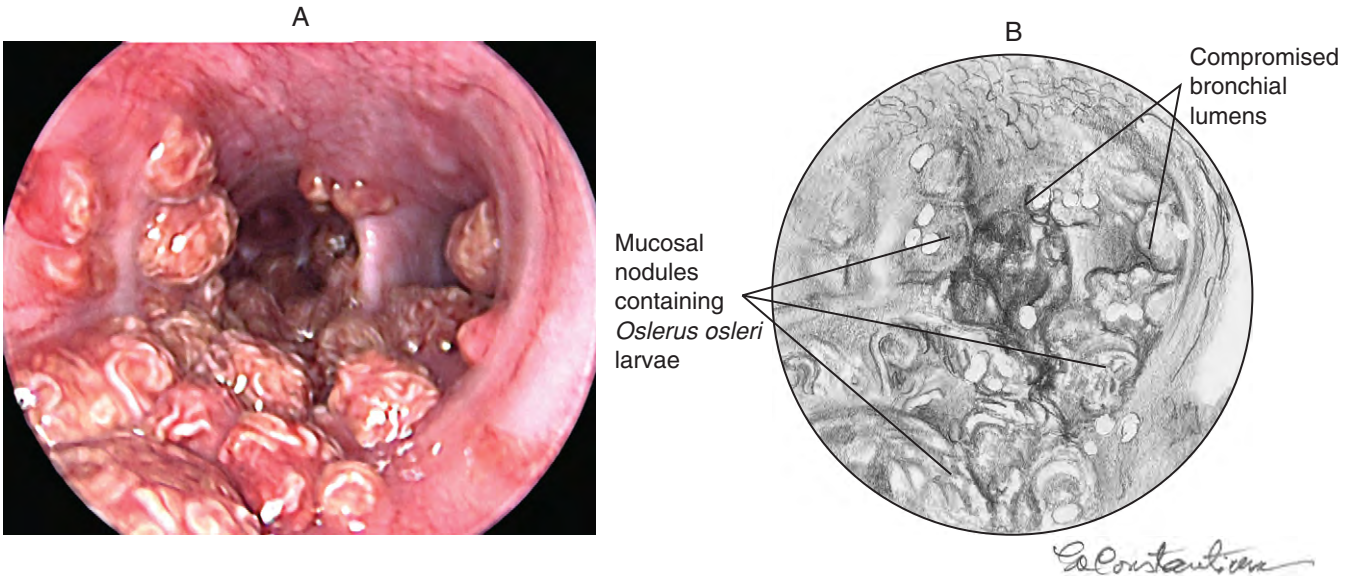



**Fig. 6-28**
Large mucosal nodules just cranial to and nearly obstructing the carina in a 14-month-old Jack Russell Terrier. Larvae characteristic of *Oslerus osleri* infection are visible inside the nodules.

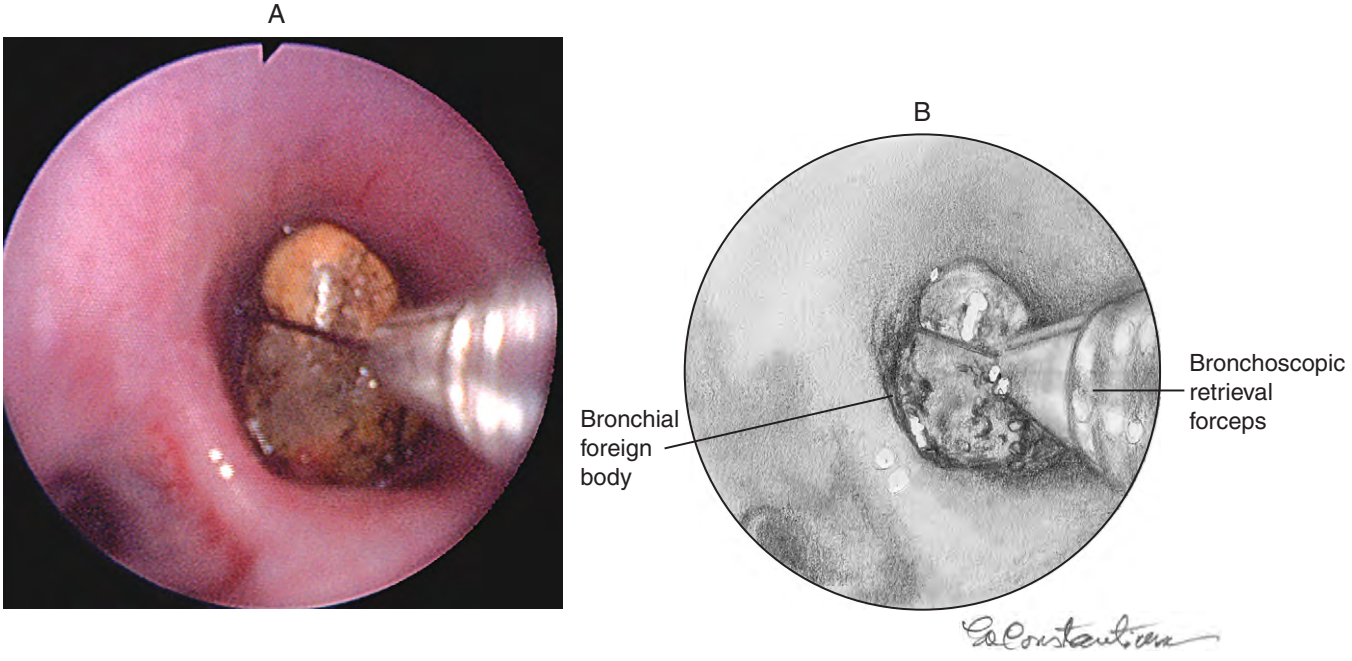



**Fig. 6-29**
A bronchial foreign body (a small rock) is retrieved with bronchoscopy from the right caudal lung lobe bronchus of a dog with acute onset of coughing and respiratory distress.

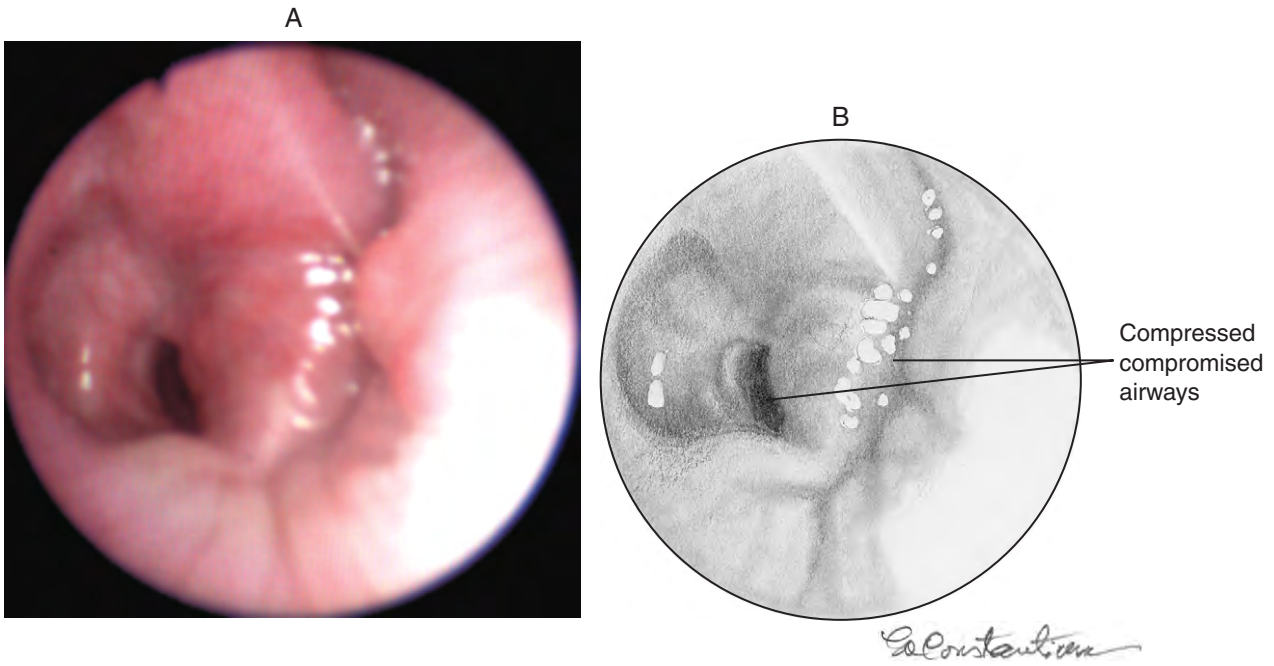



**Fig. 6-30**
Severe airway narrowing due to external compression resulting from hilar lymphadenopathy associated with systemic fungal disease (coccidioidomycosis) in a 9-year-old Dachshund. Compare these findings with the normal appearance of the carina in a normal dog seen in Fig. 6-33.

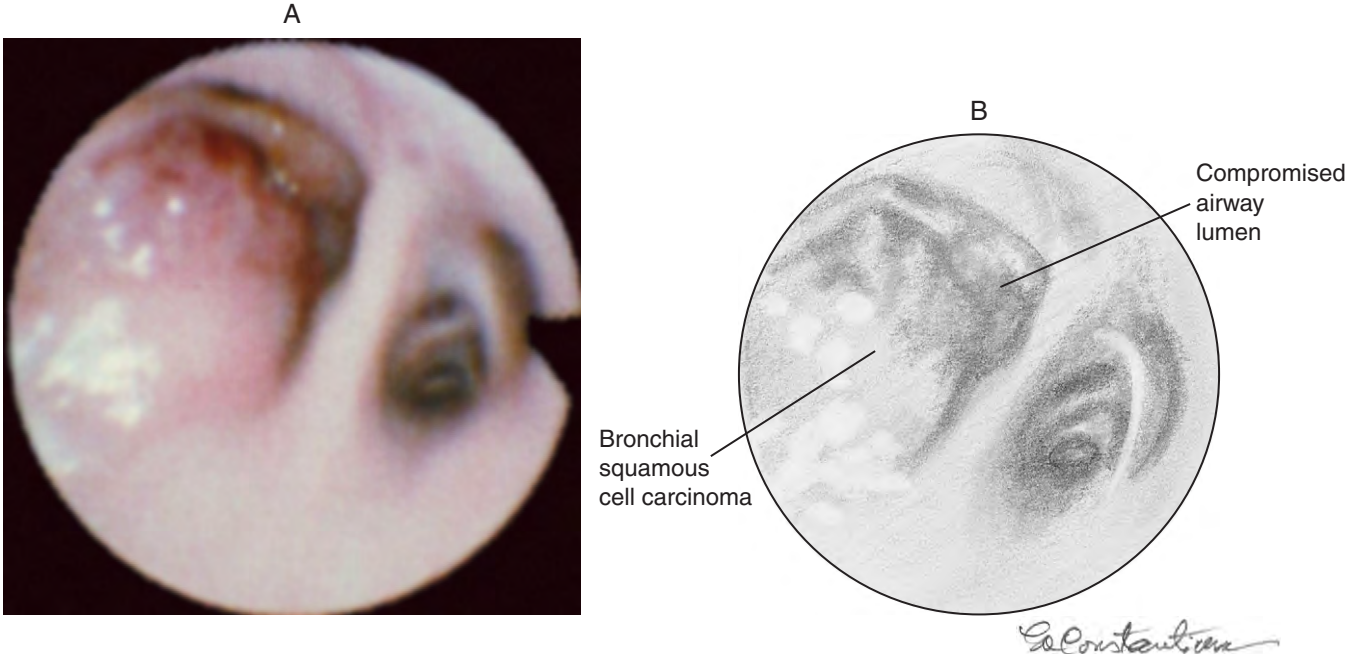



**Fig. 6-31**
Appearance of a primary lung tumor in the carina of a dog. The mucosal involvement seen in this primary squamous cell carcinoma is uncommon in that most primary lung tumors start in the periphery and compress the airways as they grow and expand.

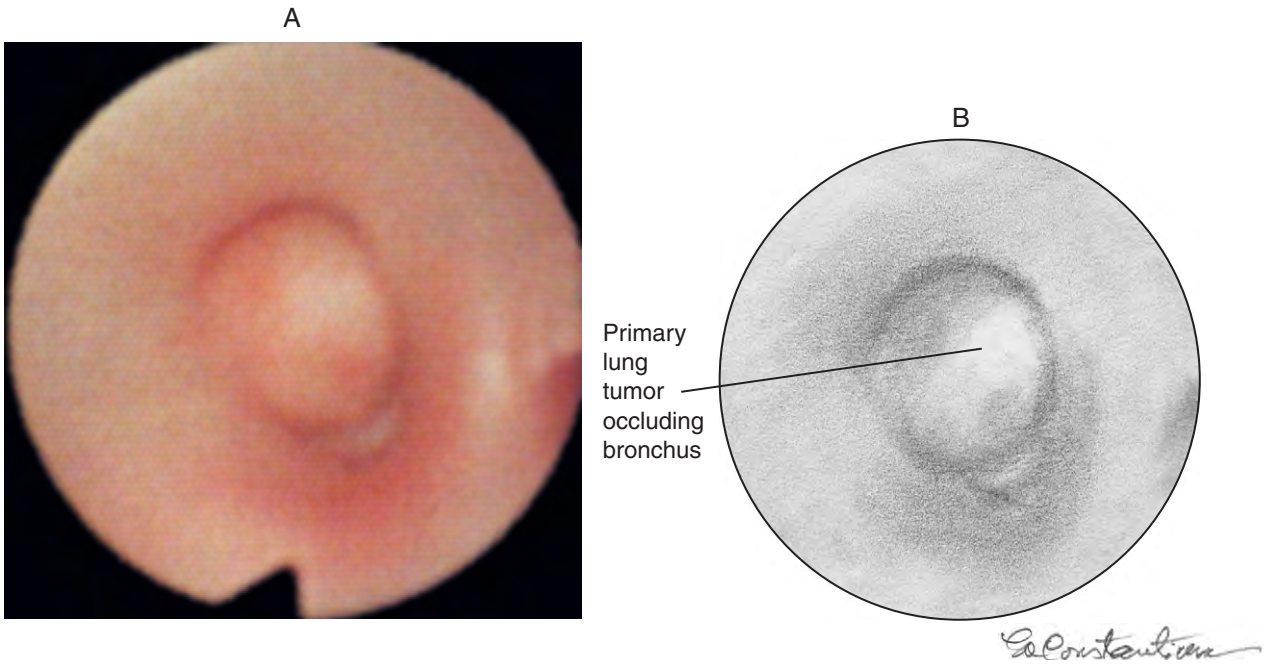



**Fig. 6-32**
Appearance of a more typical peripheral primary lung tumor in a dog.

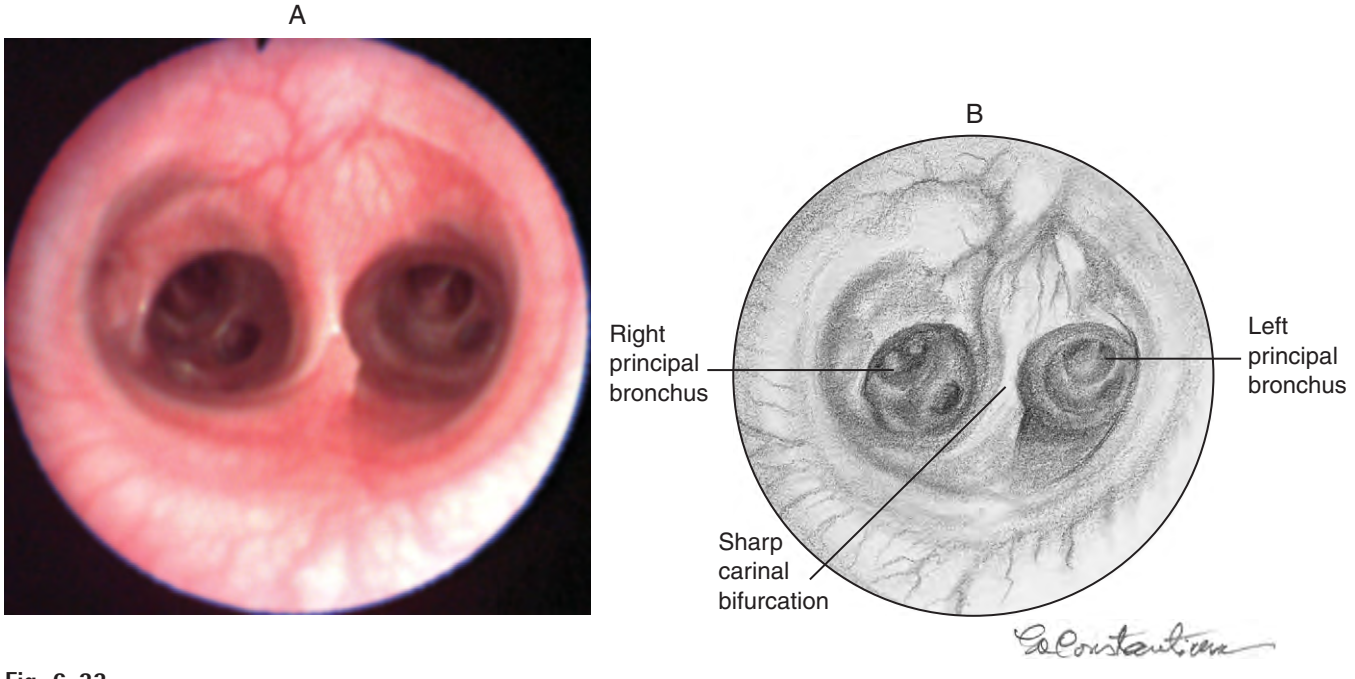



**Fig. 6-33**
Bronchoscopic appearance of a normal canine carina demonstrating the sharp V-shaped appearance. The principal bronchi are visible with the right bronchus on the left side of the figure and the left bronchus on the right side.

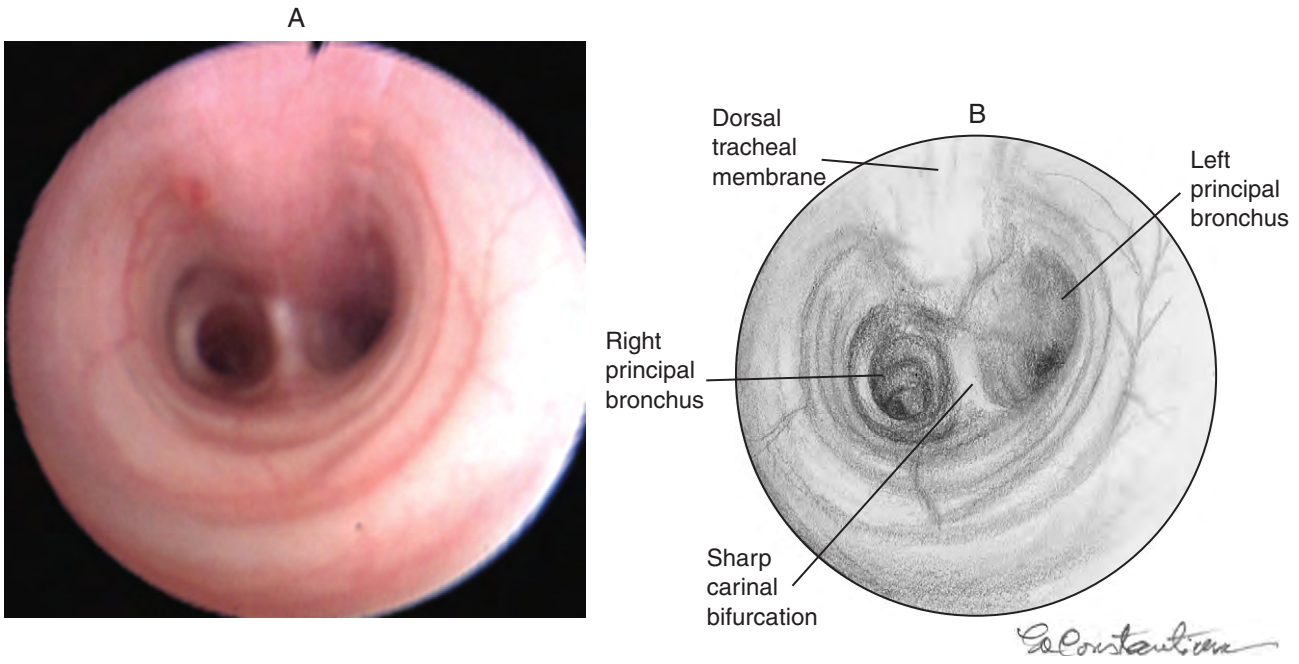



**Fig. 6-34**
Normal carina in a cat. The mucosa often is paler or has a slight yellowish tint in the feline species.

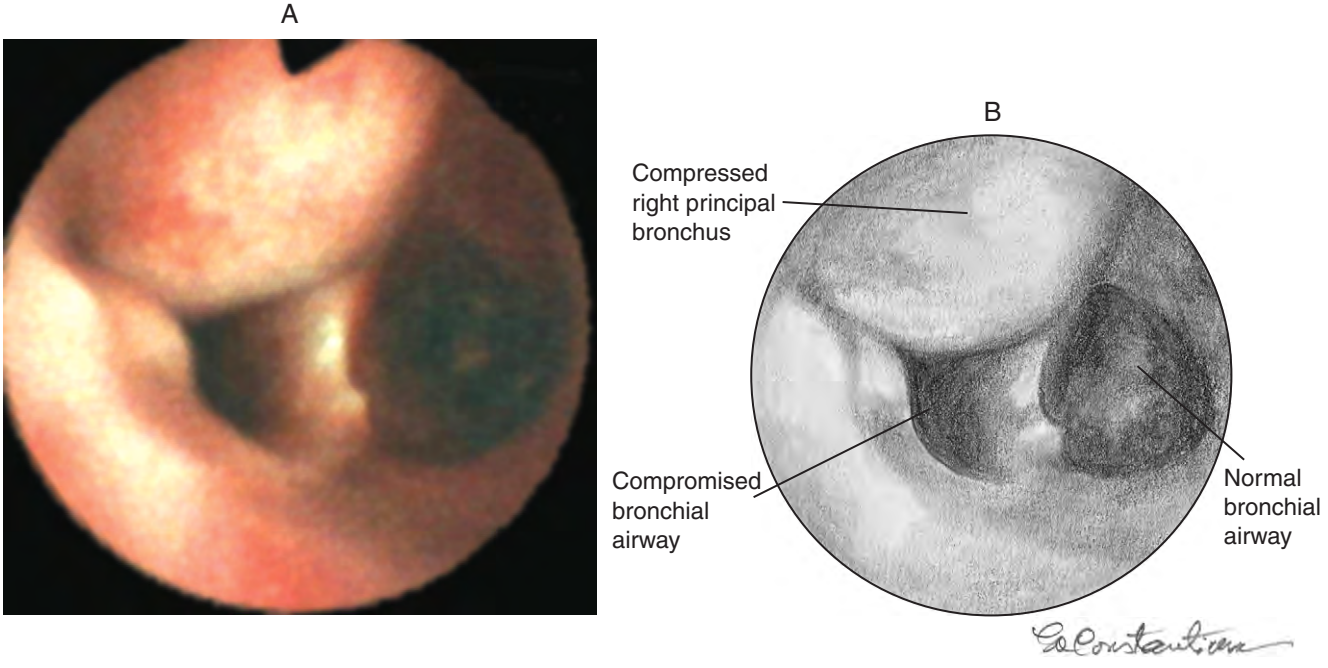



**Fig. 6-35**
Hilar lymphadenopathy compressing the right mainstem bronchus in a case of canine blastomycosis.

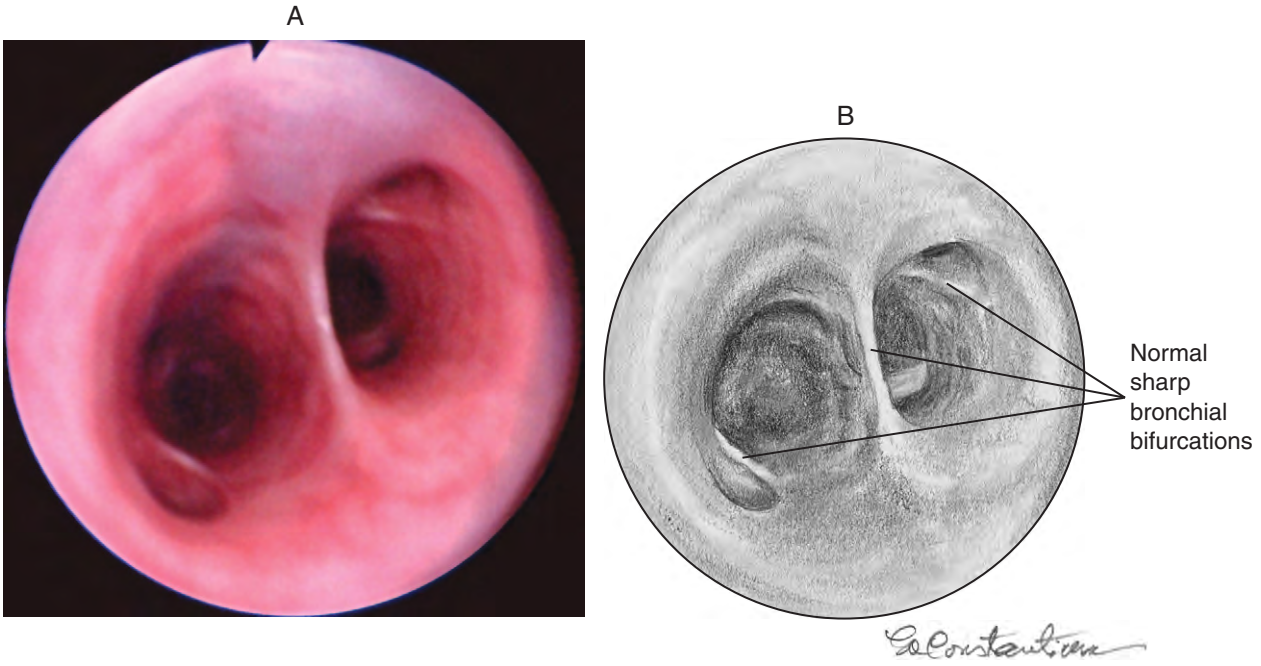



**Fig. 6-36**
Normal spurs (the bronchial bifurcations) in a dog.

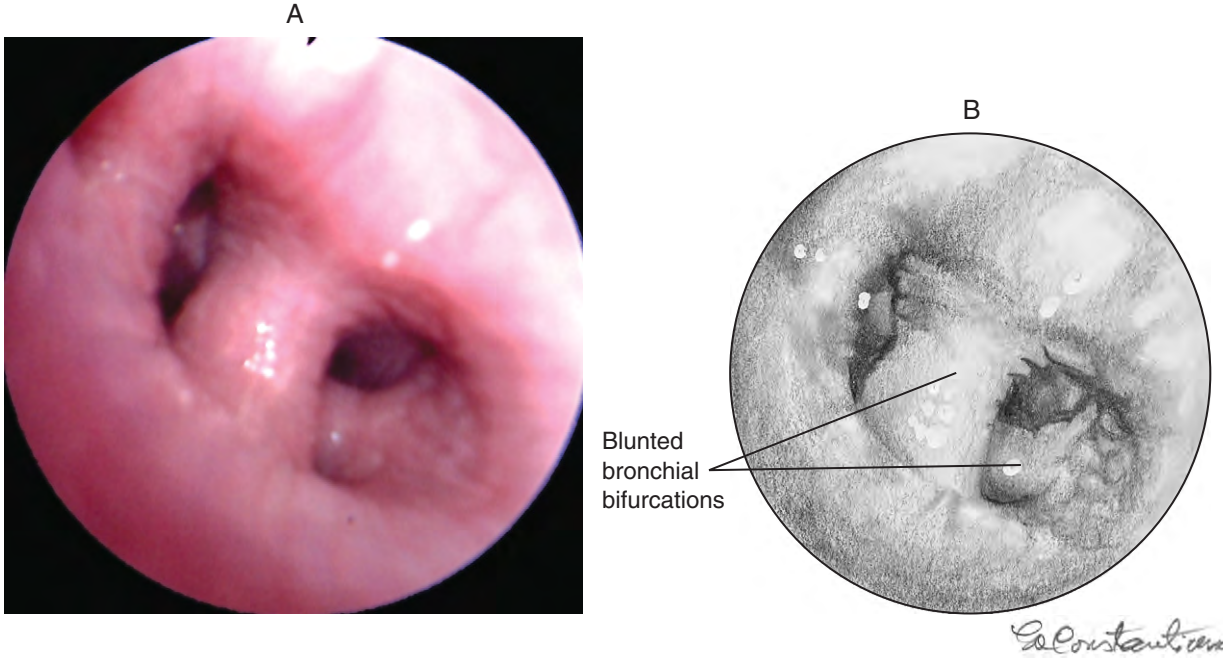



**Fig. 6-37**
Blunted spurs in a dog. Blunting occurs when the mucosa overlying the spur becomes edematous or has some degree of cellular infiltration resulting from chronic disease or inflammation.

histopathologic evaluation. Airway cytology has been the principal method of evaluating the lower airway disease in veterinary medicine. Specimens have been collected by various methods including transtracheal wash (TTW), bronchial brushing, and bronchoalveolar lavage (BAL). The different methods of sample collection require different evaluative criteria, because the cells obtained represent or come from varying portions of the airways. TTW samples collect exfoliated cells lying on the surface in the larger airways. There is no selectivity in collecting these samples because they are obtained nonspecifically with this technique. On the other hand, bronchial brushings are usually done through a bronchoscope under direct visualization but only obtain cells from a focal area. They tend to sample deeper into the mucosa than fluid washing of the surface and therefore may appear darker or more reactive under the microscope.

Bronchoscopy allows direct visualization of the airways and specific selection of the site to sample. The cells from BAL are thought to represent the distal small airways and interstitium of the lung.[14] BALs are the only technique for which normal differential cell counts have been established and standardized. Table 6-2[15-18] summarizes normal BAL differentials from dogs and cats. I prefer BAL for sampling the lower airways of dogs and cats.

To perform a BAL, the bronchoscope is first gently wedged into a segmental or smaller bronchus. The specific BAL site is selected (lobe and bronchus) based on either previous radiographs or the initial gross bronchoscopic examination. If no site is clearly affected, then BAL should be done from both of the "middle" lung lobes (right middle and caudal portion of the left cranial lobe). Once the scope is in a wedged position, 10- to 20-ml aliquots of sterile saline (depending on the size of the patient) are instilled into the airway (via the suction channel or washing pipette) and then immediately aspirated using the same syringe and gentle hand suction (Figs. 6-38 and 6-39). Ideally the procedure is repeated twice in each lobe or site. Typically a 40% to 90% return of the volume instilled is obtained, and usually a greater return is obtained from the second aliquot. Problems of poor fluid recovery may be expected if a proportionately large endoscope is used (preventing it from being wedged into a small bronchus) or when the airways are malacic. In the former situation, the fluid is dispersed into too large an area to be easily retrieved, and in the latter the airways collapse preventing the return of any significant volume of the infusate (although gentle suction may help in this situation).

It is recommended to collect BAL samples from at least two different sites (lung lobes) to ensure that a greater area of lung is evaluated. Two lavages are performed at each site, because the second lavage has been shown to be more sensitive in diagnosing both inflammatory and noninflammatory lung diseases in dogs when compared with the first lavage sample alone.[15] The sites are evaluated individually with total cell counts and a cytospin for differential cell counts. The fluid is combined for a *quantitated* BAL culture. Disposable sterile microbiology loops (Disposable Inoculation Loops, 0.01 ml, American Diagnostics, Pendleton, Ind) are used to perform quantified cultures. These loops are both inexpensive and easy to use. They are calibrated to contain 0.01 ml and the resultant colony count is multiplied by 100 to obtain the colony forming units per milliliter (CFU/ml) of BAL or other fluid (e.g., urine) (Fig. 6-40).

In normal patients, the predominant cell, in all species, is the alveolar macrophage (70%+), with usually less than 3% to 8% of all other cell types (except in the cat, which may have up to 20% eosinophils and still be considered healthy) (Fig. 6-41). Many pathologists interpret this

*Table* **6-2 Differential Cell Counts from Bronchoalveolar Lavage Fluid from Normal Dogs and Cats**

| | Scott and others* | Rebar and others† | Padrid and others‡ | King and others‡ |
|---|---|---|---|---|
| **Species** | Canine | Canine | Feline | Feline |
| **(n)** | 46 | 9 | 24 | 11 |
| **Total Cell Count/ml** | NR§ | 516 (240-360) | 303 (±126) | 241 (±101) |
| **% Macrophages** | 75 (27-92) | 83 | 64 (±22) | 70.6 (±9.8) |
| **% Polymorphonucleocytes** | 3 (0-30) | 5 | 5 (±3) | 6.7 (±4) |
| **% Eosinophils** | 3 (3-28) | 4.2 | 25 (±21) | 16.1 (±6.8) |
| **% Lymphocytes** | 10 (1-43) | 5.7 | 4 (±3) | 4.6 (±3.2) |
| **% Mast Cells** | 1 (0-5) | 2.3 | <1 (± <1) | NR |
| **% Epithelial Cells** | NR | NR | 2 (±2) | NR |
| **% Goblet Cells** | NR | NR | <1 (± <1) | NR |

**Values are median (ranges) obtained from the second lavage performed in a lobe.*
†*Values are mean (range) from six lung lobes from all dogs.*
‡*Values are mean (± SD) obtained from these cats.*
§NR, *not reported.*



**Fig. 6-38**
Performing bronchoalveolar lavage using 20 ml of sterile saline flushed through the biopsy channel of the bronchoscope and hand suction to obtain the sample.



**Fig. 6-40**
A blood agar culture plate with TNTC (too numerous to count) colonies recovered from a quantitated bronchoalveolar lavage culture. By multiplying the colony count by 100 (a 0.01-ml loop was used), the CFU/ml for this fluid is obtained. Aerobic bacterial cultures of greater than $1.7 \times 10^3$ CFU are reported to be required in canine bronchoalveolar lavage fluid to indicate infection rather than airway colonization. *Arrow* indicates a colony and represents 1 CFU.



**Fig. 6-39**
The foam on the top of the bronchoalveolar lavage fluid is due to surfactant in the sample, and the cloudy appearance of the fluid itself indicates a cellular return.

macrophage predominance in the BAL cell differential as *granulomatous* in nature (based on the large percentage of macrophages), but this is not correct.

Cultures from the lower airways are critical in establishing a specific diagnosis and in selecting an appropriate antibiotic based on sensitivity results. Upper airway contamination must be avoided to obtain accurate BAL cultures. Finding either squamous epithelium or the large bacterium *Simonsiella* spp., both of which are common to the oral cavity (Fig. 6-42), indicates upper airway contamination, and extreme caution must be used in interpretation of BAL results.

Obtaining culture samples through an endoscope is controversial because of the opportunity for sample contamination from the oral cavity as well as from an improperly cleaned endoscope channel. Guarded catheters (Microbiology Specimen Brush, Medi-Tech, Watertown, Mass) help decrease the potential for upper airway contamination of a BAL sample obtained with flexible endoscopy. The high cost of these catheters has hindered their routine use in clinical veterinary medicine, however.

An effective technique for obtaining BAL fluid for cultures and cytology without using special catheters has been used for several years. Once the initial gross visual evaluation of the lower airway has been completed, the endoscope is removed from the patient and cleaned by alternately suctioning the endoscope channel with

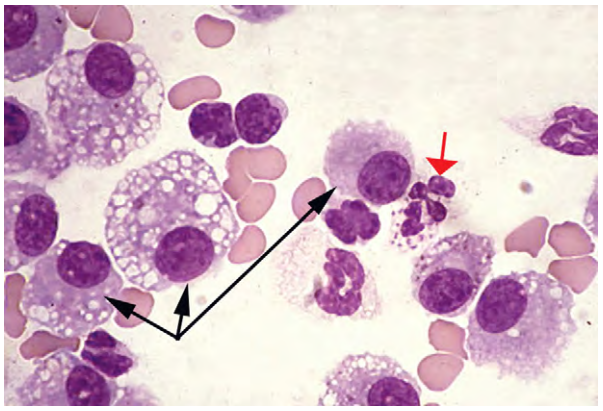


**Fig. 6-41**
Photomicrograph of a slide made from a canine bronchoalveolar lavage specimen. Note the predominance of normal alveolar macrophages (*black arrows*) and that there are intracellular bacteria in the polymorphonucleocyte (*short red arrow*). Alveolar macrophages normally represent 70% to 80% of the cells obtained from a normal canine and feline bronchoalveolar lavage. Macrophages may range from being active and having multiple phagosomes to being inactive without phagosomes.

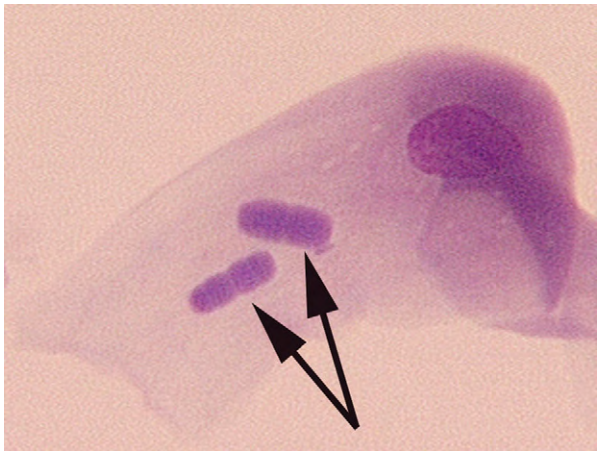


**Fig. 6-42**
Photomicrograph of a squamous epithelial cell and two *Simonsiella* spp. bacteria (*arrows*), both of which are common to the oral cavity. When these are observed in cytology specimens obtained from the lower airways, they warn about possible upper airway contamination.

sterile saline and air, replacing the endoscope, and immediately performing the BAL. With proper endoscope sterilization before each use, this technique allows for collection of samples for cytology and culture without upper airway contamination.[19] Regardless of collection technique, microbiologic results must always be interpreted in light of the cytology obtained from the same site for the most accurate interpretation.

It has recently been reported that aerobic bacterial cultures of greater than $1.7 \times 10^3$ CFU are required in canine BAL fluid to differentiate infection from airway colonization.[19] Culture results that only report "light growth" are held in suspicion when trying to determine true lower airway infection. Gram stain cytology is helpful in the interpretation of culture results; the presence of ≥2 intracellular bacteria in any of 50 high-power fields has been associated with true infection.

Although the specific role of *Mycoplasma* spp. in small animal clinical respiratory disease is still uncertain, technology advancements have allowed for easy detection. Using specialized transport media (e.g., Amies media) or polymerase chain reaction technology (based on either the actual BAL fluid or concentrated smears—cytospin prepared slides are best) combined with overnight shipment to selected laboratories, *Mycoplasma* can easily be detected in BAL fluid. Because *Mycoplasma* spp. are normal inhabitants of the oropharynx in small animals, the clinical significance of positive *Mycoplasma* samples obtained from the lower airways is still controversial.

Mucosal biopsy samples may be obtained when definite changes are seen or when a mass lesion is visualized (see Fig. 6-31). Samples obtained with endoscopic forceps are typically small and interpretation may be difficult. When a biopsy is to be performed, multiple specimens are obtained if possible to give the pathologist a greater chance to make a diagnosis. One of the biopsy samples may be gently touched to a glass slide for cytologic evaluation while waiting for the results from the histopathology study. Because of differences in the mucosa, the diagnostic return from bronchial mucosal biopsy is relatively low or is often nonspecific, especially when compared with endoscopic gastrointestinal mucosal biopsy. The routine use of transbronchial biopsy techniques (using a Wang biopsy needle or a biopsy forceps) has not been well established in veterinary medicine.

## COMPLICATIONS

Bronchoscopy is generally a safe procedure, and, if routine anesthetic precautions are taken, serious complications are minimal. A number of potential complications have been associated with bronchoscopy in human medicine, but these are uncommon with bronchoscopy in dogs and cats. In humans, the list of potentially serious complications includes those associated with anesthesia (e.g., anesthetic reaction, arrhythmias, endotracheal tube trauma, and hypoventilation), effects of the bronchoscopic procedure itself (e.g., bronchospasm, bleeding, bacteremia, and hypoxemia), and complications

that occur following completion of the procedure (e.g., fever, infection, and new pulmonary infiltrates). Few complications have been mentioned in veterinary medicine, and these few can be anticipated by a careful review of Table 6-1.

The most serious complications that I have encountered have been in patients with severe chronic obstructive pulmonary disease, specifically those with severe malacic changes and severe airway collapse (see Fig. 6-19). These animals have exercise- or stress-related cyanosis and may be distressed with cyanosis during recovery from anesthesia following bronchoscopy. Dogs with a chronic history of coughing with episodes of cyanosis or severe expiratory effort with an abdominal push while breathing at rest should be considered at high risk for development of complications. Great care must be taken in choosing an anesthetic protocol, which allows for a nonexcitable, slow anesthetic recovery. Topical lidocaine sprayed at the carina at the completion of the bronchoscopic procedure may minimize coughing and airway collapse during this critical postbronchoscopy period. Close patient monitoring (heart rate, oxygen saturation, depth of breathing) is imperative during the recovery period.

In anticipation of potential problems, it is imperative that the veterinary bronchoscopist be prepared for all eventualities. This means that he or she has a clear understanding of the patient risk factors and limitations of the equipment being used, and has both the knowledge and all drugs and equipment necessary to treat any complications.

## CONCLUSION

There is no question that bronchoscopy (including cytology and quantitated airway culture) is the gold standard for diagnosis of lower respiratory tract disease in small animals. Direct visualization of lesions, selected collection of airway samples, appreciation of dynamic airway caliber changes, and the possibility for therapeutic intervention (e.g., foreign body removal) are a few of the reasons why this diagnostic technique is superior to transtracheal aspiration biopsy or fine needle lung aspiration. The only limitations to bronchoscopy are financial, in that it is more expensive to perform a complete bronchoscopic examination and to apply the anesthesia required for the procedure. Even so, bronchoscopy should be considered *the* diagnostic test of choice in any case with significant (and especially chronic) lower respiratory tract disease in the dog and cat.

## REFERENCES


1. McKiernan BC: Bronchoscopy in the small animal patient. In Kirk RW, editor: *Current veterinary therapy*, ed 10, Philadelphia, 1989, WB Saunders.
2. Ford RB: Endoscopy of the lower respiratory tract of the dog and cat. In Tams TR, editor: *Small animal endoscopy*, St Louis, 1990, Mosby.
3. Roudebush P: Tracheobronchoscopy, *Vet Clin North Am Small Anim Pract* 20:1297-1314, 1990.
4. McKiernan BC: Diagnosis and treatment of canine chronic bronchitis. Twenty years of experience, *Vet Clin North Am Small Anim Pract* 30:1267-1278, 2000.
5. Lotti U, Niebauer GW: Tracheobronchial foreign bodies of plant origin in 153 hunting dogs, *Compend Cont Ed Pract Vet* 14:900-904, 1992.
6. Amis T, McKiernan BC: Systematic identification of endobronchial anatomy during bronchoscopy in the dog, *Am J Vet Res* 47:2649-2657, 1986.
7. McKiernan BC, Kneller SK: A simple method for the preparation of inflated anatomical lung specimens, *Vet Radiol* 24(2):58-62, 1983.
8. Venker-Van Haagen AJ: Bronchoscopy of the normal and abnormal canine, *J Am Anim Hosp Assoc* 15:397-410, 1979.
9. Venker-Van Haagen AJ and others: Bronchoscopy in small animal clinics: an analysis of the results of 228 bronchoscopies, *J Am Anim Hosp Assoc* 21:521-526, 1985.
10. Brearley MJ, Cooper JE, Sullivan M: *Color atlas of small animal endoscopy,* St Louis, 1991, Mosby.
11. Padrid PA, McKiernan BC: Tracheobronchoscopy of the dog and cat. In Tams TR, editor: *Small animal endoscopy*, ed 2, St Louis, 1999, Mosby.
12. Miller CJ and others: The effects of doxapram hydrochloride (Dopram-V) on laryngeal function in healthy dogs, *J Vet Intern Med* 16:524-528, 2002.
13. Haschek WM: Response of the lung to injury. In Kirk RW, editor: *Current veterinary therapy*, ed 9, Philadelphia, 1986, WB Saunders.
14. Hawkins EC, Denicola DB, Kuehn NF: Bronchoalveolar lavage in the evaluation of pulmonary disease in the dog and cat, *J Vet Intern Med* 4:267-274, 1990.
15. Scott M and others: Bronchoalveolar lavage of histologically normal and diseased canine lung lobes, *Vet Pathol* 30:433, 1993.
16. Rebar AH, Denicola DB, Muggenburg BA: Bronchopulmonary lavage cytology in the dog: normal findings, *Vet Pathol* 17:294-304, 1980.
17. Padrid PA and others: Cytologic, microbiologic, and biochemical analysis of bronchoalveolar lavage fluid obtained from 24 healthy cats, *Am J Vet Res* 52:1300-1307, 1991.
18. King RR and others: Bronchoalveolar lavage cell populations in dogs and cats with eosinophilic pneumonitis. Proceedings of the 7th Symposium of the Comparative Respiratory Society, Chicago, 1988.
19. Peeters DE and others: Quantitative bacterial cultures and cytological examination of bronchoalveolar lavage specimens in dogs, *J Vet Intern Med* 14:534-541, 2001.

# 7 Diagnostic and Operative Thoracoscopy

*Timothy C. McCarthy, Eric Monnet*

The minimally invasive technique of thoracoscopy allows diagnostic exploratory examination and therapeutic operative procedures to be performed in the chest through 5- to 10-mm diameter portals without having to perform a painful and traumatic thoracotomy. Visualization of intrathoracic structures and pathology is far superior to open surgery because of high-intensity light transmission, which gives excellent illumination, magnification produced by the telescopes, and ability to place the telescope into surgically inaccessible areas. Submacroscopic lesions that elude us with open surgical exploration can be easily visualized with thoracoscopy. Organs and tissues deep within the chest are no longer operated on "in the hole" because the visual field is moved into the area of the operative site. Structures too small to see easily are magnified and made obvious, allowing accurate dissection, hemostasis, and preservation of important structures. Operative stress to the patient is reduced by eliminating the tissue trauma of a thoracotomy and by decreased operative times. The old dog with pericardial effusion is typically up and running around within a few hours after minimally invasive pericardial window surgery, as if nothing was done, rather than slowly recovering from a painful sternotomy. Postoperative pain management, an area of veterinary medicine currently receiving considerable attention, is greatly facilitated by eliminating the "operative" portion of the equation.

Sample collection for histopathology, culture, and cytology can be easily and quickly done with thoracoscopy. Thoracoscopy was initially used as a diagnostic technique but is rapidly becoming an accepted operative approach to treatment in small animal medicine. Surgical procedures currently being performed include pericardial windows, subtotal pericardectomies, partial and complete lung lobectomies, foreign body removal, mediastinal mass removal, lymph node removal, thoracic duct occlusion, and persistent right aortic arch transection. Laparoscopy and thoracoscopy are similar in technique, instrumentation requirements, and basic indications, although there are important differences. Thoracoscopy is easier to perform than laparoscopy and thoracoscopy is more effective for examining the chest than open thoracotomy.

## INDICATIONS

Thoracoscopy is indicated whenever more information is needed for diagnosis and treatment of intrathoracic pathology than can be obtained with less invasive diagnostic techniques and when open surgical invasion of the chest is not indicated or desired. Specific indications for diagnostic thoracoscopy include pulmonary, mediastinal, or hilar masses, primary pulmonary disease, spontaneous pneumothorax, pericardial effusions, pleural effusions including chylothorax, and chest trauma assessment (Box 7-1). Minimally invasive thoracic surgery is potentially indicated whenever open thoracic surgery is indicated. Indications for thoracoscopy and minimally invasive thoracic surgery are only limited by operative skill level, available instrumentation, one's willingness to expand his or her ideas, and one's imagination.

Management of pleural effusion is greatly facilitated by thoracoscopy and is the most common indication for thoracoscopy in human medicine.[1] Cases with intractable pleural effusion of undetermined origin can be definitively

**Box 7-1 Indications for Thoracoscopy**

Pulmonary masses: biopsy or removal
Mediastinal masses: biopsy or removal
Pleural masses: biopsy or removal
Pleural fluid: drainage and pleural biopsy
Chylothorax: thoracic duct occlusion
Pericardial fluid: drainage or pericardial window
Hilar lymphadenopathy: biopsy or removal
Primary pleural disease: lung biopsy
Spontaneous pneumothorax: bulla localization or removal
Thoracic trauma: assessment or management
Foreign body removal

diagnosed.[2] Pleural pathology can be visually assessed using the magnification of the telescope, allowing lesions to be accurately identified. Truly representative biopsy samples can be obtained under direct visualization, which greatly increases diagnostic yield and diagnostic accuracy. Submacroscopic inflammatory nodules, early metastatic lesions, and mesotheliomas can be identified with thoracoscopy before they have grown to a size that can be seen at surgery. Lung lobe torsion can be easily identified with thoracoscopy to confirm the diagnosis; lobectomy can be performed with minimally invasive technique or a thoracotomy performed for lung lobectomy. Thoracic duct pathology can be evaluated in cases of chylothorax, and thoracic duct occlusion can be achieved using minimally invasive surgical techniques.[3] Magnification produced by the telescope greatly enhances visualization of the thoracic duct, allowing the extent and location of thoracic duct pathology to be assessed, the potential for surgical success to be evaluated, and clips to be applied for a potentially more successful occlusion.

Pericardial effusions can be accurately and effectively drained under thoracoscopic guidance and samples collected for fluid analysis, cytology, cultures, and histopathology. Permanent drainage can be established by partial pericardiectomy or by creating a pericardial window on the cranial aspect of the heart using minimally invasive surgical technique.[4,5] Instrumentation and technical skills required to perform a pericardial window are only slightly more demanding than those required for diagnostic thoracoscopy and sample collection.

Spontaneous pneumothorax management is greatly facilitated using thoracoscopy to establish the exact site of air leakage and to determine the extent of pulmonary involvement. Emphysematous degeneration of the lung can be evaluated, determining whether the lesions are localized and resectable or diffuse and inoperable involving multiple lung lobes. An unnecessary thoracotomy can be avoided in cases of diffuse emphysematous pulmonary disease when surgical resection is not beneficial. Spontaneous pneumothorax caused by migrating foreign bodies that have penetrated into the pleural space have been located and removed, and the air leakage controlled. Accurately locating the site of air leakage and the site of lesions with thoracoscopy allows accurate decisions to be made regarding the need for surgical intervention, whether resection can be completed with minimally invasive technique, and whether more effective planning of an open surgical approach is needed. The most difficult aspect of managing spontaneous pneumothorax is determining the side of the air leakage; median sternotomy has been the recommended approach for operation of spontaneous pneumothorax because it provides exposure of both hemithoraces.[6,7] If the side of the lesion can be definitively determined with thoracoscopy and even if a minimally invasive resection cannot be accomplished, lateral thoracotomy can be performed, thus decreasing operating time and morbidity and facilitating complete lobectomy if indicated. An unnecessary thoracotomy can be avoided in cases of diffuse emphysematous pulmonary disease when surgical resection is not beneficial.

Lung specimens can be obtained for assessment of primary pulmonary disease, pulmonary nodules or masses, and areas of undefined pulmonary density. Lung biopsy samples obtained with thoracoscopy for evaluation of diffuse pulmonary disease provide sufficient tissue to preserve pulmonary architecture, which greatly increases diagnostic yield.[1,8-11]

Thoracoscopy is particularly useful for diagnosing and planning surgical intervention and medical management of thoracic neoplasia. Examination, biopsy, tumor staging, and determining surgical resectability can be achieved accurately by determining location, local invasion, and lymph node involvement and by differentiating solitary from disseminated disease. Visually directed biopsies can ensure representative histopathology, which greatly increases diagnostic sensitivity.[1,9] Using thoracoscopy to determine whether a neoplastic process is surgically resectable without performing a thoracotomy avoids subjecting the patient to unnecessary major surgery. Application of minimally invasive surgical techniques can allow removal of mediastinal masses and pulmonary masses by partial or total lung lobectomy for surgical resolution. If the lesions are not amenable to minimally invasive surgical removal or if the extent or location of the lesions is technically beyond the skill level of the surgeon, then open surgical intervention can be more accurately planned.

Thoracoscopy is also effective in emergency management of chest trauma cases with hemothorax, pneumothorax, or extensive pulmonary contusions.[12] The need for surgical intervention to control bleeding and air leakage, or for resection of devitalized pulmonary tissue, can be determined. The problem can be definitively resolved with minimally invasive technique or the surgical approach that will provide the best access to the lesions can be selected, facilitating operative procedures when indicated.

The number of indications for thoracoscopy in small animal practice will increase as the applications evolve. Diagnostic thoracoscopy in lieu of an open exploratory thoracotomy is as strong an indication and as much of an application of minimally invasive technique as a major minimally invasive thoracic procedure. Procedures such as video-assisted thoracoscopy for intervertebral disk fenestration have been evaluated for application in dogs.[13] Further incorporation of diagnostic thoracoscopy and minimally invasive thoracic surgery into veterinary medicine will continue to expand the indications for thoracoscopy.

## INSTRUMENTATION

Instrumentation needed for thoracoscopy is similar to that used for laparoscopy (Box 7-2). Thoracoscopy in small animal practice can be performed without additional instrumentation than what is used for laparoscopy. Even though specialized instrumentation for thoracoscopy is not required, it is available and may facilitate most diagnostic and operative procedures. The major differences in equipment for thoracoscopy are that an anesthetic ventilator is required, an abdominal insufflator is not needed, and cannula design is different.

### Telescopes

Almost any rigid endoscopic telescope can be used for thoracoscopy (Fig. 7-1). The most common telescopes used for thoracoscopy are 10- and 5-mm diameter laparoscopes and a 2.7-mm diameter multipurpose rigid telescope. The 2.7-mm diameter telescope is best suited for cats and small dogs, the 5-mm laparoscope for medium to large dogs, and the 10-mm telescope for large to giant dogs. There is no defined size separation for application of these telescopes and each can be used through almost the full range of small animal patients. Limitations of these telescopes are present at both ends of the size spectrum. Smaller telescopes transmit less light and are less effective in large patients. The 2.7-mm telescope is shorter than the two laparoscopes, 18 cm compared with 30 cm, limiting access to some areas of the thorax in larger dogs. This can be partially overcome by careful attention to telescope portal placement. The physical size of the 10-mm telescope can be a problem in cats and in very small dogs. The 5-mm laparoscope has the widest range of patient application for small animal thoracoscopy.

Another important feature to consider when selecting a telescope for thoracoscopy is the visual angle or angle of view. This can range from 0 degrees to more than 90 degrees. Most laparoscopes are 0-degree telescopes that look straight ahead with the axis of the visual field centered on the axis of the telescope. This provides the truest image with the least image distortion and the least operator disorientation. This factor is important for the beginning endoscopist and during operative procedures. The 2.7-mm multipurpose rigid telescope and most arthroscopes have a 30-degree angle of view wherein the axis of the visual field is angled 30 degrees from the axis of the telescope. Both 0- and 30-degree telescopes are used for thoracoscopy. Advantages of an angled view are that structures can be visualized that are out of the axis of the telescope and the field of view can be greatly enlarged by rotating the telescope to project the 30-degree angle in all directions around the axis of the telescope. A 30-degree telescope facilitates thoracoscopy because the ribs of the rigid chest wall can interfere with positioning of the telescope. Thirty degrees of angle produces little distortion or disorientation and the endoscopist has the sensation of looking straight ahead. Visual angles greater than 30 degrees cause too much disorientation and are not needed or recommended for thoracoscopy.

Telescopes currently used for thoracoscopy do not have operative or biopsy channels. Additional chest wall portals are created for operative procedures, for sample collection, or for manipulation. Operating telescopes with a biopsy channel have significant limitations and are rarely used anymore.

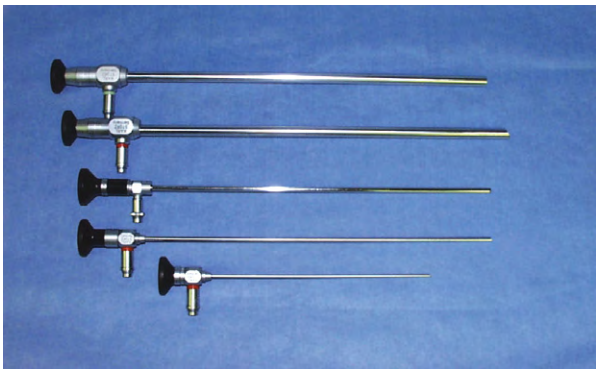


**Fig. 7-1**
Telescopes used for thoracoscopy. From top to bottom: 10-mm, 0-degree Storz laparoscope; 10-mm, 30-degree Storz laparoscope; 5-mm, 0-degree Olympus laparoscope; 4-mm, 30-degree Storz cystoscope; 2.7-mm, 30-degree Storz multipurpose rigid telescope.

**Box 7-2 Instruments for Diagnostic Thoracoscopy**

- Video tower with light source
- Telescope
- Telescope cannula
- Operative cannulae
- Palpation probe
- Biopsy forceps
- Atraumatic grasping forceps
- Metzenbaum scissors
- Suture scissors
- Suction/irrigation cannula
- Pretied loop ligatures

### Cannulae

Cannulae (Fig. 7-2) for thoracoscopy are different from those used for laparoscopy because an airtight seal is not required for thoracoscopy and because distances from the

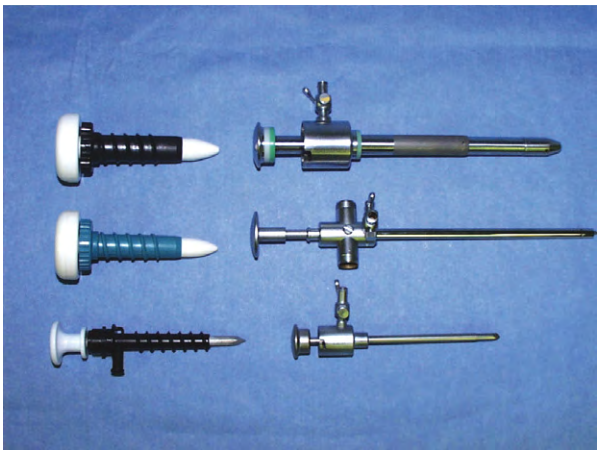


**Fig. 7-2**
Thoracoscopy cannulae and modified laparoscopy cannulae used for thoracoscopy. Top left: Disposable 11.5-mm AutoSuture Thoracoport. Top right: Reusable 10-mm Storz laparoscopy cannula with the valve mechanism removed. Middle left: Disposable 10.5-mm Thoracoport. Middle right: Reusable 5-mm Olympus laparoscopy cannula with the valve mechanism removed. Bottom left: Disposable 5-mm laparoscopy cannula with the valve mechanism removed. Bottom right: Reusable 4-mm Storz laparoscopy cannula with the valve mechanism removed.

chest wall to the organs are frequently less in the thorax than in the abdomen. With abdominal insufflation, an airtight cavity must be maintained, requiring round, tight-fitting cannulae with valves and gaskets that seal around the telescope or instruments to prevent gas leakage. Because positive pressure insufflation is not used for thoracoscopy, an airtight seal at the portal sites is not required and cannulae do not need valves. Laparoscopy cannulae can be used for thoracic surgery, but they are cumbersome because of their length, are difficult to keep in place, and interfere with instrument manipulation. Thoracoscopy cannulae differ from laparoscopy cannulae in that they do not have an airtight valve and they are shorter than laparoscopy cannulae. These cannulae are designed for use in human size patients and are too large for most small animal patients. A cannula is required for the telescope portal, but operative portals can be established and maintained effectively without a cannula by performing a minithoracotomy and passing instruments directly through these small thoracotomy incisions, which is as effective and many times is less cumbersome than using a cannula.

Cannulae are used for the telescope portal for thoracoscopy to protect the telescope and to allow a pneumothorax to form. The same telescope laparoscopy cannula can be used for thoracoscopy with the valve mechanism removed to make an open cannula. Laparoscopy cannulae are traditionally supplied with a sharp trocar for penetrating the abdominal wall that can also be used for thoracoscopy. Blunt obturators are available for most cannulae and are recommended for entering the thorax to substantially reduce the chances of damaging thoracic viscera at the time of cannula placement. Thoracoscopy cannulae do not have significant advantages over laparoscopy cannulae for the telescope portal.

## Light Sources

A xenon light source is required for thoracoscopy. Halogen light sources are inadequate because they do not produce adequate lighting. A flexible fiberoptic light cable is used to attach the light source to the telescope.

## Video Cameras

A high-quality endoscopic video camera and monitor are an absolute necessity for performing diagnostic thoracoscopy and minimally invasive thoracic operative procedures. Small, specially designed endoscopic video cameras attach directly to the telescope and the image is displayed on a video monitor. Endoscopic video cameras use CCD (charge coupled device) chips for signal acquisition. Single-chip and three-chip cameras are available. A good quality single-chip camera is more than adequate for clinical application in veterinary medicine. The added expense of a three-chip camera is not necessary except for video capture of images for publication and presentation. Advantages of video-assisted thoracoscopy include greatly enhanced image quality, ability for more than one person to observe the procedure, which allows assistants to be more effective, ability to maintain asepsis, allowing sophisticated operative procedures to be performed, and greatly facilitating transition to an open thoracotomy when indicated. Simple diagnostic thoracoscopy can be performed without video assistance using direct observation through the telescope, but its applications are limited and outdated. A video system is essential for operative procedures.

## Operative and Sample Collection Instruments

Laparoscopic sample collection instrumentation (Fig. 7-3) is applicable to thoracoscopy. A basic diagnostic instrumentation set for thoracoscopy includes biopsy forceps (apposing cup or punch types), grasping forceps, scissors, palpation probe, pretied ligature loops, and a fluid aspiration or combination aspiration-irrigation cannula (see Box 7-2). This limited set of instruments allows a wide variety of samples to be collected and simple operative procedures to be performed. Solid tissue and lung biopsies can be

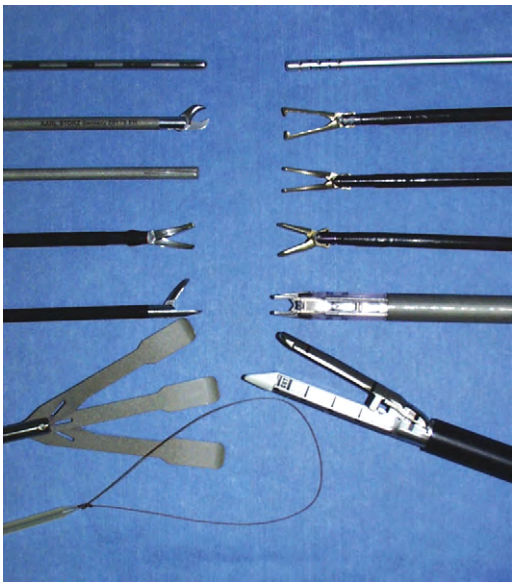


**Fig. 7-3**
Operative instruments used for thoracoscopy. Left side from top to bottom: 5-mm graduated manipulation probe, 5-mm suture scissors, 5-mm knot pusher, 5-mm disposable Metzenbaum scisssors, 5-mm biopsy forceps, 10-mm disposable fan retractor, and a pretied Endoloop ligature. Right side from top to bottom: 5-mm suction-irrigation catheter, 5-mm disposable aggressive tissue grasper, 5-mm disposable tissue dissector (curved mosquito hemostat), 5-mm disposable duck bill tissue grasper, 10-mm vascular clip applicator, and 10-mm endoscopic gastrointestinal anastomosis stapler.

obtained for histopathology and impression cytology. Liquid samples can be harvested for fluid analysis, cytology, and bacterial and fungal cultures. These instruments and Tru-Cut type biopsy needles can be used effectively for obtaining biopsy samples. Long spinal needles can be used for fine needle aspirates.

Additional instrumentation required for basic, minimally invasive thoracic surgery is not extensive (Box 7-3). The simpler minimally invasive surgical procedures can be performed with the small number of hand instruments listed for diagnostic procedures. Most hand instruments are available in 5- and 10-mm sizes. Staying with one size of instruments decreases cost and facilitates the technical aspects of performing minimally invasive surgery. As sophistication and complexity of the procedures being performed increases, more instruments, more expensive instruments, and multiple sizes of instruments may be needed and can be added as expertise and indications warrant. Pretied suture loops, clip applicators, tissue retractors,

**Box 7-3 Instruments for Operative Thoracoscopy**

Diagnostic thoracoscopy instruments (see Box 7-2)
Aggressive grasping forceps
Tissue dissectors
Knot pusher
Fan retractors
Hook retractors
Hemostatic clip applicators
Endoscopic gastrointestinal anastomosis staplers
Radiofrequency electrocautery

linear endoscopic gastrointestinal anastomosis (GIA) staplers, lasers, monopolar and bipolar radiofrequency electrocautery, computerized radiofrequency generators, and harmonic scissors can be added to the surgical armamentarium for more advanced operative procedures.

As the level of knowledge and experience increases and as skill level develops, more procedures will be done and instrumentation needs will increase. The list of instruments available for minimally invasive surgery is extensive. Almost every instrument available for open surgery has been developed for minimally invasive application.

Standard surgical instruments can also be used for some thoracoscopic diagnostic and operative procedures. An airtight seal at the portal sites is not required for thoracoscopy, distance to many lesions is relatively short, and minithoracotomy operative portals can be used to provide access with Metzenbaum scissors, hemostats, thumb forceps, sutures, and standard surgical suction tips for tissue manipulation, sample collection, and operative procedures.

Specialized endotracheal tubes for one-lung ventilation are used when the sophistication of thoracoscopic surgical procedures reaches the level at which one-lung ventilation is required. Double-lumen endotracheal tubes specifically designed for one-lung ventilation in humans are too short for large dogs and have too large a diameter for smaller dogs. Standard veterinary endotracheal tubes can be placed "too deep" for standard intubation and achieve selective bronchial blockage. Endobronchial blockers can also be used in combination with standard endotracheal tubes to selectively occlude and ventilate specific areas of the lungs.

A hydraulically operated surgical table that tilts in multiple directions greatly facilitates both diagnostic thoracoscopy and minimally invasive thoracic surgery. Gravity is the best retractor for minimally invasive surgery and using a table that tilts lengthwise in both directions and to both sides greatly facilitates procedures. A table with an electrically powered hydraulic system that can be controlled with a joystick accessible from the

sterile field is available for small animal application. This table allows for easy repositioning of the patient during the procedure to take advantage of gravity for tissue and organ retraction.

## PATIENT PREPARATION

Preparation of patients for thoracoscopy is essentially the same as for a standard open thoracotomy. Anesthetic considerations are also similar to those for an open thoracotomy when performing diagnostic thoracoscopy and the simpler minimally invasive thoracic operative procedures. A cuffed endotracheal tube, intermittent positive pressure breathing, adequate monitoring, and supportive treatment are used. With more sophisticated and complex operative procedures, selective intubation with one-lung ventilation may be required or pleural insufflation may be needed. The area of chest wall that is shaved, prepared, and draped for aseptic surgery is as large as or larger for thoracoscopy than the area that would be used for an open thoracotomy. A sufficiently wide area of the chest wall is prepared to allow placement of the camera portal, two or more triangulated operative portals, and a chest drain tube.

Preparation is also designed to allow conversion to an open thoracotomy without the need for redraping. This is strongly recommended so that when the diagnostic evaluation determines that an open thoracotomy is indicated or when emergency conversion is required during a minimally invasive surgical procedure the transfer can be accomplished quickly, effectively, and aseptically. Preparation for conversion is done by ensuring that an adequate area is shaved, prepared, and draped for a thoracotomy incision and that surgical instrumentation is readily available. Even the simplest diagnostic procedure can require conversion.

Patient positioning is selected based on the location of the lesions or the area of the thorax to be examined and based on the specific surgical procedure to be performed. Dorsal recumbency or either lateral recumbent position can be used. Dorsal recumbency with a paraxiphoid camera portal is effective for evaluation and operation of ventral thoracic structures including the pericardium, cranial mediastinum, and bilateral examination of all but the most dorsal portions of the lungs and pleural surfaces. Lateral recumbency with a lateral camera portal allows more complete examination of the dorsal thoracic structures and hilar areas on the selected side, but it is limited to unilateral access. Multiple positioning techniques are effective and are consistently used with position and technique based on the needs of the individual patient rather than on superiority of one technique over another.

## TECHNIQUE: ANESTHESIA AND PNEUMOTHORAX

Anesthetic requirements for thoracoscopy are similar to those for open thoracotomy. Intermittent positive pressure breathing using a mechanical ventilator is required for minimally invasive thoracic surgery just as it is required for open thoracic surgery. Ventilator requirements and technique of operation are the same for the simple semiopen pneumothorax technique and with pleural space insufflation as they are for open thoracic surgery. With one-lung ventilation ventilator tidal volume is decreased and the rate is increased because functional lung volume is decreased when one of the lungs is excluded from the ventilator circuit. Preanesthetic medications, induction drugs, and maintenance anesthetics are the same as are used for open thoracotomy. The protocol I use includes preanesthetic administration of butorphanol and glycopyrrolate subcutaneously, induction with intravenous propofol or with sevoflurane by mask, and maintenance with sevoflurane.

An open, gas-filled optical space must be established to allow for thoracoscopy to be performed. This optical cavity provides a working space for the telescope and operative instruments, thus enabling the end of the telescope to be kept away from tissues and allowing visualization. A semiopen pneumothorax is created for thoracoscopy and minimally invasive thoracic surgery by allowing air into the pleural space so that lungs collapse away from the rigid chest wall that is supported by the ribs.

This follows the same basic principle as for laparoscopy but is also the main difference between laparoscopy and thoracoscopy. An open, gas-filled space is required for both techniques to provide a cavity for placement of the telescope and operative instruments. Without this open space, the end of telescope is in constant contact with tissue and nothing can be seen. In contrast to laparoscopy in which the peritoneal cavity is insufflated with carbon dioxide ($CO_2$) to distend the abdomen and hold the abdominal wall up away from the viscera. For thoracoscopy, a pneumothorax is created by allowing air into the pleural space so the lungs collapse away from the rigid chest wall that is supported by the ribs. With abdominal insufflation, an airtight abdominal cavity must be maintained and all portals must use tightly fitting cannulae with valves and gaskets that seal around the telescope and instruments to prevent gas leakage. Positive pressure insufflation is not commonly used for thoracoscopy. When not using insufflation, an airtight seal at the portal sites is not needed or desired.

Three different techniques are used for creating and maintaining a pneumothorax: a simple semiopen pneumothorax with standard endotracheal intubation, pleural

space insufflation, and one-lung ventilation with selective intubation. Each technique has advantages, disadvantages, and specific indications.

Standard intubation with intermittent positive pressure breathing and a "semiopen" pneumothorax is the simplest of the techniques and works well for diagnostic procedures and for most simpler minimally invasive surgical procedures. Two different methods can be used to establish a pneumothorax for thoracoscopy. One approach uses the Veress needle to penetrate the chest wall so that air can be introduced into the pleural space to establish a pneumothorax. The telescope cannula is then introduced using a sharp trocar after the pneumothorax has been established. The second technique uses blunt dissection and a blunt obturator to place the telescope cannula through the chest wall before establishing a pneumothorax. Air is then allowed to enter the pleural space through the telescope cannula. Pneumothorax is established much faster with this technique because air is entering through a 5- or 10-mm cannula rather than through a small Veress needle. This second technique is superior and has almost completely replaced the first technique because it is faster, easier, and carries less risk of trauma to the thoracic viscera.

One-lung ventilation, the procedure of choice in human thoracoscopy, becomes necessary with more complex surgical procedures but is not necessary for diagnostic thoracoscopy or many of the simpler minimally invasive thoracic surgical procedures performed in dogs and cats. One-lung ventilation uses selective bronchial intubation with a special double-lumen endotracheal tube or with endobronchial blockade and complete collapse of the lung on the side of the invaded hemithorax.[14-17] This approach has the distinct advantages of improved visualization due to reduced lung volume and reduced tissue movement with ventilator excursions. These advantages greatly facilitate performing complex surgical procedures. One-lung ventilation has its own set of problems and complications,[16,18-20] the most important being greatly increased complexity and difficulty of the anesthetic component of thoracoscopy. Selective intubation is a difficult, time-consuming procedure that requires bronchoscopy to accurately place the double-lumen endotracheal tube or endobronchial blocker. As the level of sophistication of operative thoracoscopy procedures in dogs and cats increases, one-lung ventilation will become necessary and will become part of the standard protocol for thoracoscopy.

Pleural insufflation is the least desirable of the techniques for establishing an optical space in the thorax and is not needed, recommended, or desired for routine diagnostic thoracoscopy or minimally invasive thoracic surgery. Adequate lung collapse can be achieved in most cases without the increased complexity or risk of insufflation. The occasional case with stiff, noncompliant lungs that do not collapse well with a semiopen pneumothorax alone may benefit from insufflation. Studies have shown that thoracic insufflation with $CO_2$ to pressures of 5 mm Hg has minimal deleterious effects on cardiopulmonary function.[21] This establishes that insufflation can be used when necessary but is rarely required for evaluation of the thorax and for sample collection. Otherwise, insufflation increases the complexity of the procedure by requiring an insufflator, $CO_2$, and maintenance of airtight portals. Insufflation also increases the risks of thoracoscopy with the potential for overinflation, tension pneumothorax, and severe cardiopulmonary compromise.[22]

## ACCESS TO THE THORACIC CAVITY: TELESCOPE PORTALS

Portals for access to the thoracic cavity include lateral intercostal, transdiaphragmatic or paraxiphoid, and cranial or thoracic inlet.* The first two techniques have equal indications, advantages, benefits, and drawbacks and the approach selected is based on the needs of each individual case, not on the superiority of one technique over the other. The cranial portal is a translation from the human surgical technique of mediastinoscopy and has limited if any application in small animal thoracoscopy.

### Paraxiphoid Telescope Portal

For the telescope portal (Fig. 7-4), the patient is placed in dorsal recumbency or in a dorsal oblique position with the patient's sternum tipped away from the surgeon. The patient is draped to include an area from the thoracic inlet to the cranial one third of the abdomen and the ventral half of the lateral thoracic walls. This provides exposure for the telescope portal adjacent to the xiphoid cartilage, lateral intercostal operative portals, chest drain placement, and ability to convert to an open sternal splitting thoracotomy if needed.

The telescope portal site is located by palpation of the notch between the xiphoid cartilage and the costal arch. A short skin incision (2 to 3 cm) is made either to the right or left of the xiphoid process between the costal arch and the xiphoid. An access tract is created into the pleural space using a hemostat and blunt dissection directed craniad, dorsad, and slightly laterad from the skin incision. The telescope cannula is inserted through this tract using a blunt obturator rather than a sharp trocar. If a disposable laparoscopy cannula and trocar with a spring-loaded trocar guard are used, the guard

**References 10, 11, 15, 17, 23, 24.*

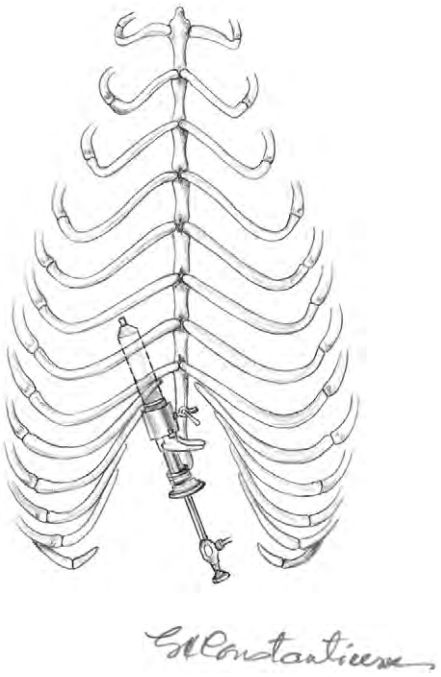


**Fig. 7-4**
Paraxiphoid telescope portal with the patient in dorsal recumbency and the telescope portal placed in the xiphoid notch on the right side and directed into the right hemithorax.

mechanism is fired before insertion by pushing the tip of the assembly against a towel or gauze sponges. This locks the guard over the sharp end of the trocar and effectively converts it into a blunt obturator. Once the cannula is in the chest, the obturator is removed and the cannula valve is held open or the valve assembly is completely removed to facilitate air leakage to establish the pneumothorax. With this technique the risk of organ damage is minimized and an adequate pneumothorax is created by the time the telescope can be inserted.

The telescope is inserted in one hemithorax and is separated from the contralateral hemithorax by the ventral mediastinum. The ventral mediastinum typically appears as a curtain-like structure hanging from the sternum (Fig. 7-5). The normal ventral mediastinum is thin and translucent with vascular structures surrounded by fat and may have scattered fenestrations. Occasionally, the mediastinum is complete and, rather than hanging on the midline, is compressed against the chest wall contralateral to the side with the pneumothorax from placement of the telescope portal. If the chest is entered and there is no visible ventral mediastinum, then examination of the chest walls reveal that one side has a branching pattern of blood vessels and scattered fat, which is the mediastinum overlying the chest wall (Fig. 7-6). To access the contralateral hemithorax, the mediastinum is penetrated through one of the fenestrations or by pushing the telescope through an avascular translucent area to create a fenestration. This is easily performed in most patients

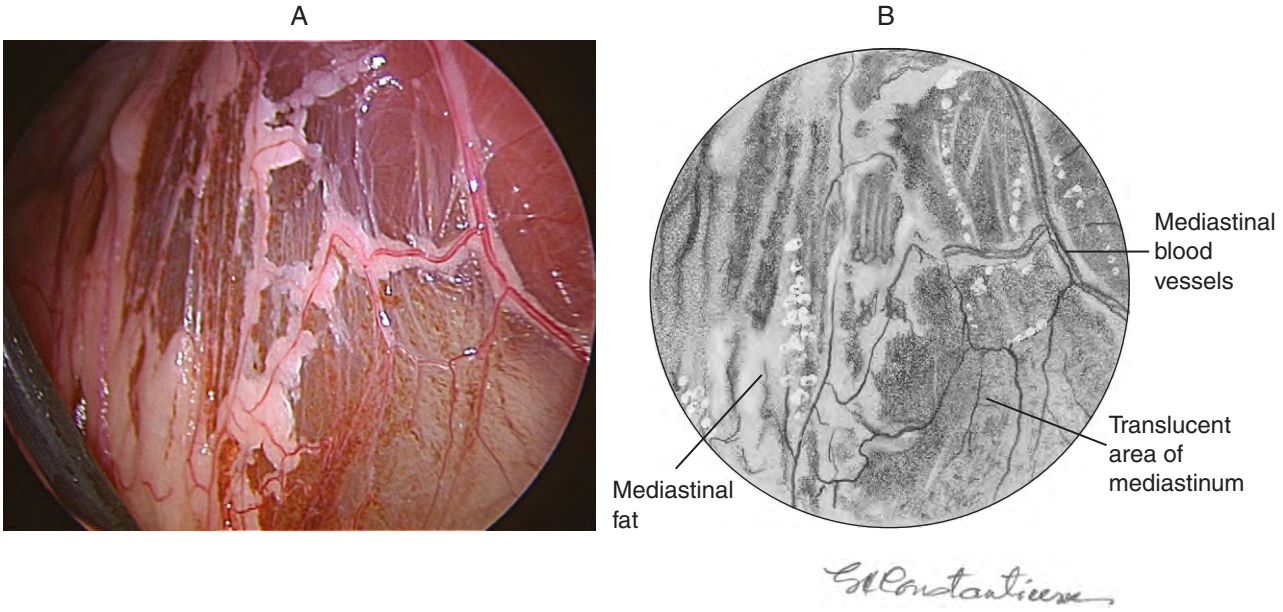



**Fig. 7-5**
The ventral mediastinum is visible as an incomplete curtain of tissue hanging from the sternum and contains blood vessels with areas of fat.

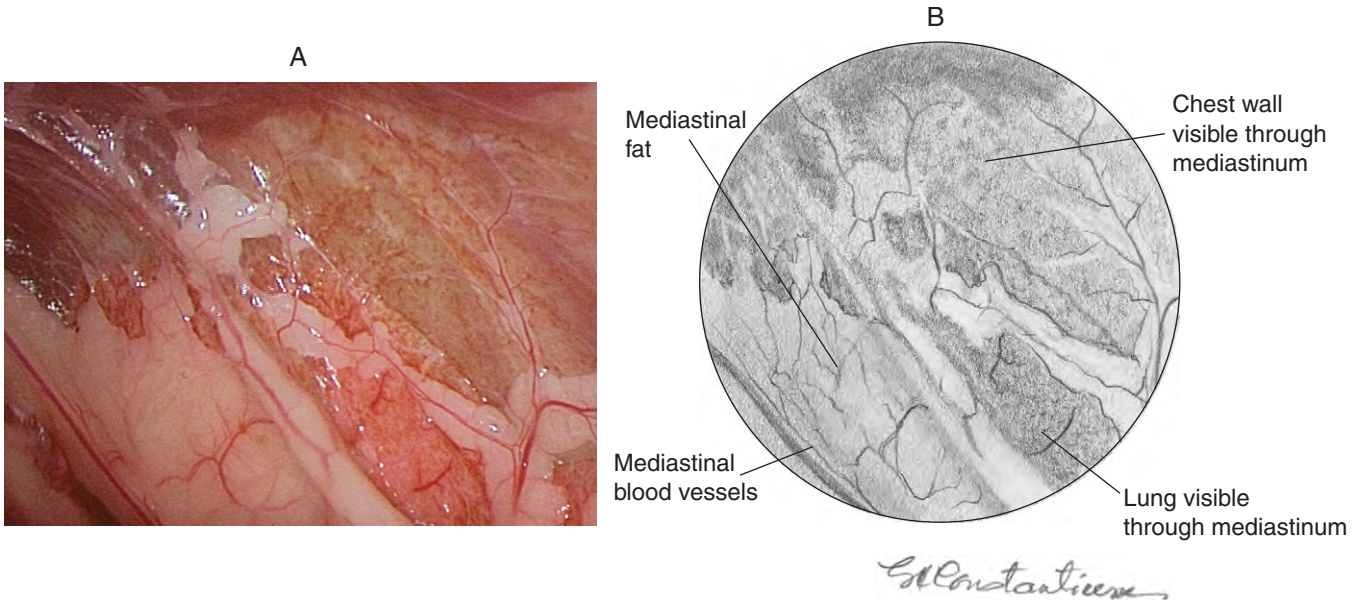



**Fig. 7-6**
When there is a complete mediastinum and the resulting pneumothorax is unilateral, the mediastinum is displaced away from the side of the pneumothorax and is seen as a pattern of blood vessels and fat against one of the chest walls. It is not visible as a curtain hanging from the sternum until it is incised to equalize the pressures between the two sides of the chest.

without risk of instrument damage and without bleeding or significant tissue trauma. If the mediastinum is thickened or cannot be penetrated easily, then operative portals are placed and a hole is cut in the mediastinum. The mediastinum can be cut off of the sternum if needed to facilitate visualization of the contralateral hemithorax when performing minimally invasive operative procedures.

## Lateral Telescope Portal

A site for the telescope portal is selected that is not directly over the lesion to be examined or the area of interest for operative procedures in the chest but is close enough to allow access for visualization. Biopsy or other sample collection instrumentation can then be placed directly over the lesion or operative portals based on the principles of triangulation. Many lateral chest wall telescope portal sites have been described.[10,15,17,23-25] For some procedures, the portals are well defined, but for most, portal site selection is done case by case.

Lateral chest wall telescope portal placement is most commonly performed with blunt technique. A short skin incision (2 to 3 cm) is made at the site selected for portal placement. Blunt dissection with a hemostat creates a tract through muscle and fascia into the pleural space perpendicular to the chest wall. An angled tunnel, as is used for chest tube placement, does not work well for thoracoscopy portals because the overlying tissue interferes with instrument movement. The telescope cannula with a blunt obturator or with a locked trocar guard is inserted through the tissue tract. When the cannula is in the pleural space, the obturator is removed, pneumothorax is established, and the telescope is inserted. This is the safest and quickest technique, and is used almost exclusively.

Lateral chest wall telescope portal placement can also be performed with the Veress needle and a sharp trocar technique. A small skin incision is made at the site selected for telescope placement. The Veress needle is inserted through the chest wall into the pleural space and air is allowed to enter the pleural space until the lungs are sufficiently collapsed for trocar and cannula placement. A large pneumothorax is not required, but sufficient lung collapse is needed to allow placement of the endoscope cannula with its sharp trocar without damaging the lungs or other thoracic viscera. Additional air can be allowed to enter the pleural space to increase the pneumothorax after placement of the telescope cannula if needed. The Veress needle is removed when an adequate pneumothorax has been created. The telescope cannula and trocar assembly are inserted through the chest wall through the same incision. Placement of the cannula trocar assembly must be done carefully and without excessive depth of penetration to prevent damage to the thoracic viscera. A two-hand technique is used, with one hand placed on the chest wall around the cannula and the other hand placed on the end of the cannula assembly. The two hands are placed so that they are separated by the desired depth of penetration.

The cannula is forced through the chest wall with the upper hand using a back and forth rotational movement until the chest wall is penetrated. If too much force is applied and the trocar suddenly penetrates the chest wall, it is stopped when the upper hand hits the lower hand and the chance of intrathoracic damage is minimized. Once the cannula is in the pleural space, the trocar is removed and replaced with the telescope. The extent of pneumothorax is evaluated and adjusted to provide adequate space for examination.

## ACCESS TO THE THORACIC CAVITY: OPERATIVE PORTALS

Techniques for establishing operative portals are the same for all patient positions. Technique does vary depending on whether operative portal cannulae are used and on the type of cannula. Sites for operative portal placement are selected to allow access to lesions for tissue manipulation and for sample collection. The easiest and most effective method for selecting operative portal sites is to palpate the chest wall with visualization through the telescope and to locate the portal site by intercostal muscle indentation produced by palpation. Palpation is repeated in different areas until the appropriate portal site is determined. For biopsy of tissues or masses that do not need to be manipulated, the portal is placed directly over the site to be biopsied. When manipulation of tissues is required for examination, for sample collection, or for minimally invasive surgical procedures, portal sites are selected based on the principles of endoscopic instrument triangulation.[17] To apply this concept, all portals are on the same side of the lesion or area to be operated, the portals are placed far enough apart and are located so that the instruments do not interfere with each other, the area to be examined can be reached from the portals with the instruments being used, and the visual field of the telescope and the operative instruments all converge on the lesion or area of interest.

Operative ports can be established with or without a cannula. If cannulae are used, they can be placed with a sharp trocar or with blunt dissection and a blunt obturator. With all three techniques, the deep surface of the chest wall is observed with the telescope while the portal is being established to avoid trauma to thoracic viscera. For cannula insertion with a sharp trocar, a short skin incision is made at the portal site and the cannula trocar assembly is inserted with the same technique used for sharp trocar telescope portal placement. Blunt cannula placement is performed by making a short skin incision, bluntly dissecting through the chest wall with a hemostat, and passing the cannula and blunt obturator assembly through the hole in the chest wall. To create an operative portal without a cannula, a short skin incision is made and the fascia, muscles, and pleura are bluntly dissected to establish a minithoracotomy into the chest cavity. Instruments are passed through this tissue tract without placing a cannula.

## PORTAL CLOSURE AND PLEURAL SPACE MANAGEMENT

When examination, sample collection, or minimally invasive operative procedures have been completed, instrumentation is removed, the portals are closed, and the lungs are reexpanded. The technique for pleural space management depends on the extent of thoracic disease present and the type and complexity of the surgical procedure performed.

The biopsy or operative portal cannulae are removed first and the chest wall portals closed with interrupted sutures in the fascia and skin. Five-millimeter portals are closed with subcutaneous and skin layers and 10-mm or larger portals are closed with deep fascial, subcutaneous, and skin layers. Closure of all portals must achieve an airtight seal.

When only fluid collection or a simple solid tissue biopsy is done and there is no pleural fluid, no evidence of air leakage, and no evidence of hemorrhage, the pleural space can be evacuated through the camera portal cannula until the lungs are well expanded as visualized with the telescope. Lung expansion is observed with the telescope while the lungs are reexpanded with intermittent positive pressure breathing. When the lungs are adequately expanded, the telescope and cannula are removed and the portal closed. A telescope cannula with a valve and gasket facilitates this procedure.

A second technique places a chest tube through the telescope cannula. When this technique is used, the pleural drain tube is placed through the telescope cannula well into the chest, the cannula is removed over the end of the chest tube, leaving the tube in place, and the tissues of the camera portal are closed in multiple layers around the chest tube. Underwater seal drainage with suction is applied until no air or fluid is produced from the tube. This technique is used when there is minimal fluid production from the disease process and when there is minimal risk of postoperative bleeding or air leakage. In most cases in which this technique is used, the chest tube is removed while the patient is recovering from anesthesia either before or at the same time as the endotracheal tube is removed. The paraxiphoid telescope portal is best suited for this technique and chest tubes placed at this site are left in place for up to 24 hours following minimally invasive pericardial window surgery.

In cases of significant thoracic disease in which there is increased risk of pleural fluid accumulation, bleeding, or air leakage from more complex surgical procedures or

because of the disease process, placement of a standard chest drain tube is required and its management is the same as that for an open thoracotomy. For this approach, the chest tube is not placed through a portal site because it is difficult to achieve an airtight seal around the tube. Standard subcutaneous tunnel chest tube placement technique is used.

With all these techniques, postoperative chest radiographs are recommended before chest tube removal or immediately after conclusion of the procedure if a chest tube is not placed.

Intermittent positive pressure breathing is continued until the lungs are fully reexpanded and the patient's condition is stable. Transition is then made to spontaneous breathing. Patient monitoring is continued until the patient recovers from anesthesia and the patient's condition is stable. Thoracoscopy is a minimally invasive technique involving far less trauma, less anesthesia, and less time than surgery, but the chest is still invaded, the lungs collapsed, and cardiopulmonary compromise incurred. Adequate patient monitoring and supportive treatment are essential to realizing the benefits of thoracoscopy over thoracotomy.

## POSTOPERATIVE RECOVERY

Postoperative recovery is much faster with minimally invasive thoracic surgery than with an open thoracotomy. Patients are typically fully recovered, pain-free, and acting like nothing was done within a few hours after the procedure. The need for pain management, the amount of drug required, and the duration of treatment is substantially less than with conventional open surgery. The amount of postoperative hospitalization time after minimally invasive surgery is dictated more by the disease process and by anesthetic recovery than by the surgical procedure itself. Many patients can be released from the hospital on the day of the procedure and most can be released on the day after surgery, with very few requiring further hospitalization.

## THORACOSCOPIC FINDINGS

Visualization of intrathoracic structures with thoracoscopy is far superior to what can be seen with an open thoracotomy because of the excellent lighting, magnification produced by the telescopes, and ability to place the telescope into surgically inaccessible areas of the chest. Lateral recumbency and lateral endoscope placement allow visualization of the structures of each hemithorax but not the contralateral hemithorax. The ventral paraxiphoid portal allows bilateral examination of the chest but is limited to ventral structures.

Chest wall structures can be visualized and the internal surfaces of the ribs, muscles, blood vessels, and nerves can be clearly defined (Fig. 7-7). The lungs can be examined over most of their surfaces (Fig. 7-8). The underside of the lungs and the interlobar fissures can be evaluated by displacement of pulmonary tissue with a manipulation probe, tissue graspers, or retractors. Close-up observation of the

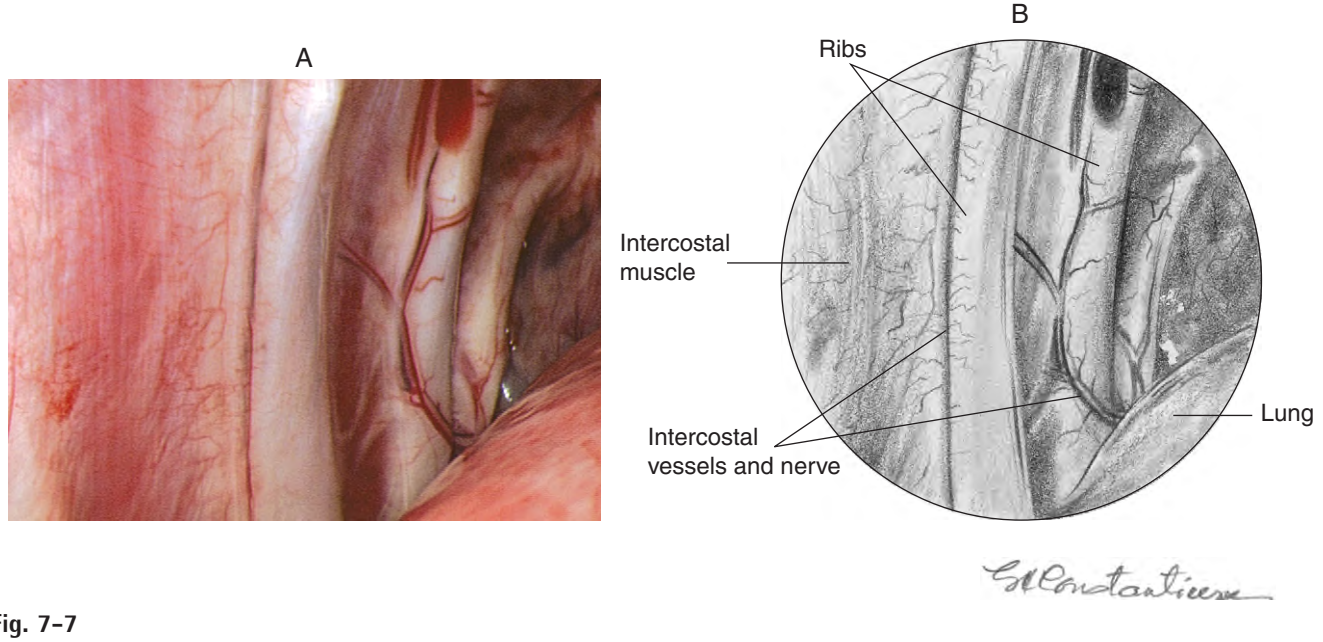



**Fig. 7-7**
Normal chest wall structures. The internal intercostal muscles, ribs, intercostal vessels, and intercostal nerve can be seen under the clear parietal pleura.

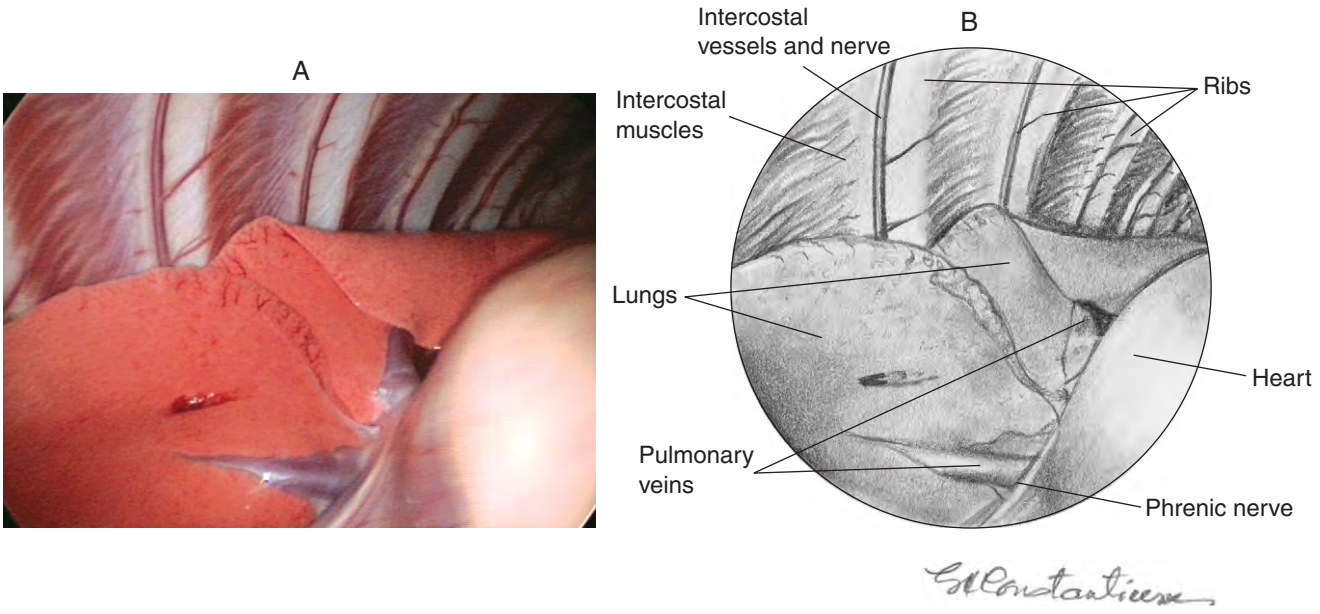



**Fig. 7-8**
The surface of the lung lobes can be examined over most of their surface. The amount of the lung surface that can be examined varies with patient position, disease present, telescope portal placement, operative portal placement, and operator skill.

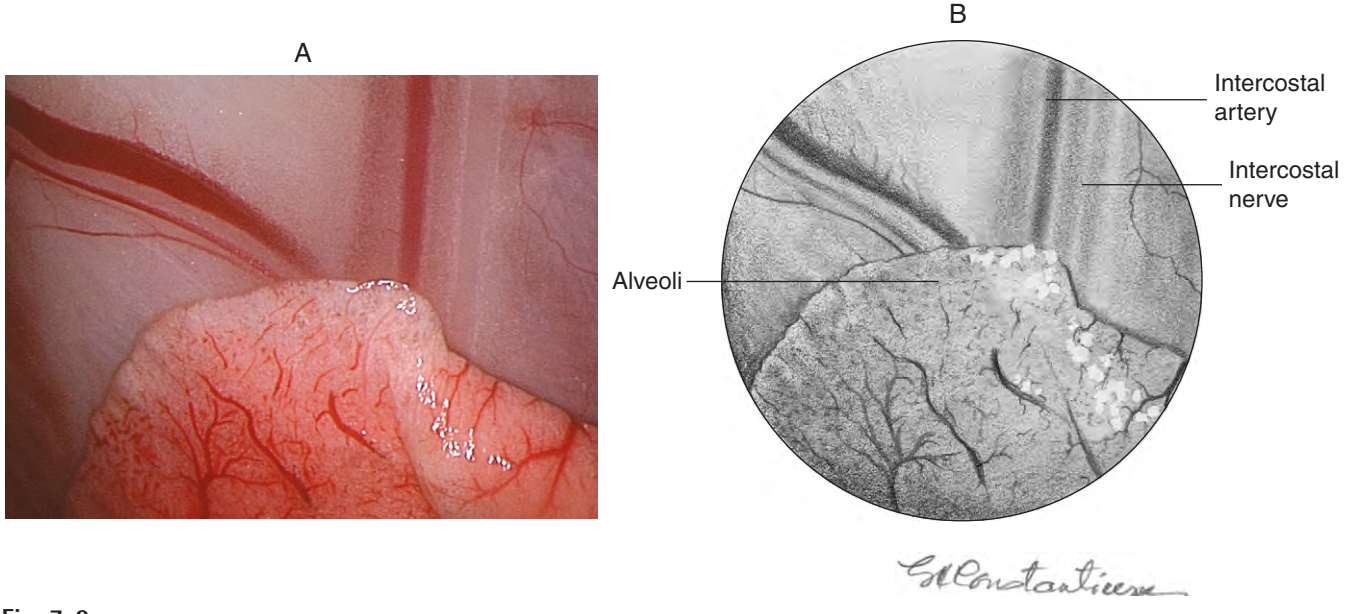



**Fig. 7-9**
A close-up view of the lung surface with alveoli visible because of the magnification of the telescope and video system.

lung surfaces allows visualization of the superficial alveoli because of the magnification produced by the telescope (Fig. 7-9). The thoracic surface of the diaphragm can be evaluated and the muscle fibers defined (Fig. 7-10), and the recess of the diaphragm can be visualized (Fig. 7-11). Visceral and parietal pleural surfaces can be easily and accurately assessed over the majority of its extent. Normal pleura are smooth and shiny with no visible opacity. The normal pericardium is slightly opaque, obscuring clear visualization of the details of cardiac structures, but movement of the heart and the larger anatomic features can be seen (Fig. 7-12). The phrenic nerve can be seen coursing

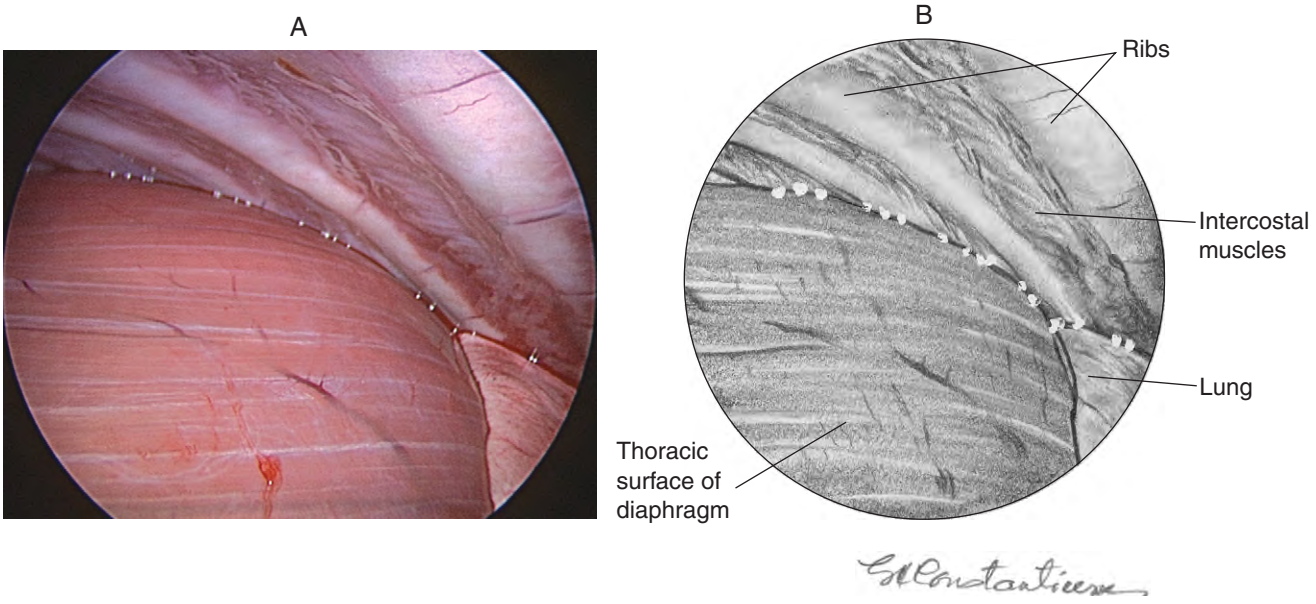



**Fig. 7-10**
The thoracic surface of the diaphragm.

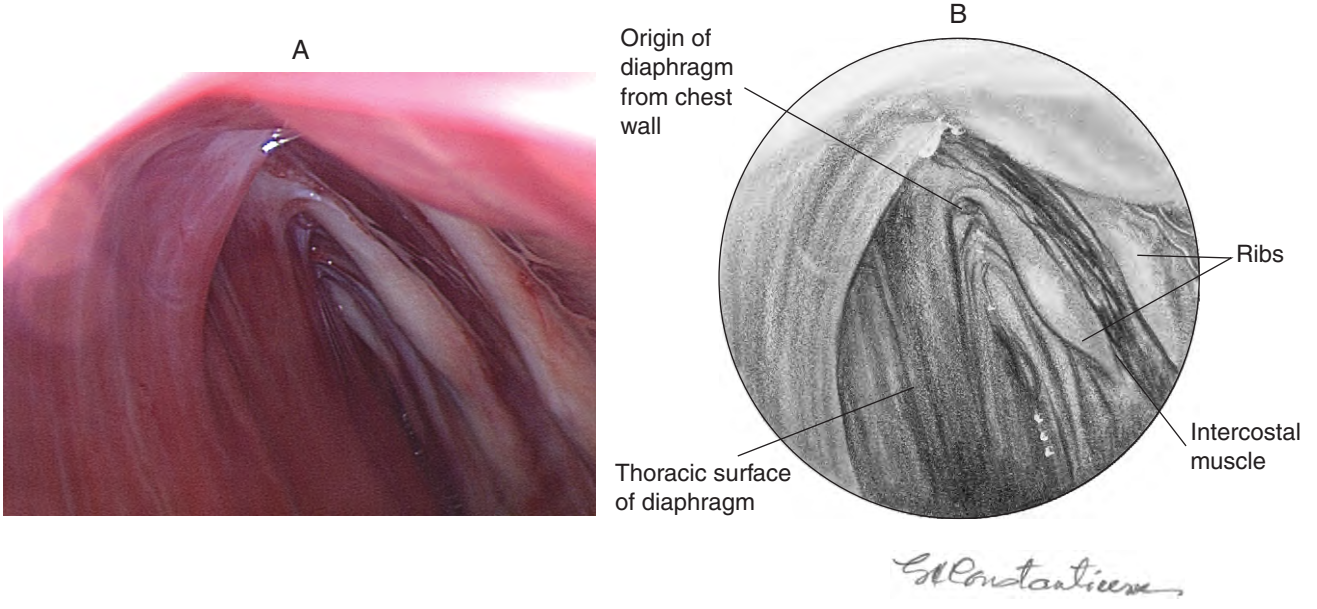



**Fig. 7-11**
The recess of the diaphragm.

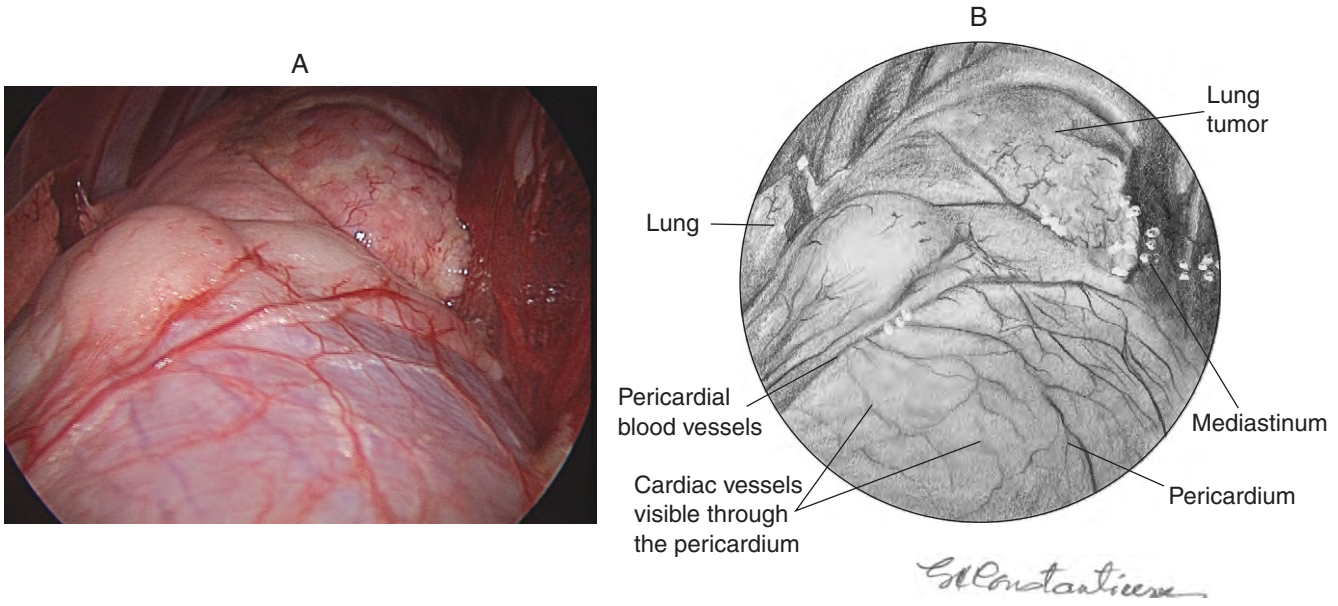



**Fig. 7-12**
The normal pericardium is smooth and translucent, allowing visualization of cardiac movement but obscuring clear visualization of the heart. The mass in the upper left is a primary lung tumor.

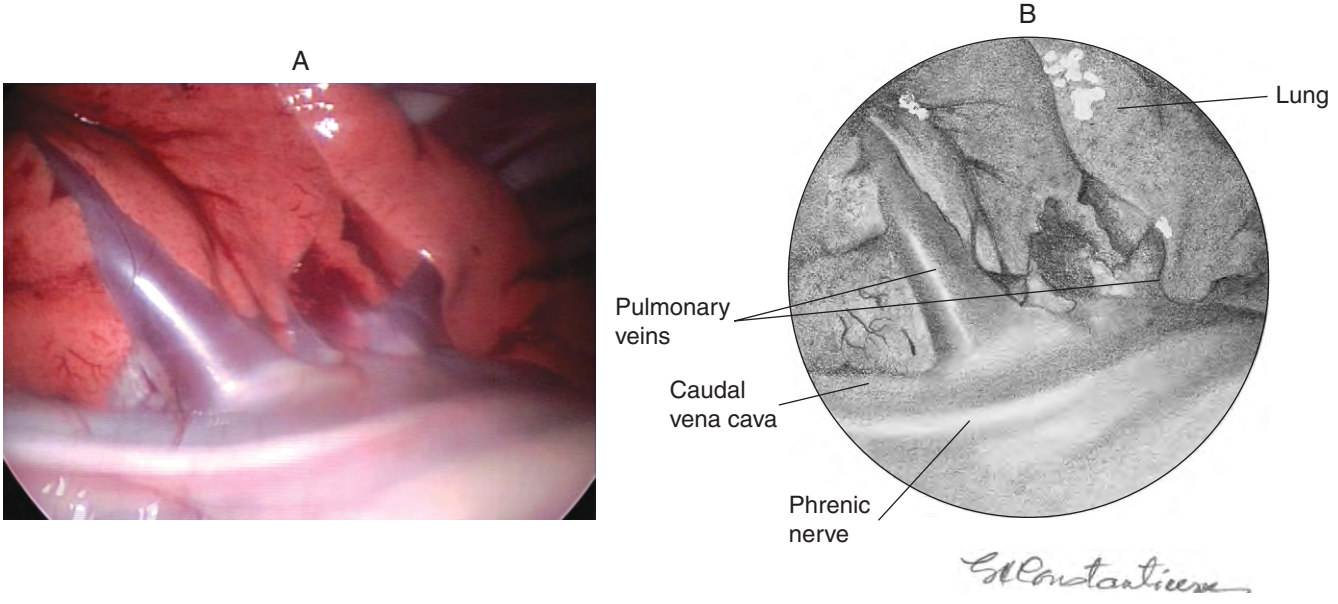



**Fig. 7-13**
The structures of the pulmonary hilus can be visualized with thoracoscopy.

across the pericardial surface (Fig. 7-13) and the sympathetic trunk can be found dorsal and lateral to the thoracic vertebral bodies. Structures of the hilus can be defined, including the pulmonary artery and veins (Figs. 7-8 and 7-13), primary bronchi, and hilar lymph nodes. Major blood vessels, thymus, trachea, lymph nodes, and lymphatic vessels of the cranial mediastinum can be located and defined (Fig. 7-14). The sternal lymph nodes can be visualized (Fig. 7-15) and biopsied or removed. The caudal vena cava and esophagus can be seen on the right side in the caudal thorax, and the aorta can be seen on the left side (Fig. 7-16).[26] Thoracic ducts can be visualized and followed on the dorsal chest wall in the caudal chest (Fig. 7-17) and in the cranial mediastinum.

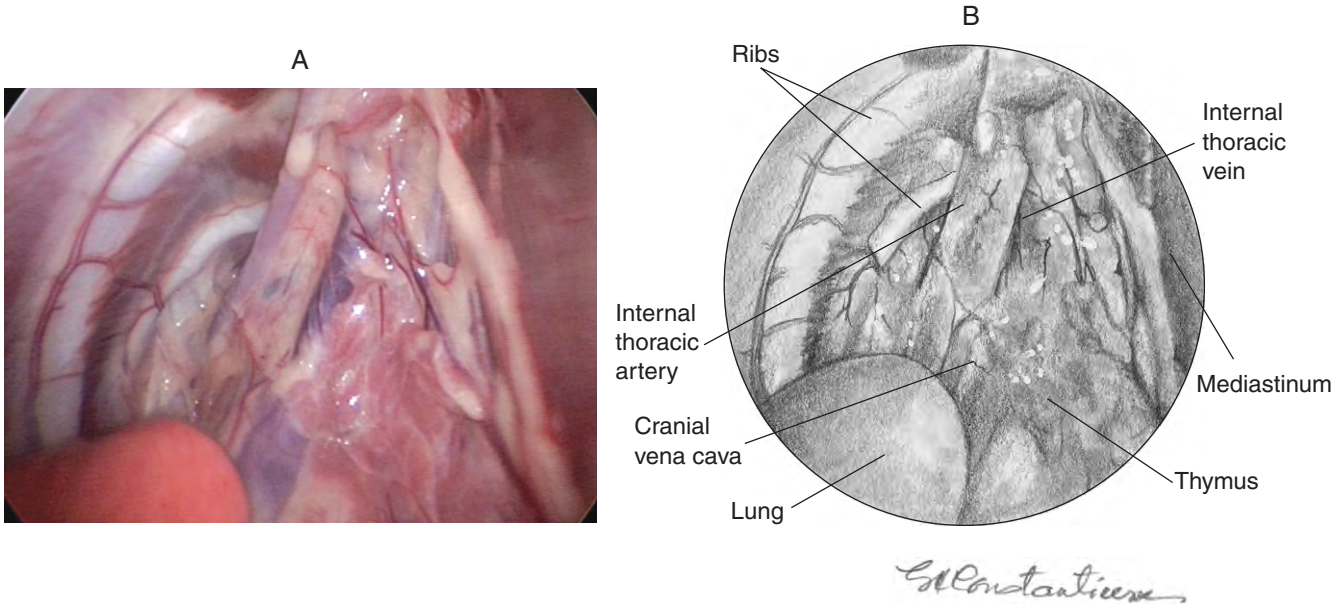



**Fig. 7-14**
The normal cranial mediastinum of a young dog.

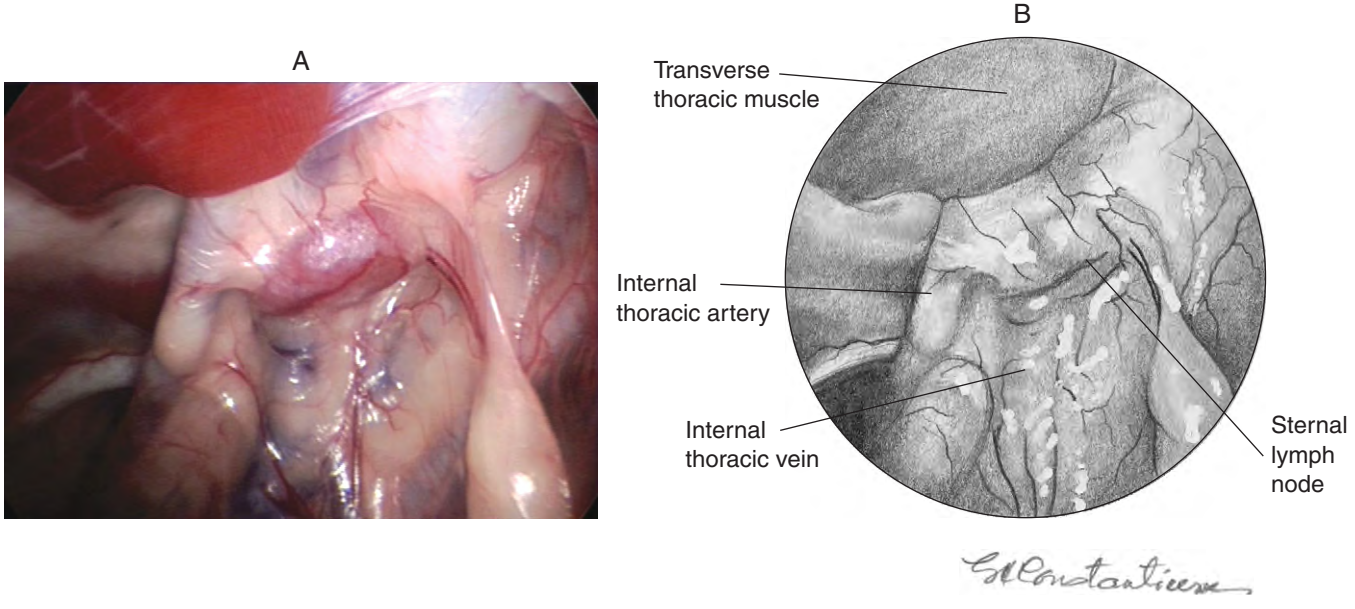



**Fig. 7-15**
Normal sternal lymph node.

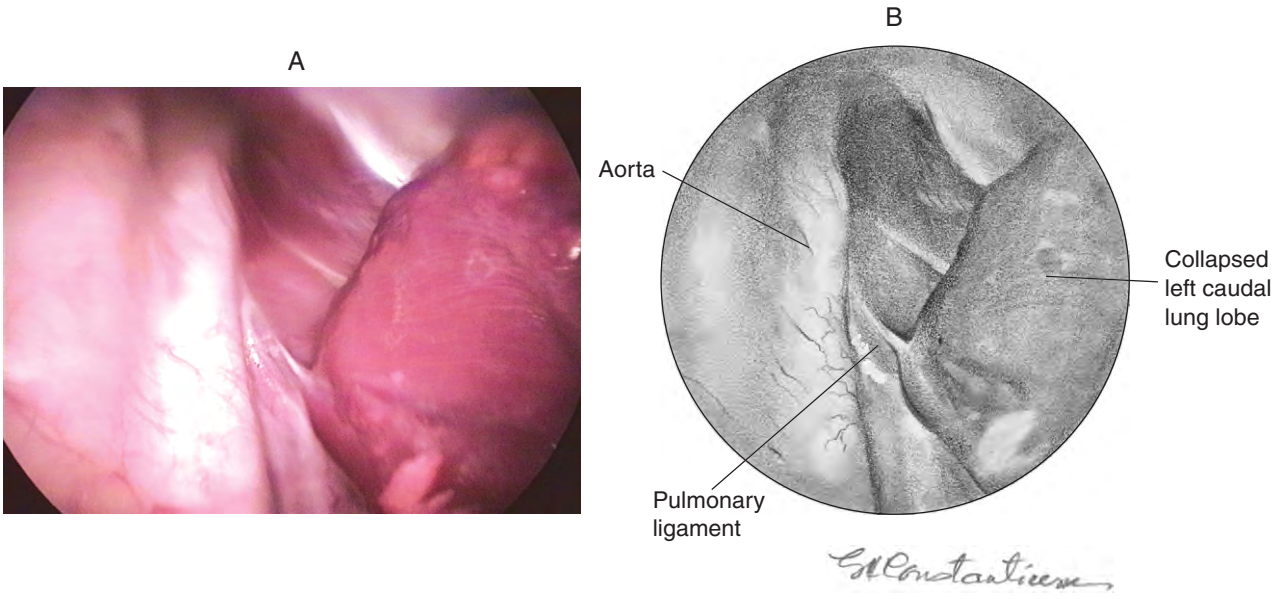



**Fig. 7-16**
Aorta, left caudal lung lobe, and pulmonary ligament in the left caudal thorax.

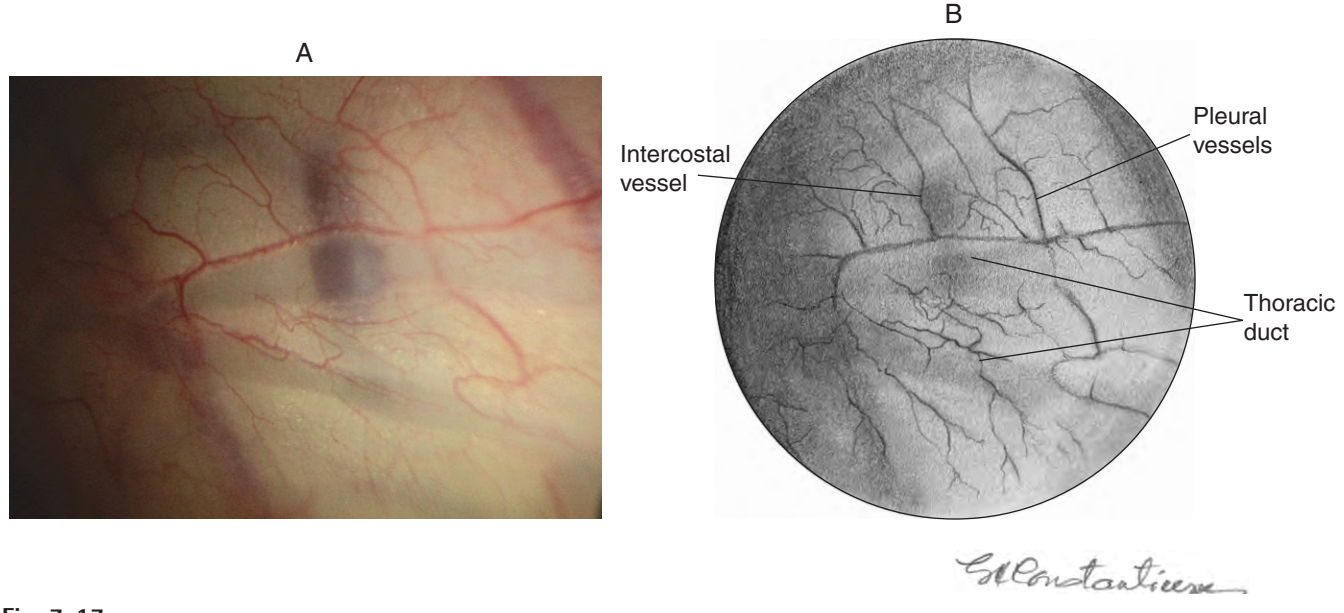



**Fig. 7-17**
A close-up view of the thoracic duct in a cat.

## THORACIC PATHOLOGY

Abnormalities that have been found with thoracoscopy in dogs and cats have included primary and metastatic neoplasia, enlarged cranial mediastinal and hilar lymph nodes, pericardial effusion and pericarditis, ruptured and intact emphysematous bullae, migrating foreign bodies, pulmonary lacerations and contusions, thoracic duct pathology, inflammatory and neoplastic pleural lesions, and diaphragmatic hernias.

In cases with significant pleural or pericardial fluid sufficient to compromise cardiopulmonary function under anesthesia, every effort is made to evacuate the fluid before anesthetic induction. If it is not possible to remove all the pleural fluid before performing thoracoscopy, then as soon as the telescope portal is placed into the thorax, an aspiration tube is passed through the endoscope cannula or through an operative portal, suction is applied, and the remainder of the fluid is removed. If there is sufficient residual pericardial fluid, a Veress needle is placed into the pericardium with endoscopic visual guidance to evacuate the fluid. Samples of the pleural or pericardial fluid can be collected for fluid analysis, cytology, or bacterial and fungal cultures.

Fine needle aspirates can be obtained of solid masses for cytologic examination. Biopsy specimens can be obtained from solid tissue masses, lymph nodes, or lung for histopathology. Samples can be collected with endoscopic biopsy forceps, endoscopic operative instruments, or conventional sample collection instrumentation. Tru-Cut biopsy needles work well for collecting biopsy samples from large lung and from mediastinal or hilar masses, but with small masses there is an increased risk of penetrating structures deep to the mass while attempting sample collection. Standard hypodermic needles of sufficient length, spinal needles, or Menghini needles can be used for fluid collection and for fine needle aspiration.

### Neoplasia

Diagnosing intrathoracic neoplasia, staging disease, and determining resectability are major applications of thoracoscopy.[1,9,27,28] Large pulmonary masses (Fig. 7-18) and smaller superficial pulmonary masses can be seen directly (Fig. 7-19), and many deep pulmonary masses can be located by the overlying pulmonary changes. The appearance of lung tumors varies from small nodules (Figs. 7-19, 7-20, and 7-21) to large, variably colored masses (Figs. 7-18 and 7- 22). The primary limitation in visualizing and collecting biopsy samples of lung tumors is when intrapulmonary masses are small and deep. Mediastinal neoplasia can be seen as small masses on the pleural surface (Fig. 7-23), as large single operable masses (Fig. 7-24), or as multiple inoperable masses partially filling the cranial chest (Fig. 7-25). The variation in appearance, number, size, and location of lesions covers the full spectrum of intrathoracic neoplasia. Pleural lesions can be assessed better with thoracoscopy than with any other technique. Small, submacroscopic pleural (Fig. 7-26) and pericardial (Fig. 7-27) plaques or nodules can be visualized because of the magnification of the telescope, and lesions can be accurately biopsied to greatly enhance the accuracy of diagnosis.

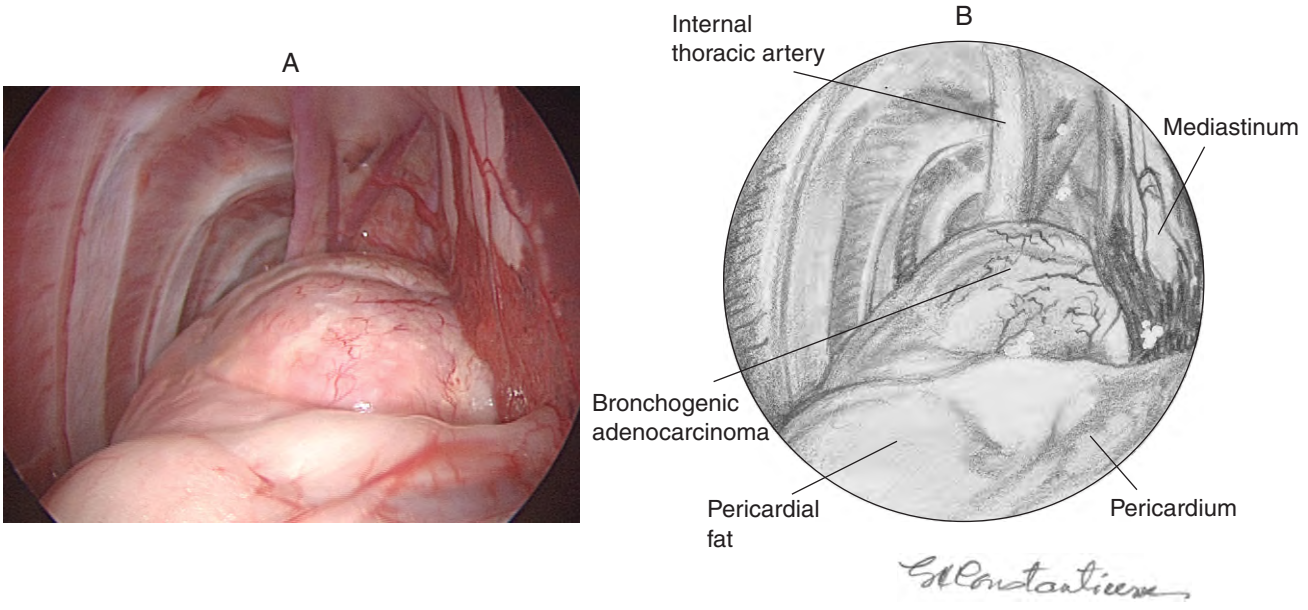



**Fig. 7-18**
A primary pulmonary bronchogenic adenocarcinoma in the right cranial lung lobe in a dog.

## Pneumothorax

Spontaneous pneumothorax and pneumothorax due to trauma or secondary to foreign body migration can be effectively evaluated and managed with thoracoscopy.[12,28] Trauma is the most common cause of pneumothorax in small animal veterinary medicine and most cases resolve without medical or surgical intervention. Some trauma patients with extensive or persistent air leakage require treatment with pleural drainage or surgical intervention. Many cases requiring surgical intervention can be evaluated with thoracoscopy and managed with minimally invasive technique without subjecting an already traumatized patient to the additional traumatic insult of an open thoracotomy.

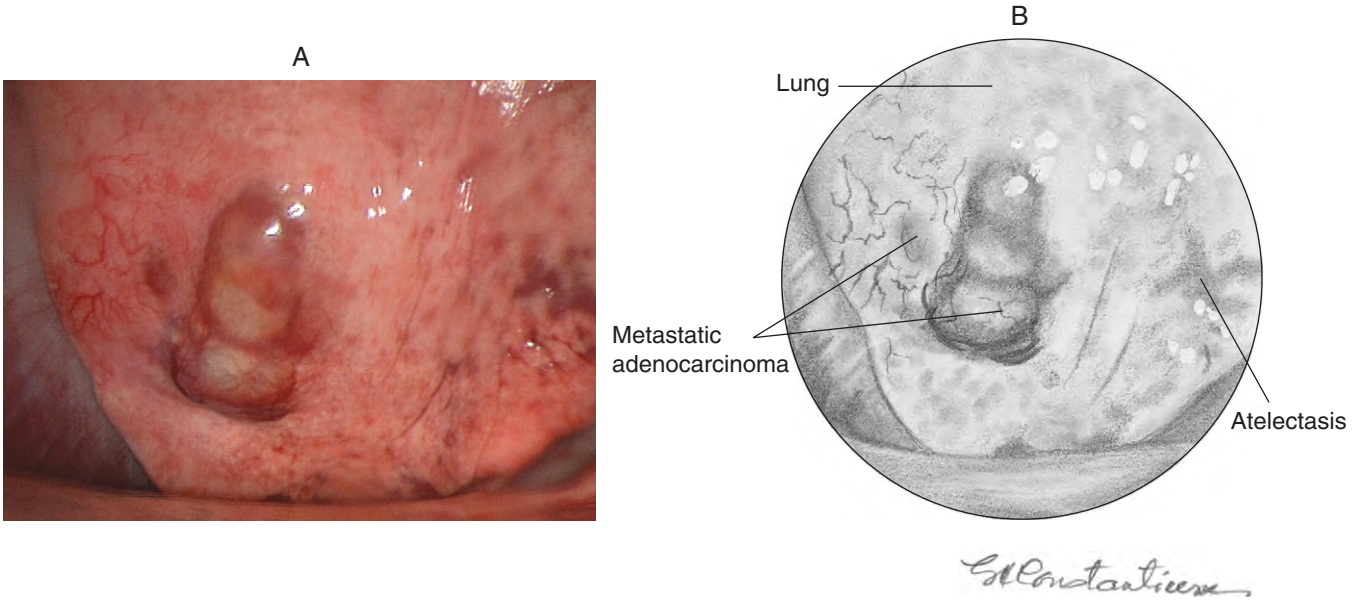



**Fig. 7–19**
A small metastatic adenocarcinoma of undetermined origin on the dorsal surface of the right cranial lung lobe in a dog, which is visualized by elevating the lung with a manipulation probe.

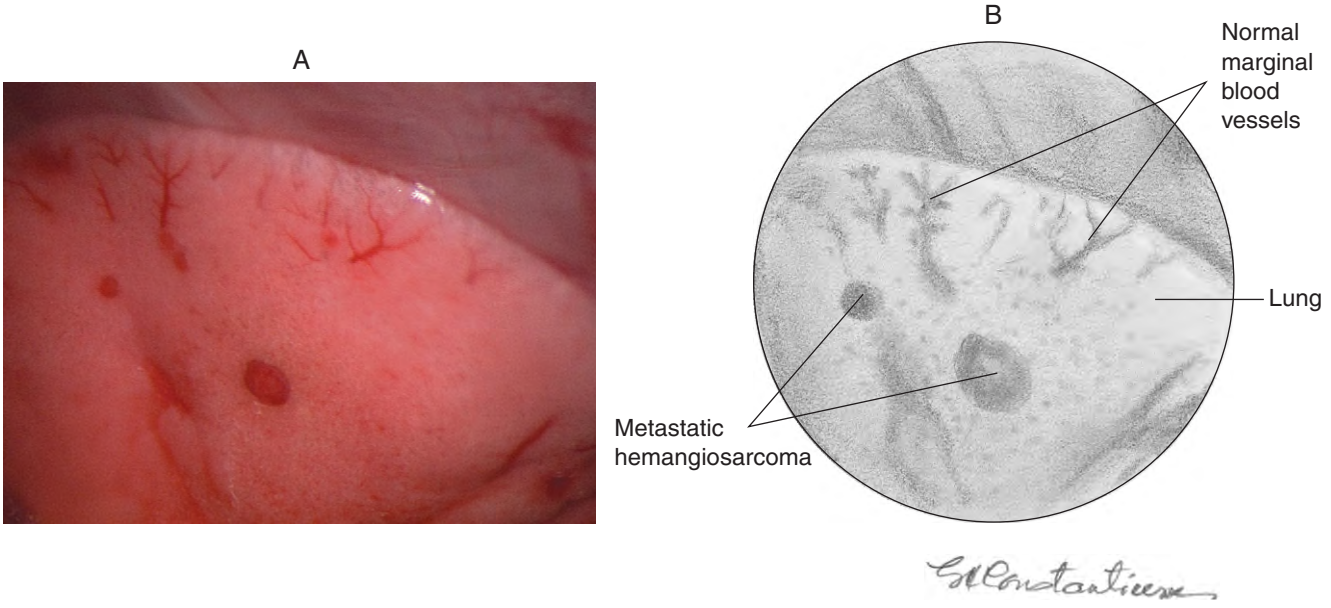



**Fig. 7–20**
Small metastatic hemangiosarcoma lesions in a dog with widely disseminated neoplasia.

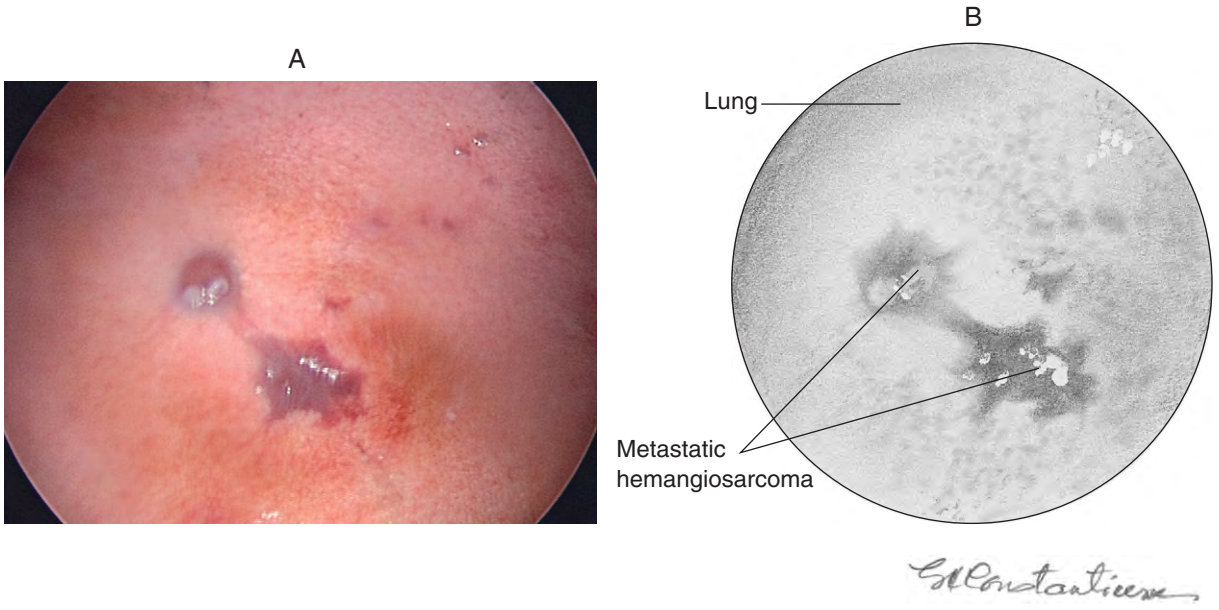



**Fig. 7-21**
A small metastatic hemangiosarcoma in the lung of a dog with pleural and pericardial effusion resulting from a primary splenic hemangiosarcoma.

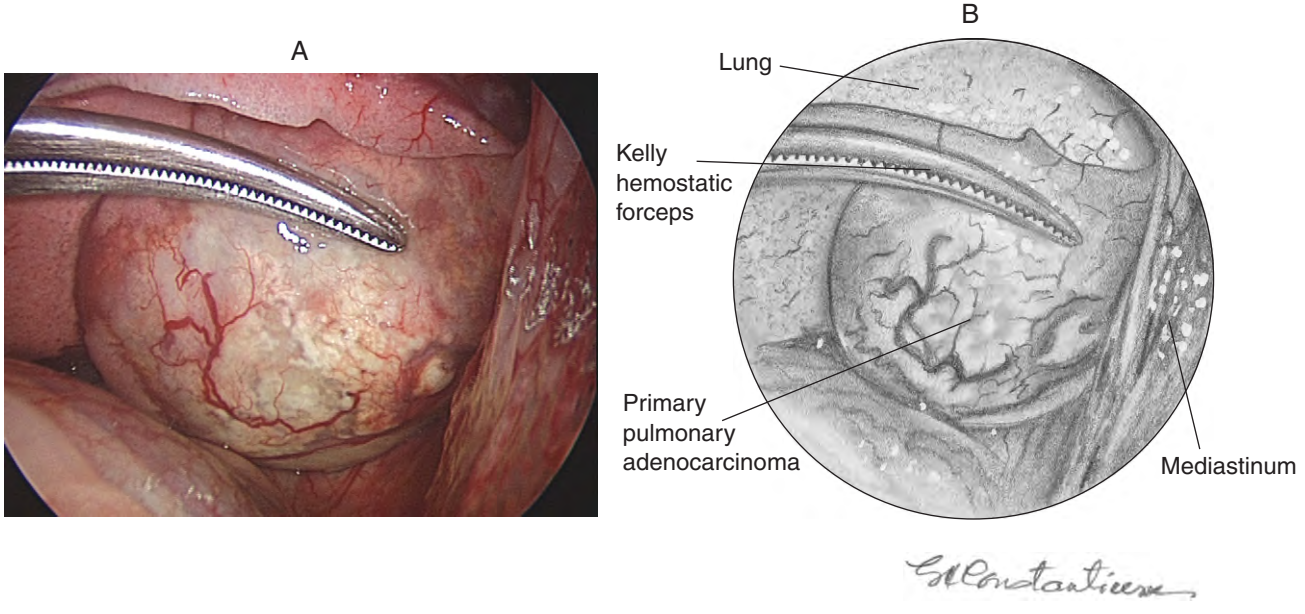



**Fig. 7-22**
Large, multicolored primary papillary pulmonary adenocarcinoma in a dog.

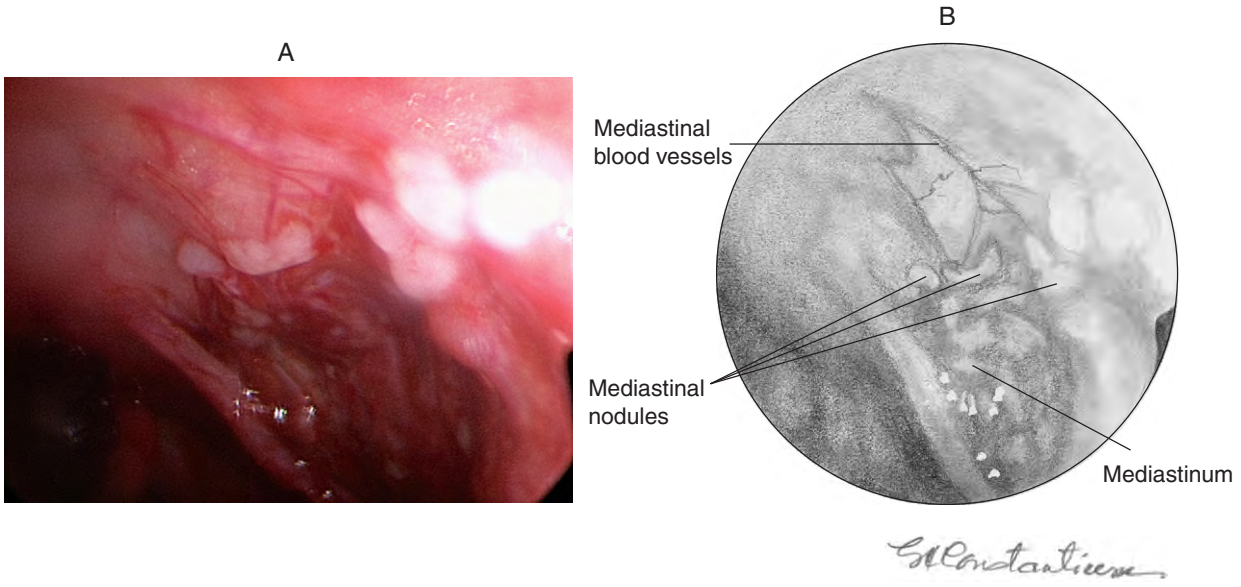



**Fig. 7-23**
Multiple small neoplastic nodules in the ventral mediastinum of a dog. Similar lesions were widely disseminated over the pleural surfaces. Histopathology was suggestive of mesothelioma.

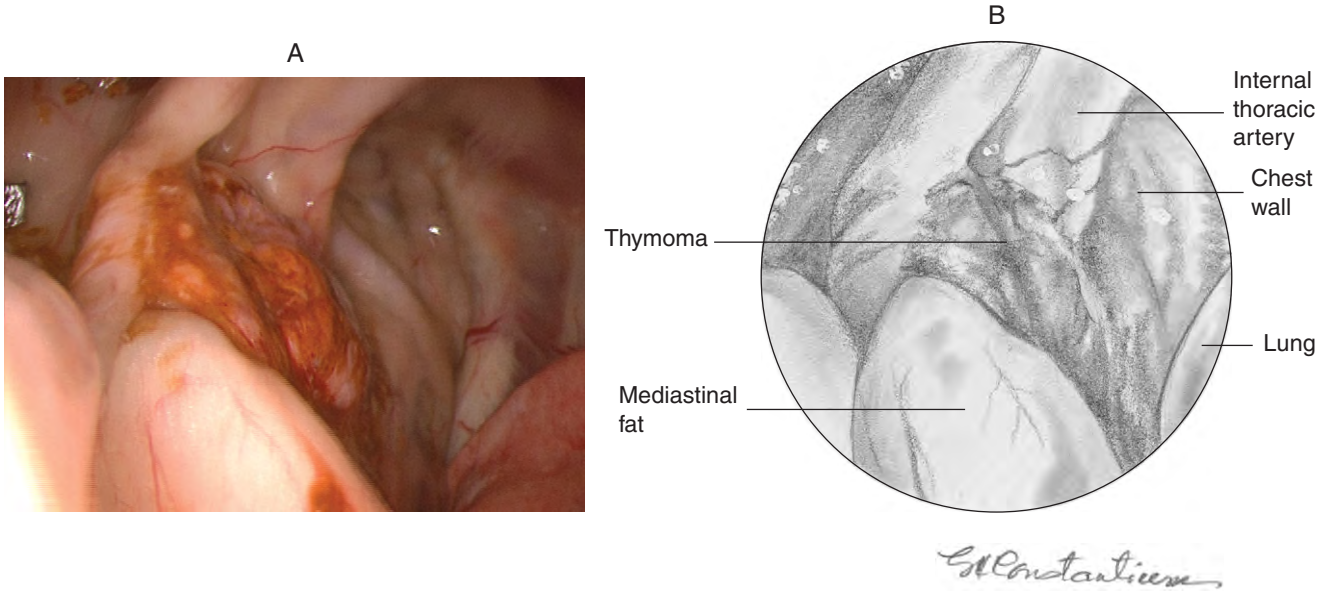



**Fig. 7-24**
Cranial mediastinal mass in a dog. Biopsy revealed this mass to be a thymoma.

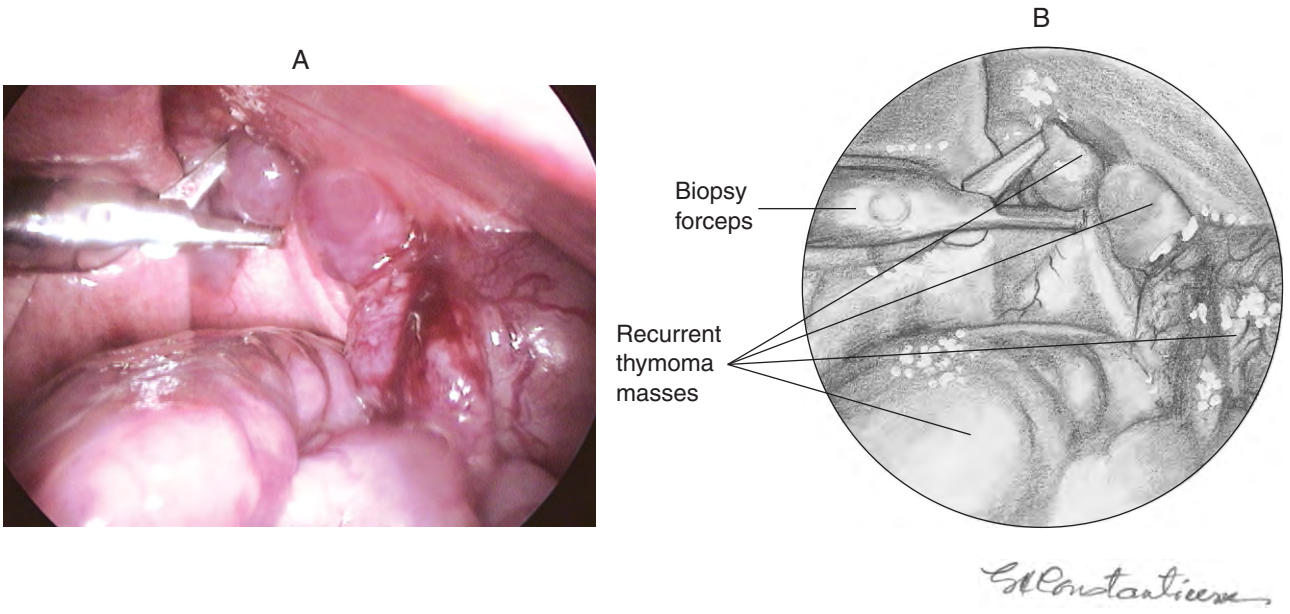



**Fig. 7-25**
Multiple cranial mediastinal masses in a dog with recurrent thymoma that had been removed with an open sternal splitting thoracotomy 5 months previously.

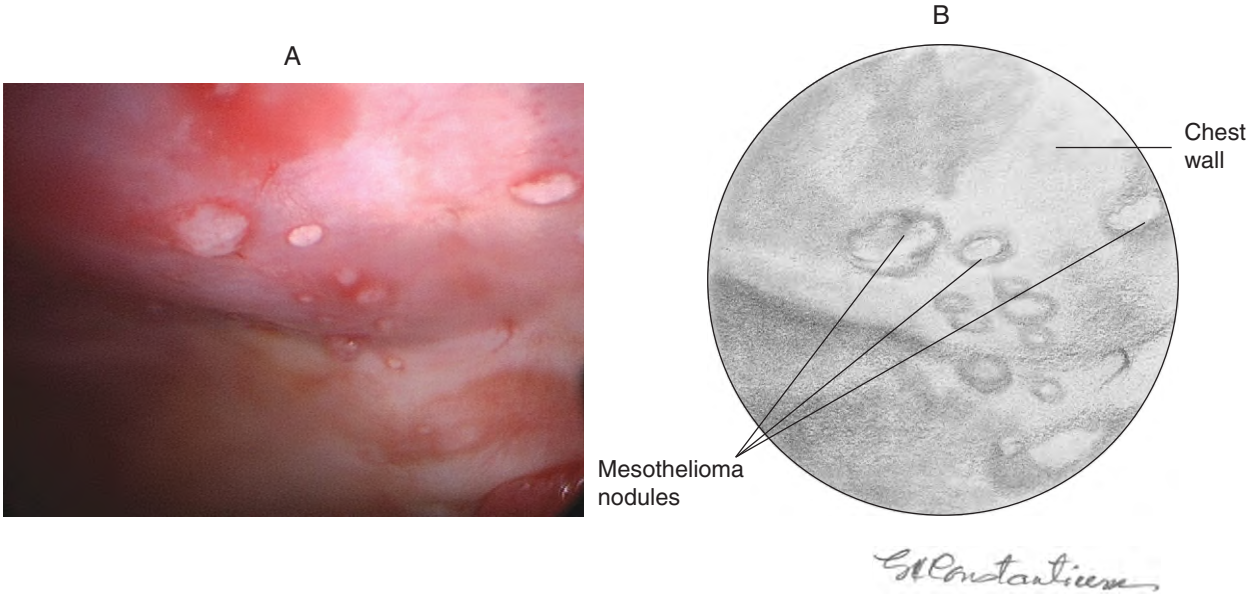



**Fig. 7-26**
Multiple submacroscopic nodules in a dog with pleural effusion resulting from a mesothelioma.

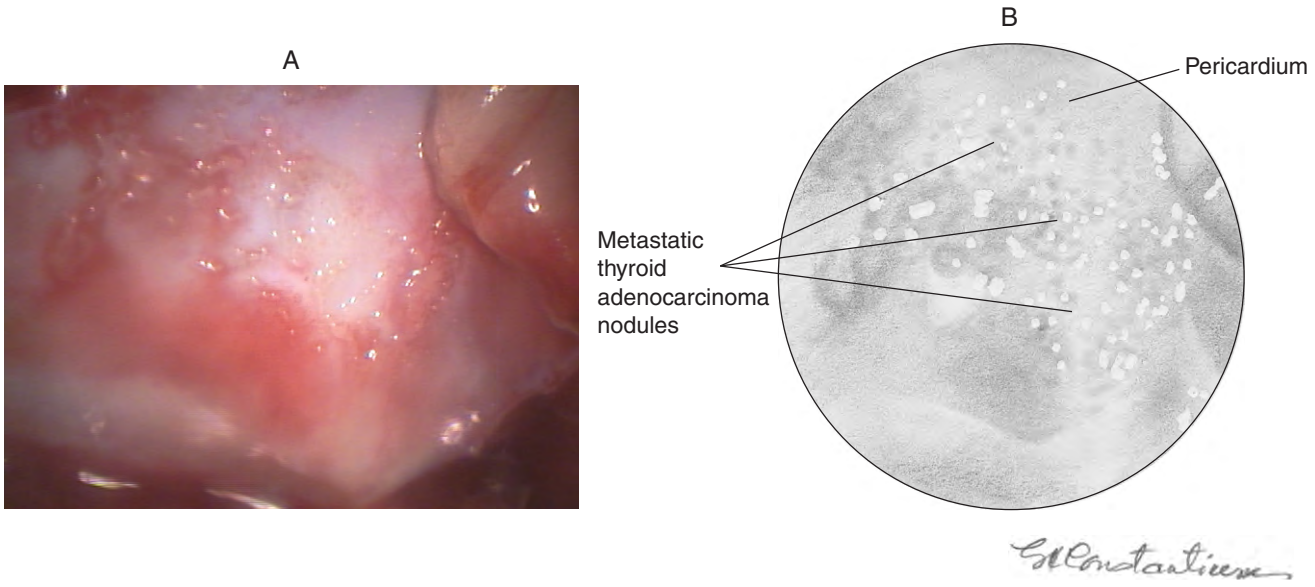



**Fig. 7-27**
Multiple submacroscopic nodules on the deep surface of the pericardium in a dog with pericardial effusion. Biopsies revealed that the nodules were metastatic thyroid adenocarcinoma.

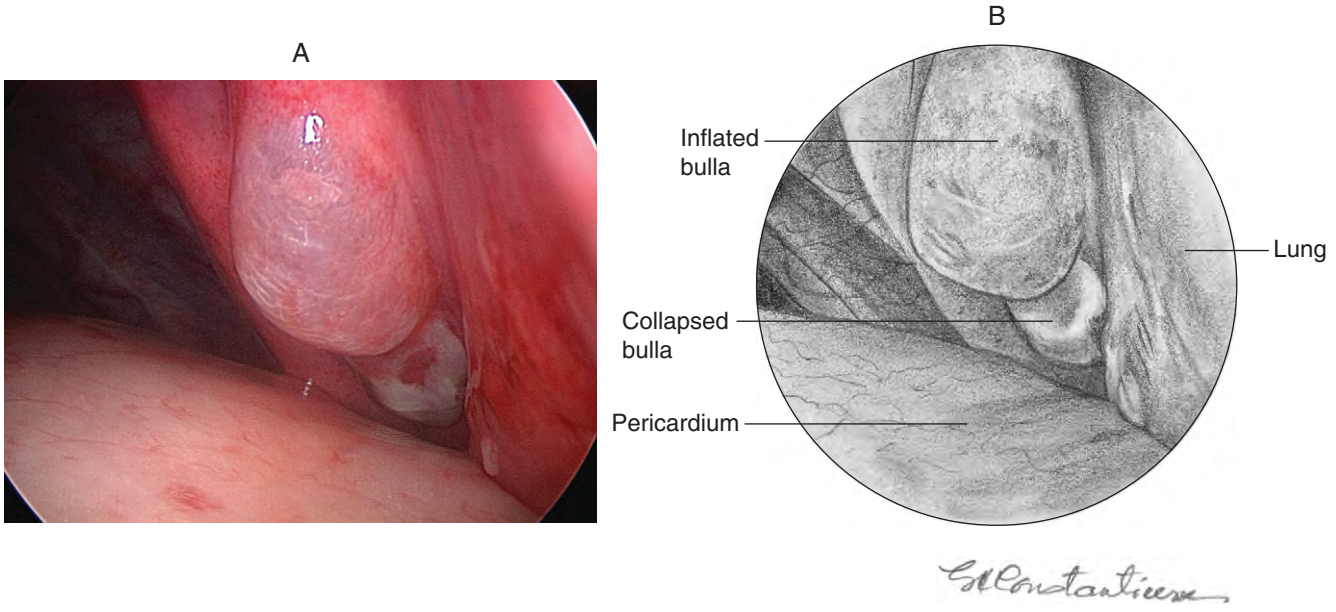



**Fig. 7-28**
Emphysematous bullae on the medial surface of the left cranial lung lobe of a dog with spontaneous pneumothorax. The inflated bulla was not the source of the active air leakage. The active air leakage was coming from the more distant collapsed bulla.

Ruptured emphysematous bullae are the most common cause of spontaneous pneumothorax (Fig. 7-28). Migration of penetrating foreign bodies with subsequent air leakage can also cause spontaneous pneumothorax (Fig. 7-29). The most difficult part of managing spontaneous pneumothorax cases is locating the site of the air leakage with noninvasive procedures before surgical intervention. The site of active air leakage can be found and the cause defined effectively and with minimal trauma using thoracoscopy. Cases that do not respond to conservative treatment with chest tubes and continuous or intermittent underwater seal drainage with suction require surgical correction. Because pulmonary lobectomy is more difficult to perform through a ventral sternotomy incision

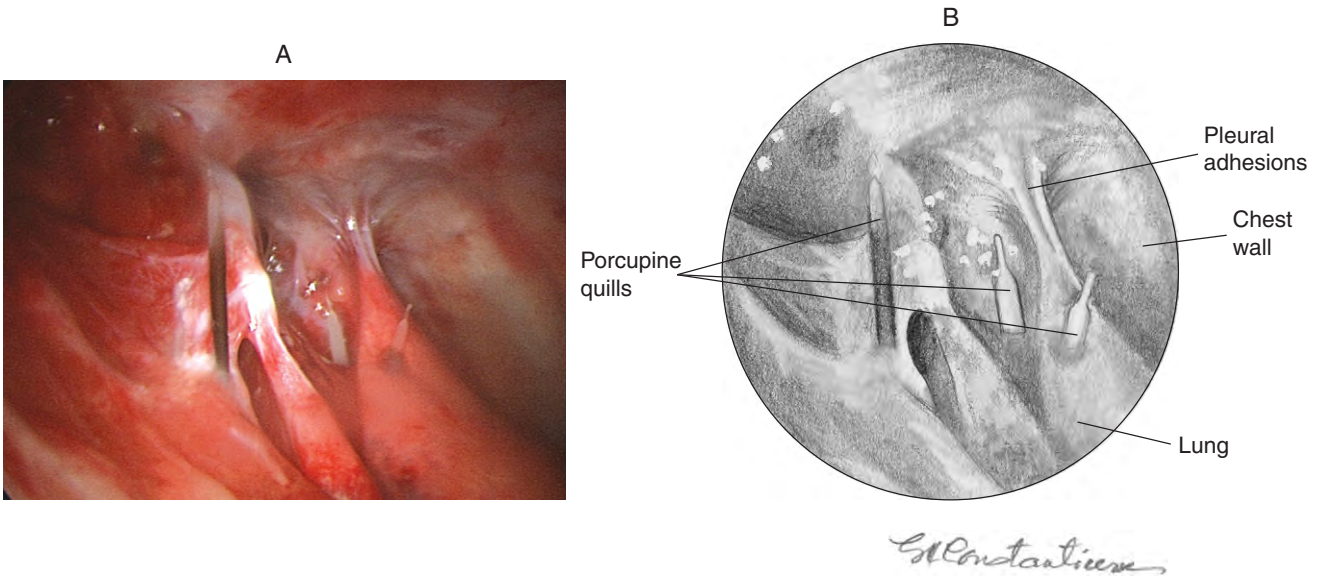



**Fig. 7-29**
Porcupine quills in the thorax of a dog with pneumothorax and pericardial effusion.

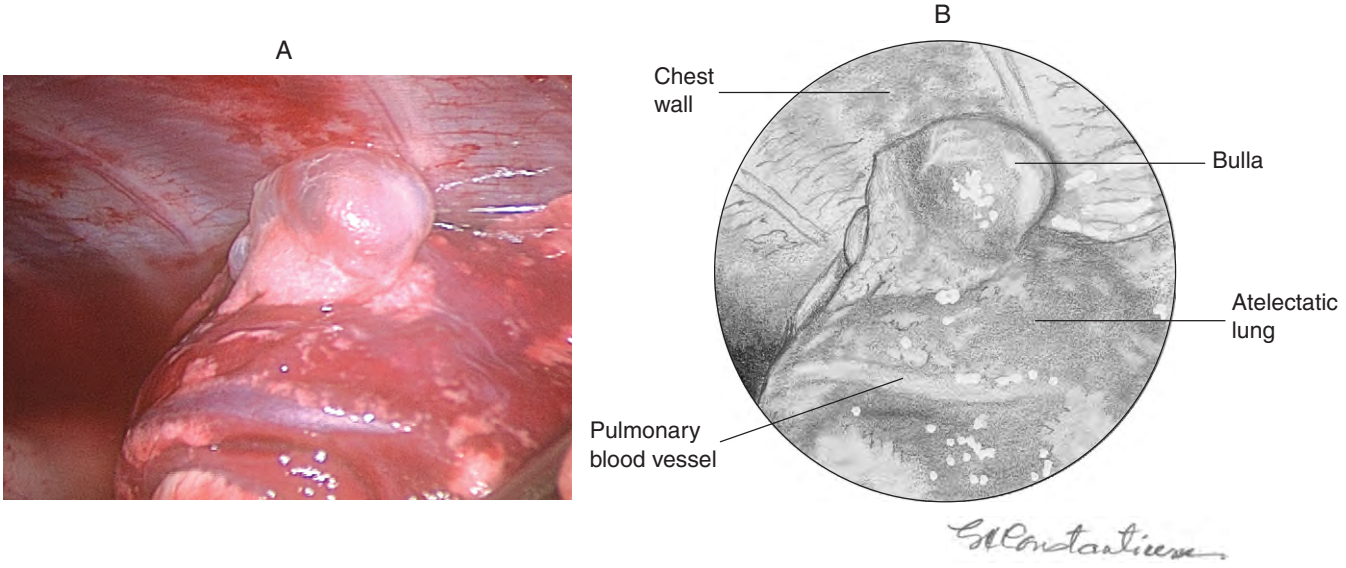



**Fig. 7-30**
Emphysematous bulla on the dorsal aspect of the left cranial lung lobe in a dog with persistent pneumothorax. The apex of the cranial lung lobe was retracted caudally to expose the lesion on the dorsal aspect of the lung lobe.

than through a lateral intercostal thoracotomy, it is desirable to determine the side of involvement before surgery. The site of active air leakage can be visualized via thoracoscopy and thus the side of involvement can be determined to greatly facilitate surgical planning. Pulmonary degeneration with bulla formation and air leakage can occur at solitary site or at multiple sites in multiple lung lobes. With solitary sites, surgical removal controls the current air leakage and substantially reduces the incidence of recurrence. When multiple sites are found in multiple lung lobes, open surgical intervention may control the current episode of air leakage but may not have a significant effect on the incidence of future episodes of pneumothorax. Open surgical intervention is of questionable value in these cases. Bullae appear as variable-sized, air-filled (Figs. 7-28 and 7-30) or collapsed (see Fig. 7-28) structures protruding from the pulmonary surface. The ruptured, leaking bulla may or may not be air filled, and determining the exact location of air leakage is critical. Flooding the area with saline through a second portal allows visualization of air leakage to facilitate localization of the lesion (Fig. 7-31). Foreign bodies that

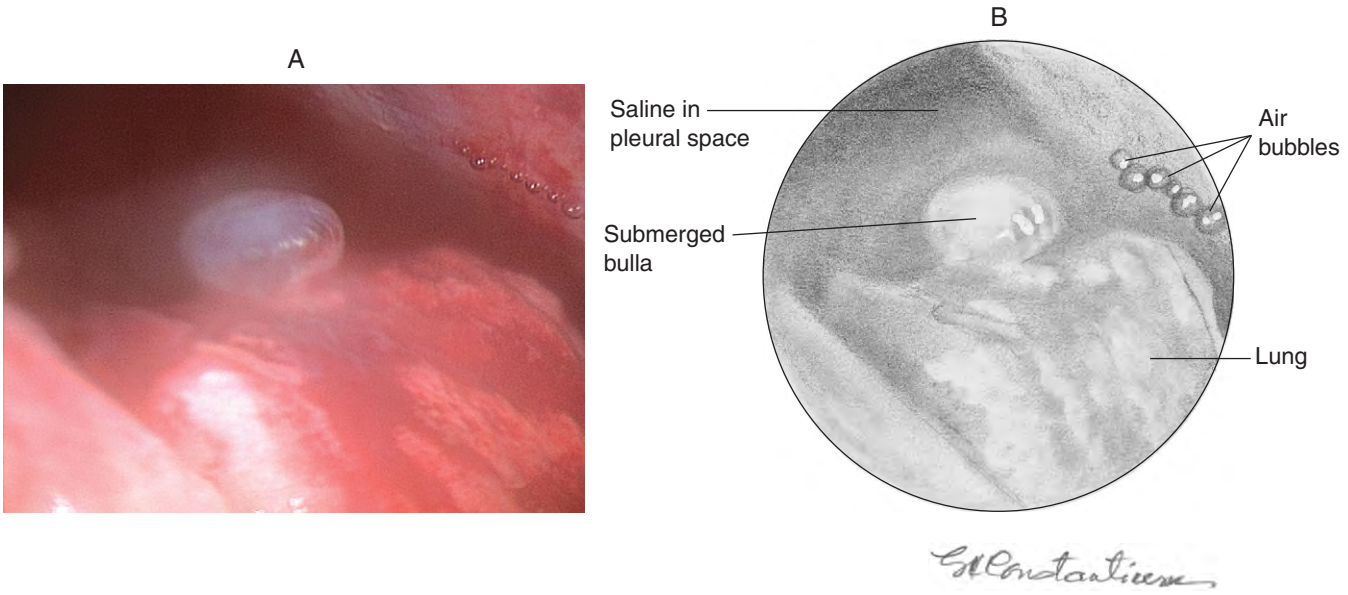



**Fig. 7-31**
Pleural space flooded with saline to look for air leakage from the emphysematous bulla in the left cranial lung lobe of the dog in Fig. 7-30.

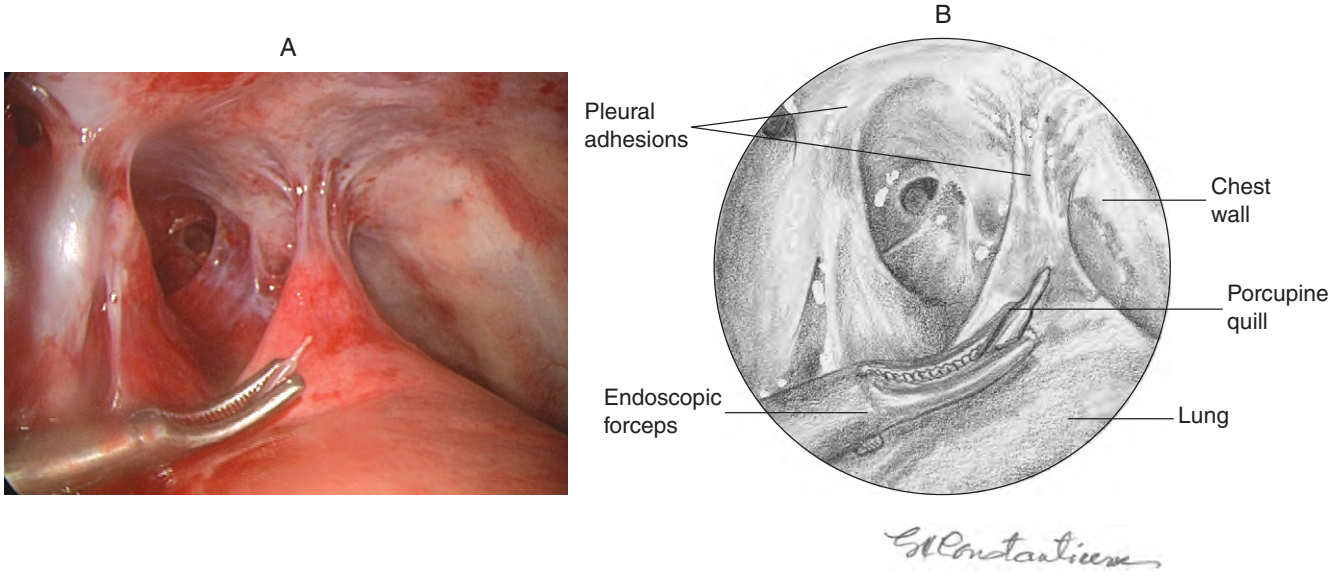



**Fig. 7-32**
Removing the porcupine quills from the lungs of the dog in Fig. 7-29. More than 40 quills were removed using minimally invasive technique.

penetrate from the lung into the pleural space are another less common cause of spontaneous pneumothorax and can also be located (see Fig. 7-29) and removed (Fig. 7-32) with thoracoscopy. Adhesions, exudate, and inflammation present around the site of foreign body penetration may make examination more difficult. Minimally invasive surgical techniques can be used to close the site of air leakage or to remove involved segments of lung lobes.

## Hilar Lymph Node Enlargement

Enlarged hilar lymph nodes are seen between the lung lobes when they are partially collapsed for thoracoscopy (Fig. 7-33). The nodes can vary in appearance from large but otherwise normal to grossly distorted neoplastic masses. Biopsy specimens can be obtained (Fig. 7-34) when the lymph nodes are enlarged, and lymph node removal can be performed with minimally invasive technique.

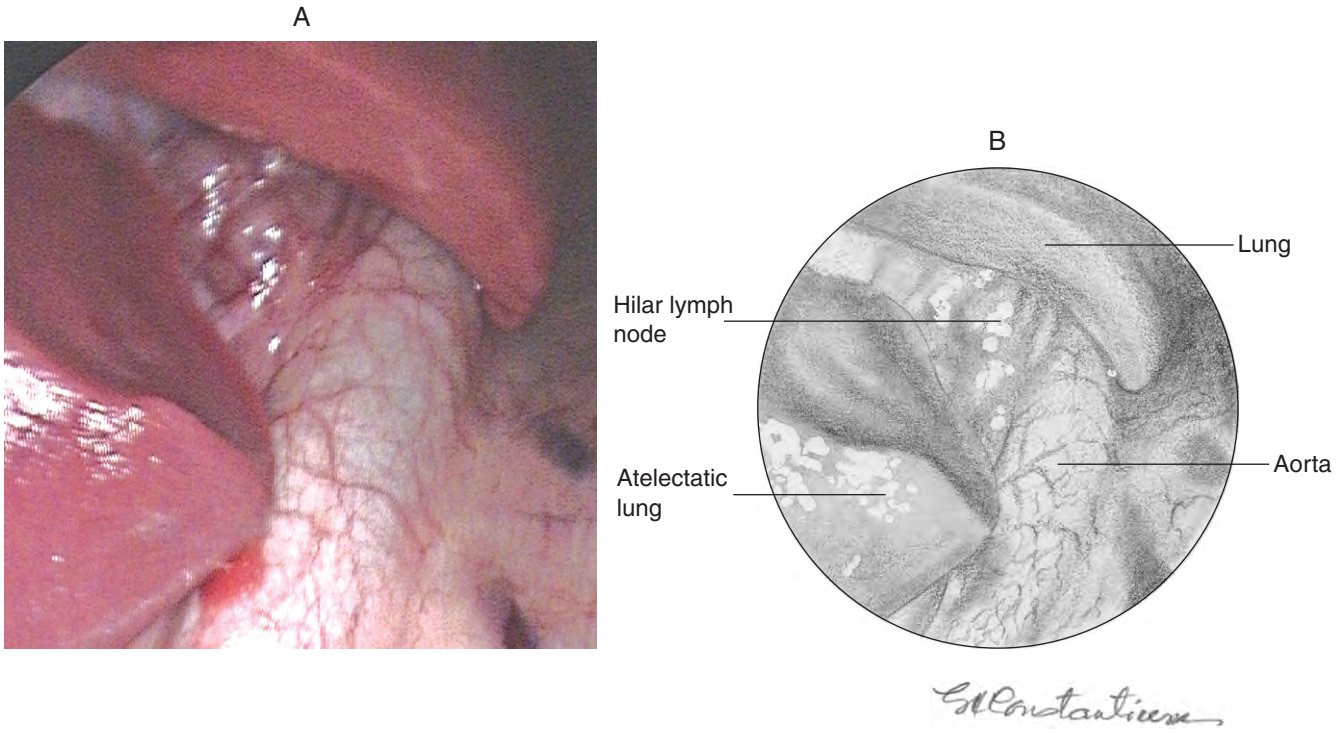



**Fig. 7-33**
Enlarged hilar lymph nodes in a dog.

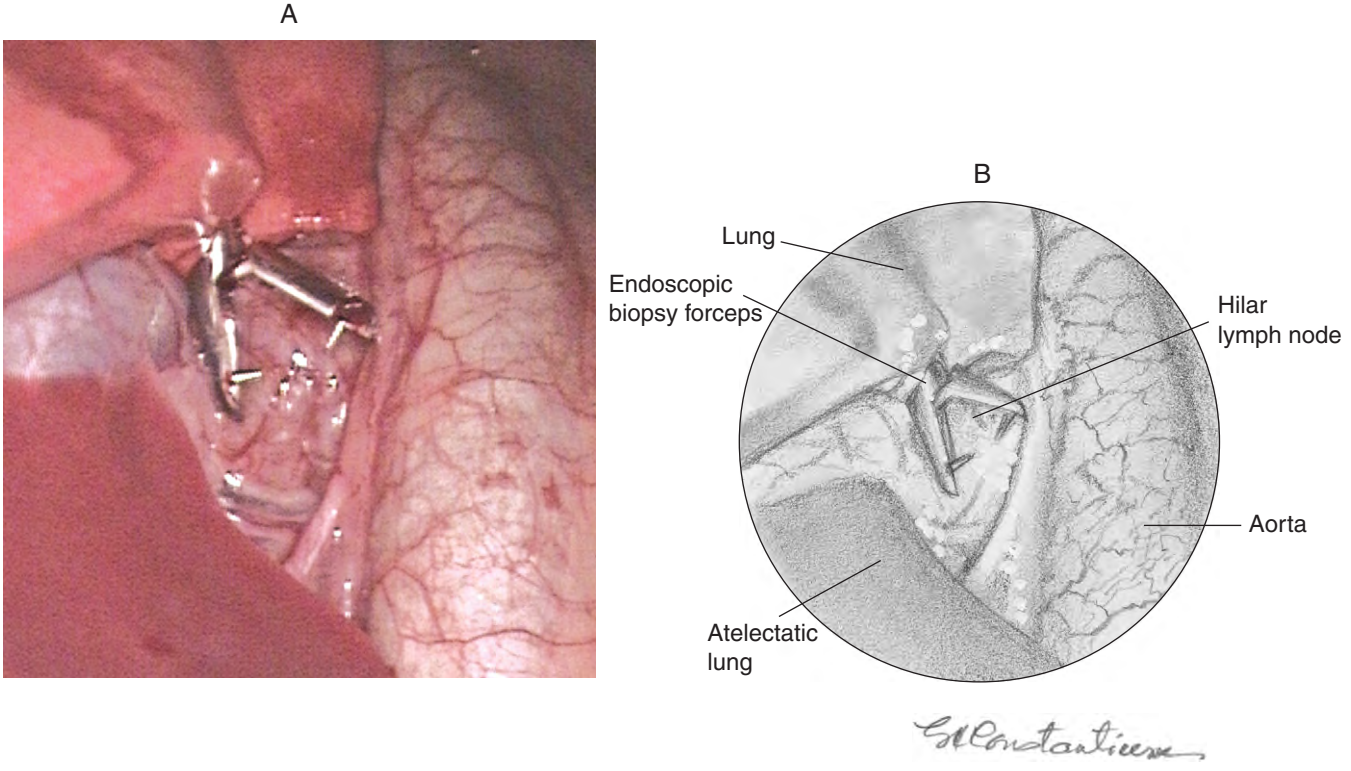



**Fig. 7-34**
Obtaining biopsy specimens from enlarged hilar lymph nodes in the case in Fig. 7-33.

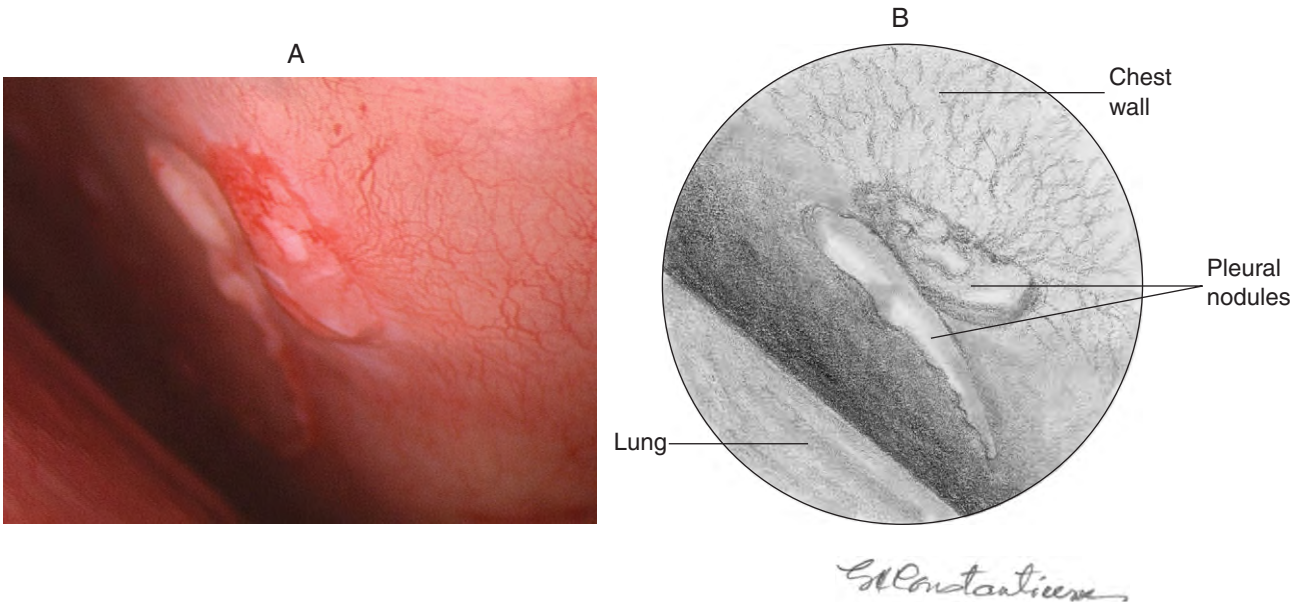



**Fig. 7-35**
A submacroscopic pleural lesion in a dog with pericardial and pleural effusion. Histopathology revealed aggregates of macrophages containing hemosiderin and reactive mesothelial cells.

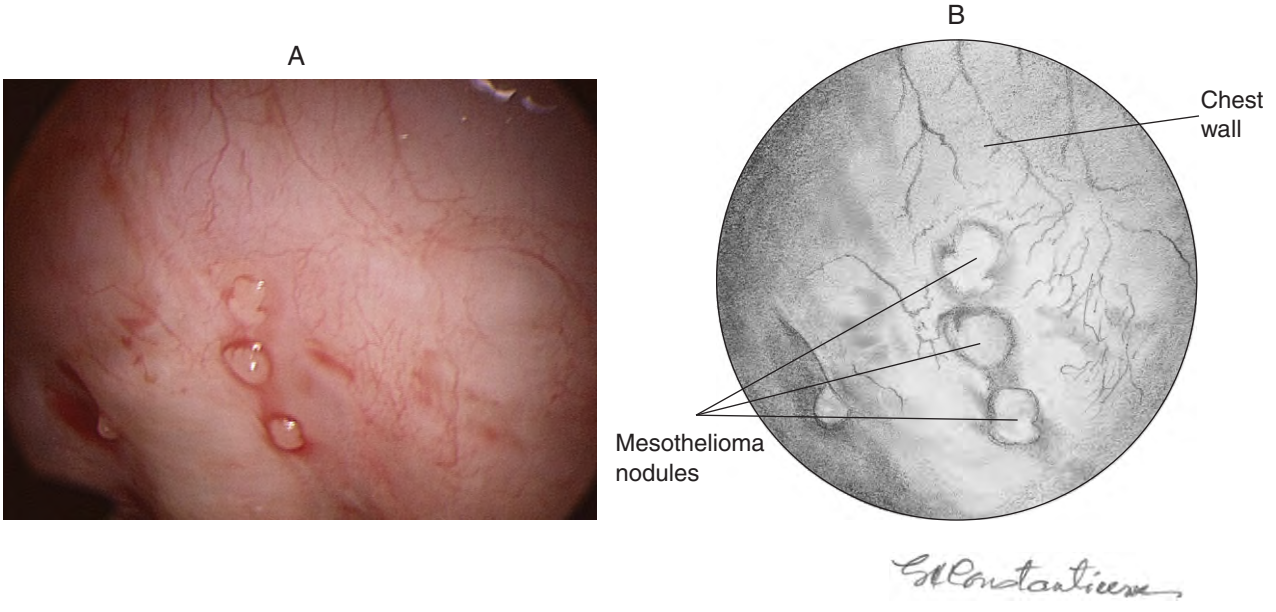



**Fig. 7-36**
Multiple submacroscopic pleural nodules in a dog with chronic pleural effusion. Biopsy specimens were obtained to diagnose mesothelioma.

## Pleural Effusion

The oldest indication for thoracoscopy is pleural effusion.[1] Samples of the fluid can be collected for cytology, analysis, and cultures. Pleural lesions can be evaluated and selectively biopsied to diagnose or rule out neoplasia (Figs. 7-23, 7-26, 7-35, and 7-36). Diagnostic accuracy of thoracoscopy for pleural effusion secondary to neoplasia approaches 100%.[1] Thoracic duct anatomy and integrity can be evaluated in cases with chylothorax (Fig. 7-37), the extent of constrictive pleuritis determined (Fig. 7-38), and parietal pleural fibrosis assessed (Fig. 7-39). Pleural fluid loculation can be differentiated from solid tissue masses,

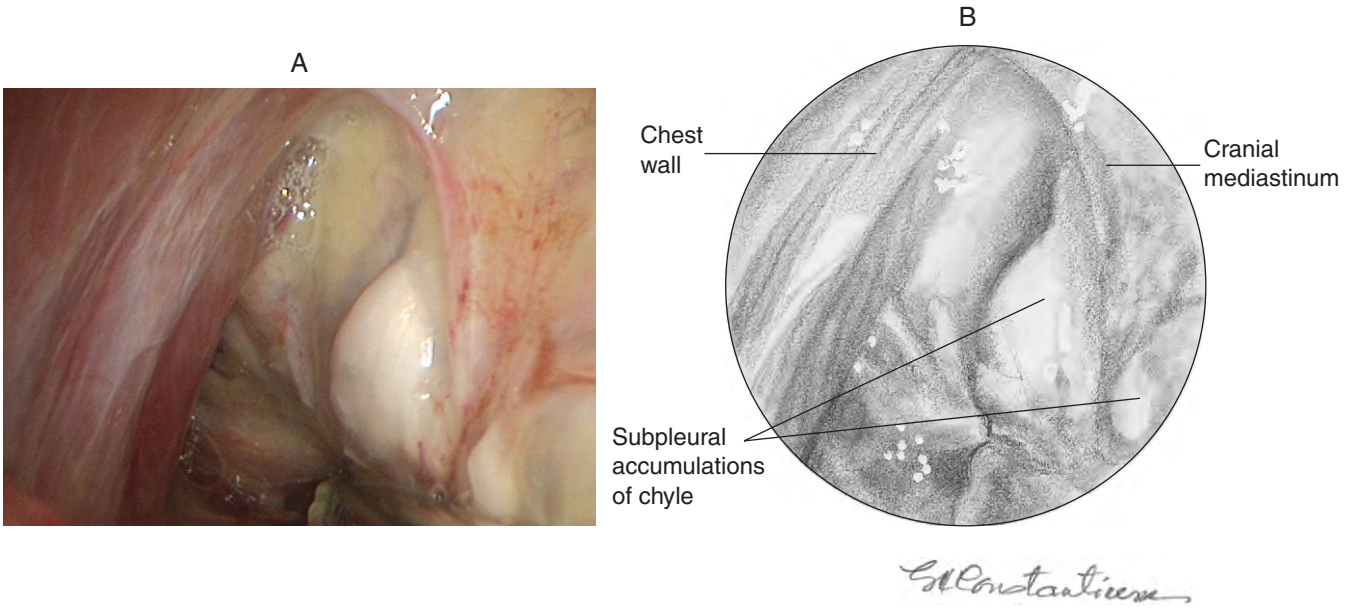



**Fig. 7-37**
Chyle trapped under the pleura in the cranial mediastinum of a cat with chronic chylothorax caused by constrictive pericarditis.

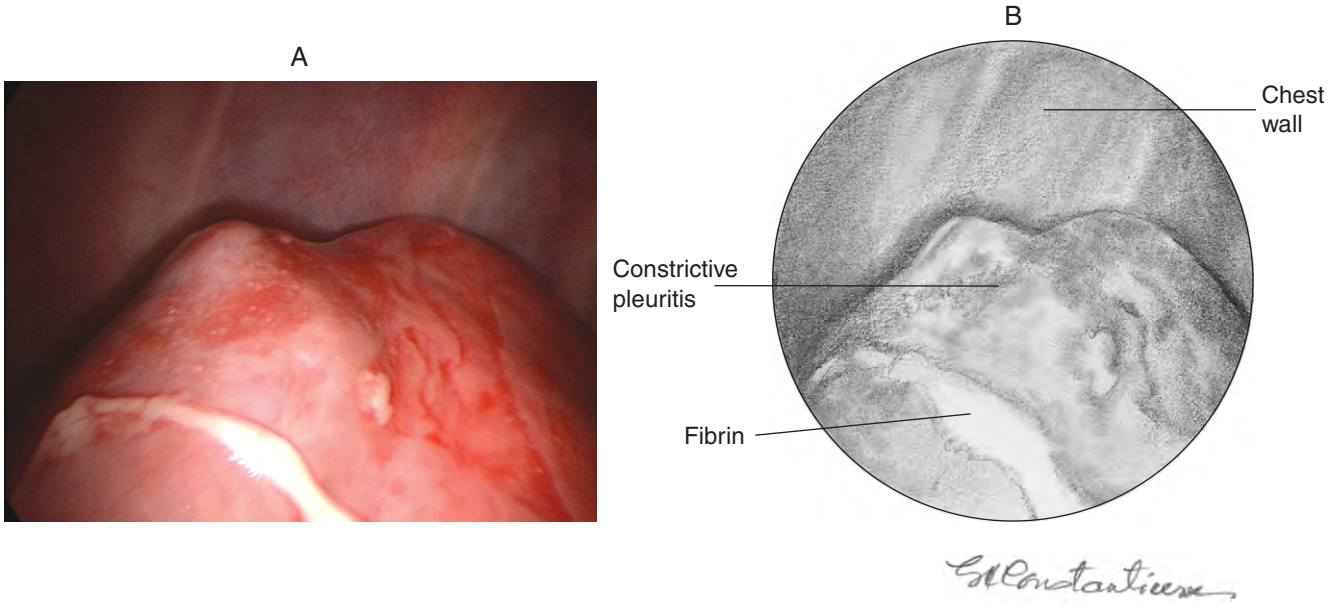



**Fig. 7-38**
Constrictive pleuritis causing lung collapse in a cat with chronic chylothorax.

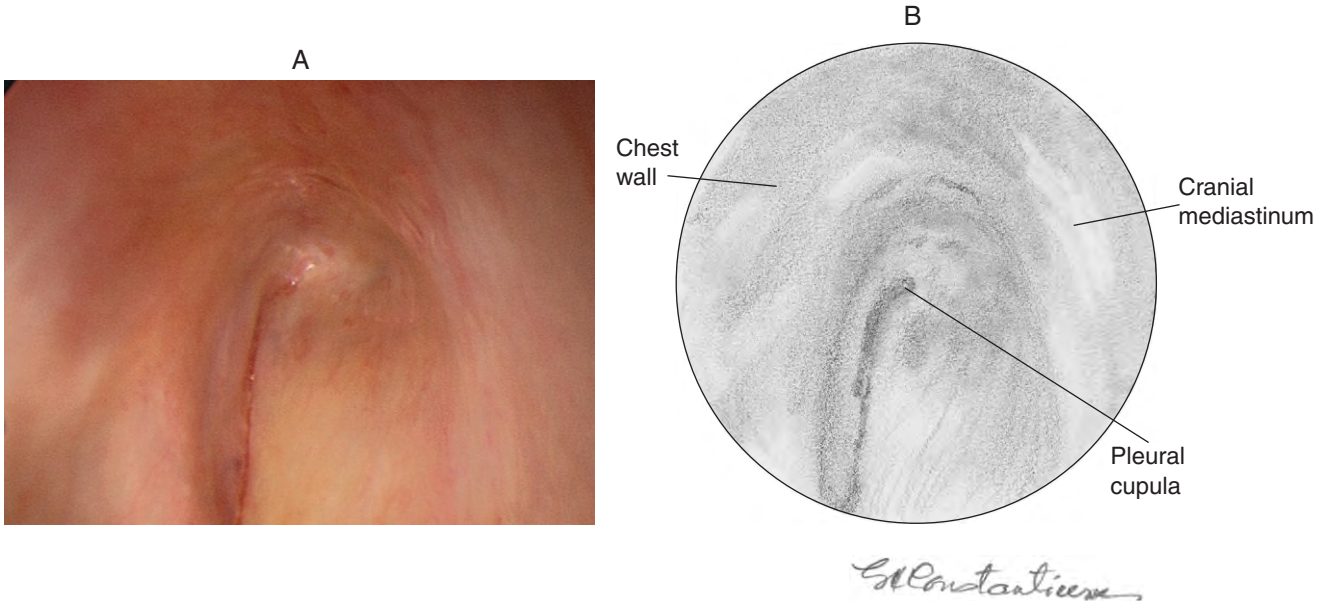



**Fig. 7-39**
Marked parietal pleural fibrosis in the left cranial thorax of the cat in Fig. 7-38 with chronic chylothorax.

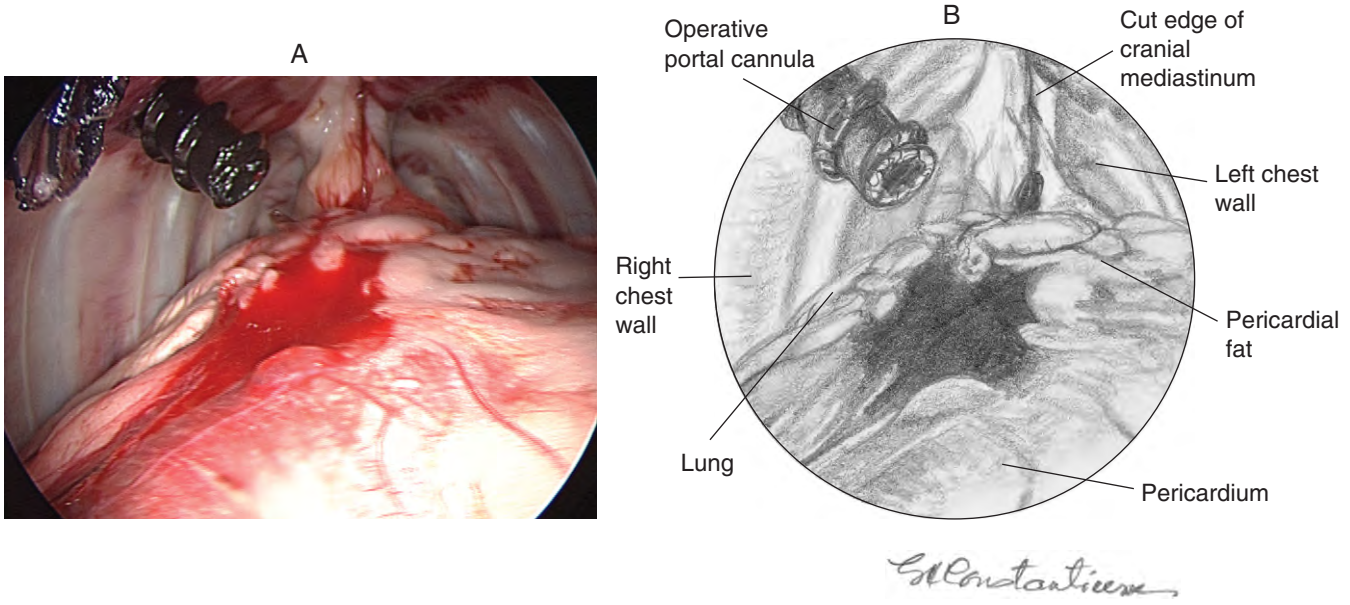



**Fig. 7-40**
An enlarged distended pericardium in a dog with pericardial effusion caused by metastatic hemangiosarcoma from a primary in the spleen.

and fluid cavities and adhesions can be broken down under direct visualization to allow more complete fluid removal.[27] Thoracic duct occlusion and pericardectomies can be performed with minimally invasive technique. Pericardiectomy has produced dramatic results in some cases of chylothorax with complete resolution of fluid production.[29] Efficacy of pericardiectomy is currently being evaluated for treatment of chylothorax in cats and in dogs.

## Pericardial Effusion

Establishing permanent pericardial drainage by creating a pericardial window is a highly effective treatment for pericardial effusions.[4,5] The large, distended pericardial sac can be examined and defined effectively by thoracoscopy (Fig. 7-40). Occasionally pericardial masses can be identified through the intact pericardium (Fig. 7-41). If there was inadequate evacuation of pericardial effusion

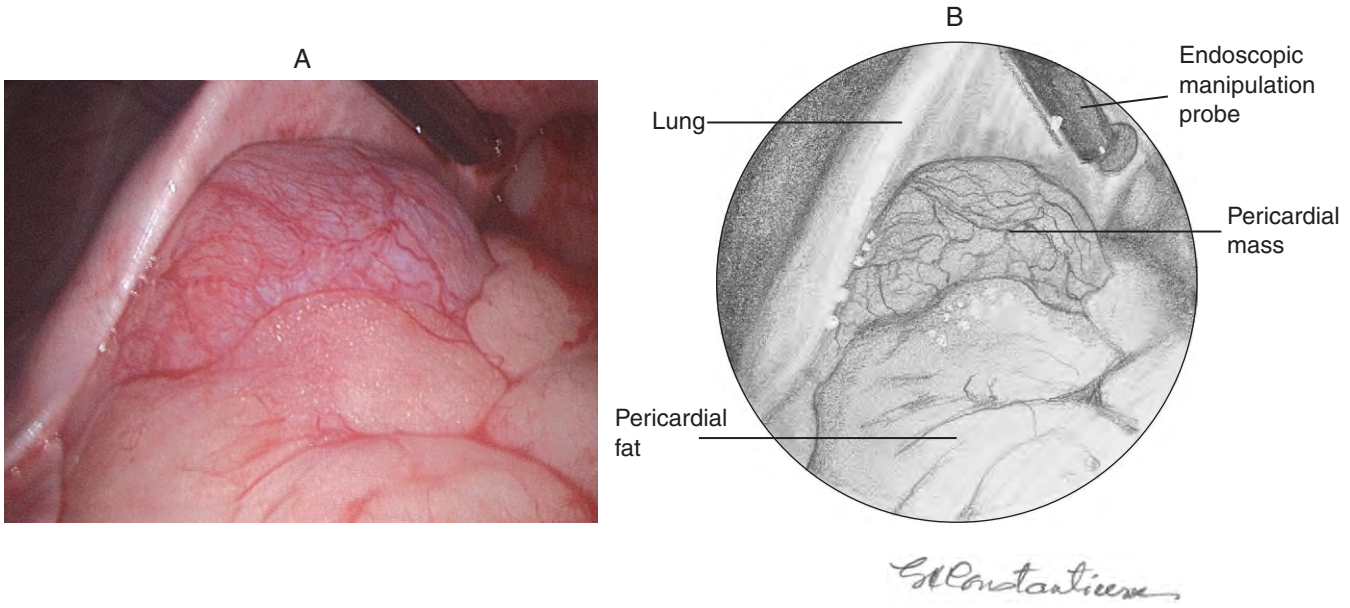



**Fig. 7-41**
A heart base mass visible through the intact pericardium in a dog with pericardial effusion.

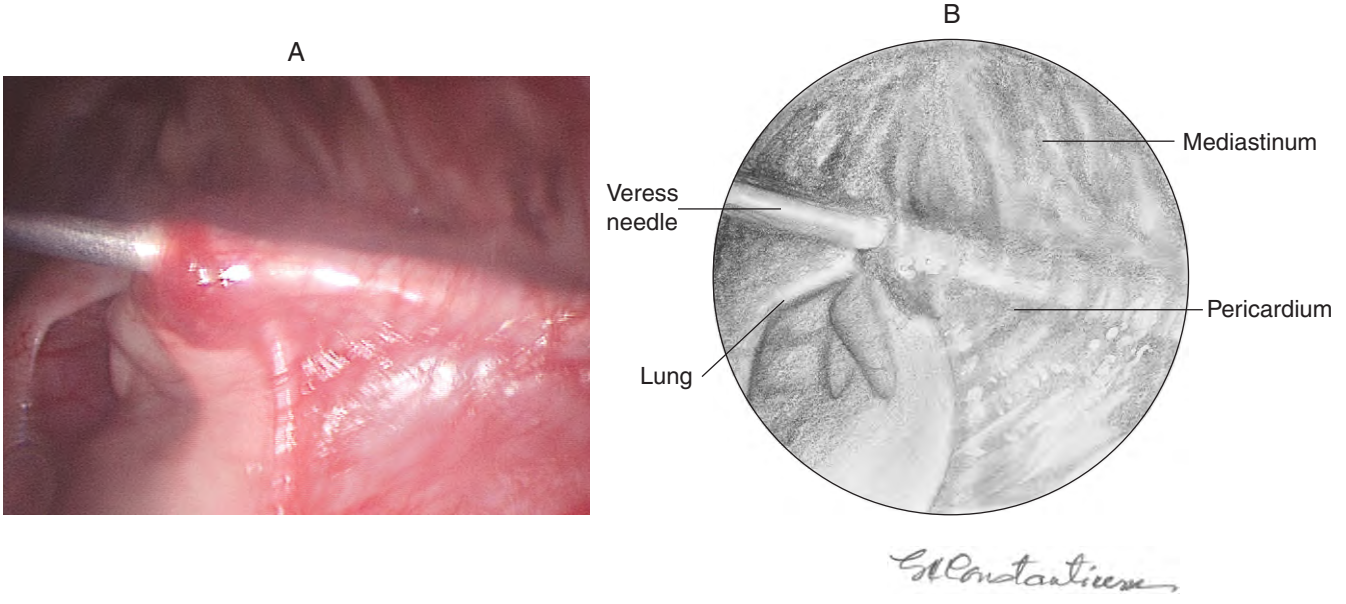



**Fig. 7-42**
Veress needle draining pericardial effusion under thoracoscopic guidance.

before thoracoscopy, the pericardium can be tapped or catheterized and drained under direct visualization (Fig. 7-42). A pericardial window can then be created on the anterior surface of the heart by removal of a 2- to 3-cm square patch of pericardium (Fig. 7-43). A pericardial window allows continued drainage that prevents recurrent cardiac tamponade and can be a definitive treatment for pericarditis or a highly effective palliative management for neoplastic processes within the pericardium. The operative procedure to create a pericardial window requires only slightly more than diagnostic instrumentation and technique.[1,10,17,24,28] The removed portion of pericardium is also available for diagnostic biopsy and culture. Extension of thoracoscopy into the pericardium, or

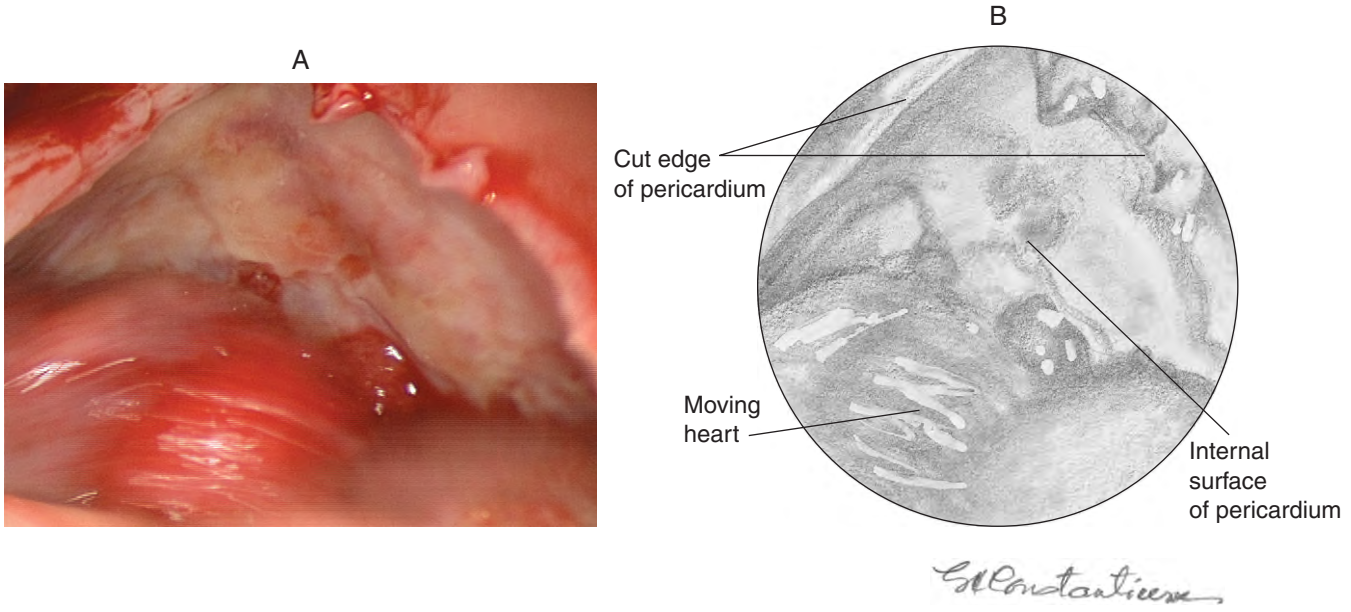



**Fig. 7-43**
Completed pericardial window in a dog with chronic pericarditis.

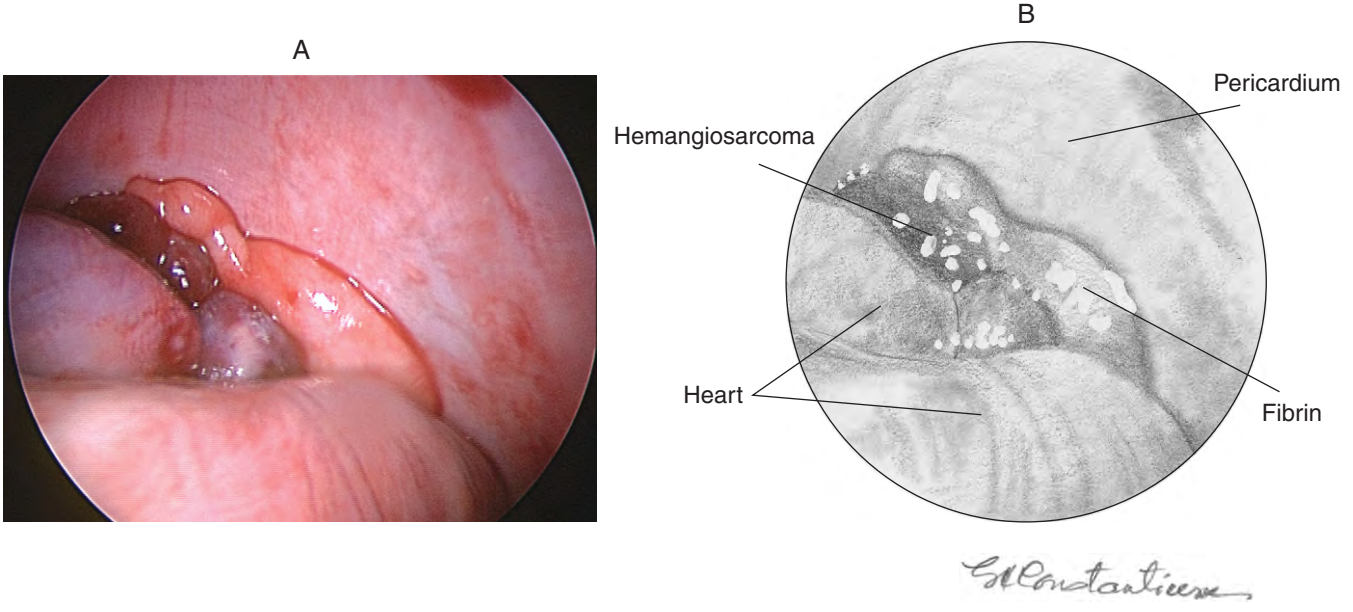



**Fig. 7-44**
A heart base mass visualized through a pericardial window. Biopsy specimens were obtained and revealed the mass to be a hemangiosarcoma.

pericardioscopy, can be used for visualization and biopsy of intrapericardial masses (Figs. 7-44 and 7-45). Complete examination of the heart base is difficult from the paraxiphoid approach, but reasonable visualization can be achieved and is increasing with increased experience.

## Diaphragmatic Hernia

The diaphragm can be visualized effectively with thoracoscopy and its integrity assessed.[28,30] Soft tissue densities in the caudal mediastinum evaluated by thoracoscopy have been found to be diaphragmatic hernias with omental or organ herniation (Fig. 7-46).

## Primary Pulmonary Disease

Diagnostic sensitivity for diffuse pulmonary disease is greatly increased when thoracoscopy is used to obtain large lung biopsy specimens (Fig. 7-47).[1,8,11,28,31] The diagnostic yield of thoracoscopy surpasses needle aspiration,

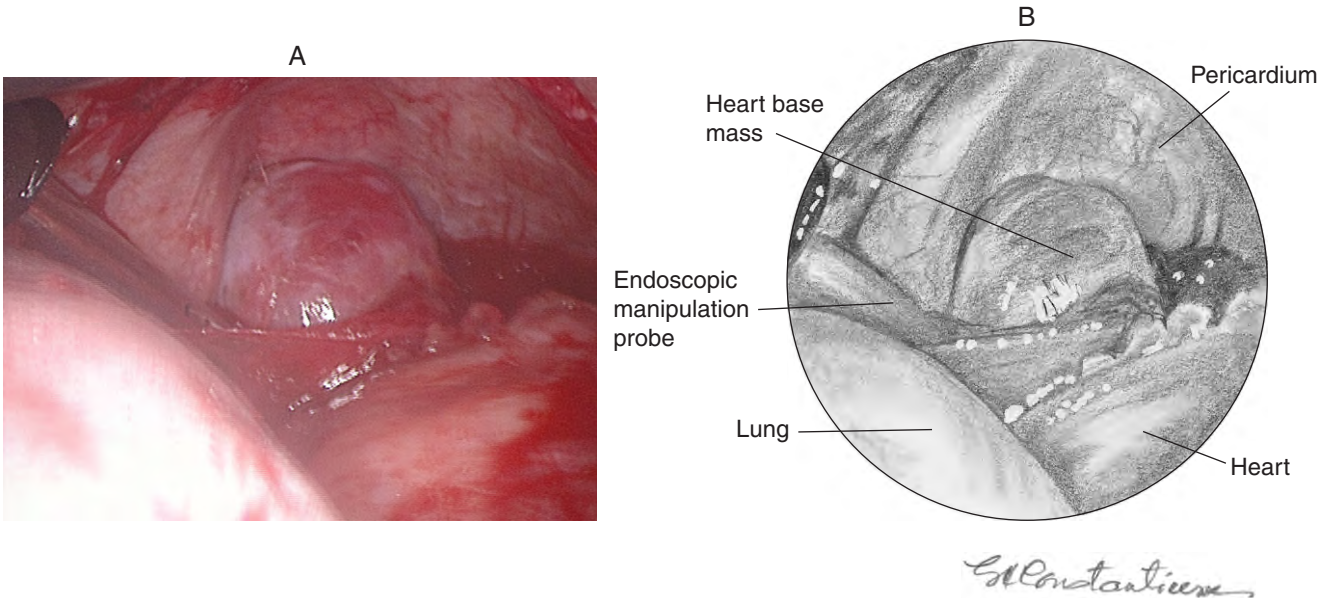



**Fig. 7-45**
A heart base mass visualized through a completed pericardial window.

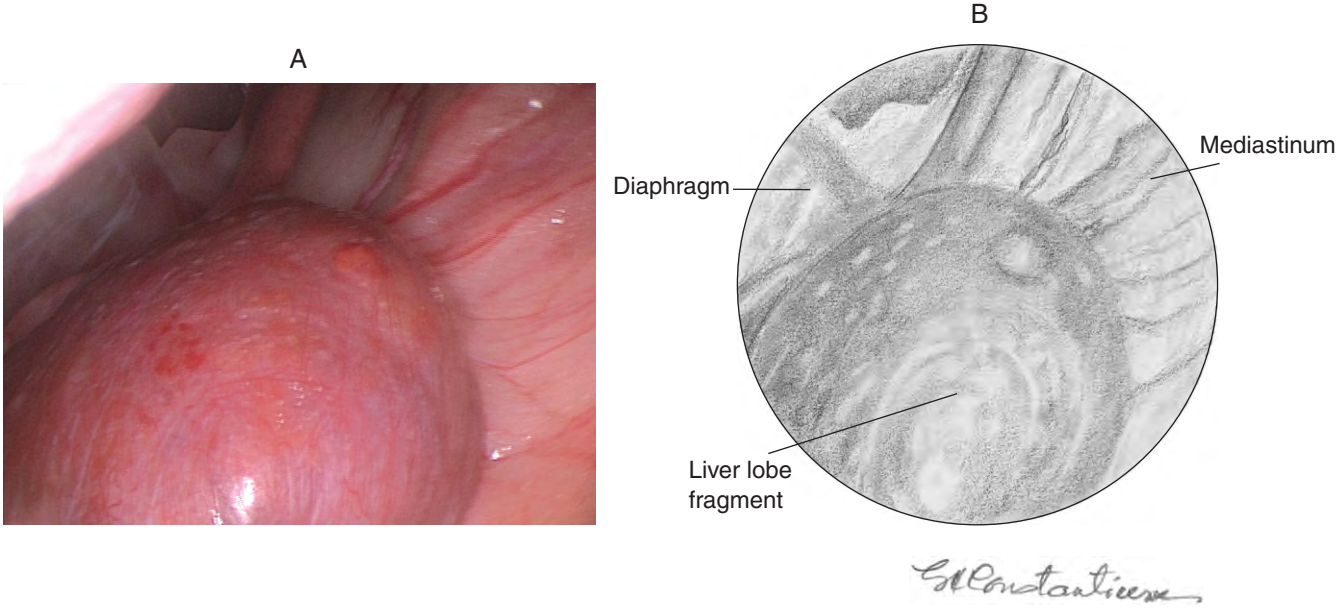



**Fig. 7-46**
A portion of liver lobe in the chest of a dog with chronic diaphragmatic hernia that presented with pericardial effusion.

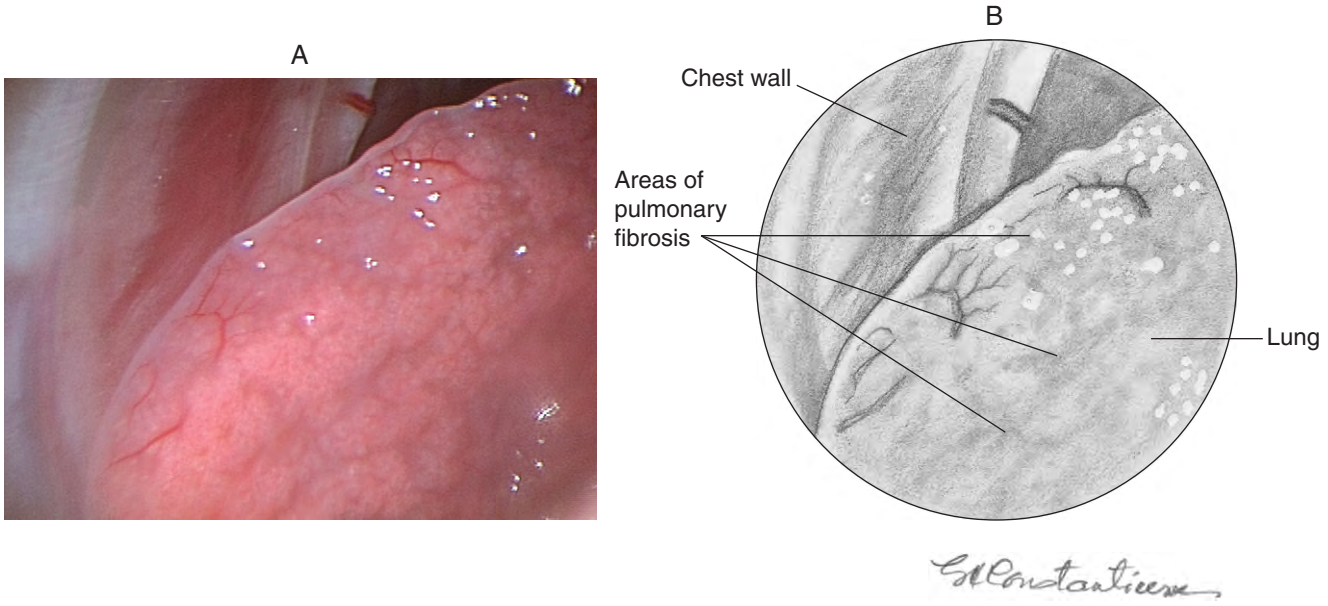



**Fig. 7-47**
Pulmonary fibrosis in a cat with chronic respiratory disease.

brush cytology, and transbronchial biopsy.[1] An adequate portion of lung can be obtained to allow histopathologic evaluation of parenchymal disease and pulmonary architecture.[1,8,11] Biopsy specimens of pulmonary tissue can be obtained with biopsy forceps (either apposing cup or punch types), Tru-Cut biopsy needles, wedge or apical resections with endoscopic staplers, or apical resections with pretied ligature loops.* Minimally invasive partial or complete lung lobectomies can be used to manage intractable pneumonia, lung abscess, and primary lung tumors.

## OPERATIVE PROCEDURES (Box 7-4)

### Pericardial Window

Creation of a window in the pericardium establishes permanent drainage for patients with pericardial effusion.[4,5] This technique is minimally invasive with greatly reduced operative trauma and postoperative pain.[32] Indications for permanent pericardial drainage include neoplastic effusions, hemorrhage from neoplastic masses, inflammatory disease, and idiopathic effusions. This procedure prevents cardiac tamponade in the future by allowing drainage of pericardial fluid into the pleural space. Results with this procedure are excellent, with long-term resolution in cases of idiopathic or inflammatory disease and dramatic improvement in quality of remaining life in cases of neoplasia.

When performing a pericardial window, the patient is placed in dorsal recumbency and a paraxiphoid telescope portal is established. There are two options for placing operative portals. The first places both portals on the right side and the second places one portal on the right side and one on the left side. Each has advantages and disadvantages, with the choice between the two related mostly to the surgeon's preference. The first option places operative portals in the right fifth to seventh intercostal space and in the right ninth or tenth intercostal space (Fig. 7-48). The second option places portals in the left and right ninth to tenth intercostal spaces (Fig. 7-49). All portals are

**Box 7-4 Operative Thoracoscopy Procedures**

Partial lung lobectomy
Lung lobectomy
Pericardial window
Subtotal pericardiectomy
Thoracic duct occlusion
Persistent right aortic arch correction
Hilar lymph node excision
Mediastinal mass excision
Foreign body removal

*References 8, 10, 11, 15, 17, 27, 28.*

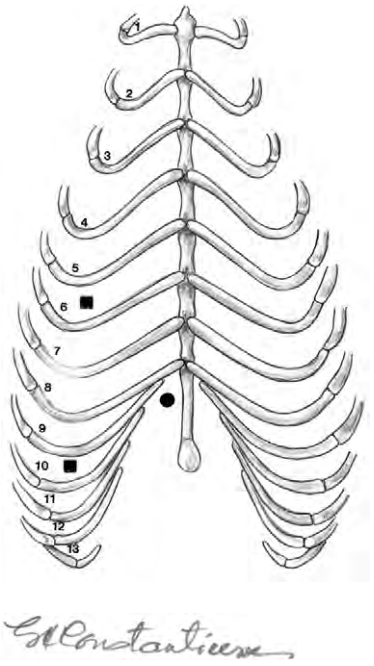



**Fig. 7-48**
Portal sites for performing a pericardial window with the patient in dorsal recumbency—a paraxiphoid telescope portal (*circle*), and both operative portals (*squares*) on the right side of the chest.

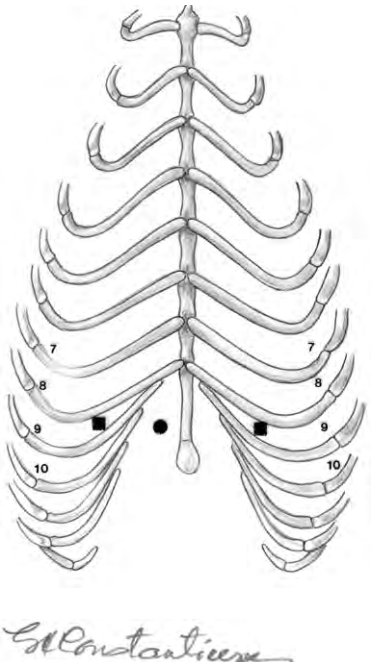



**Fig. 7-49**
Portal sites for performing a pericardial window with the patient in dorsal recumbency—a paraxiphoid telescope portal (*circle*), and operative portals (*squares*) on the right and left sides of the chest.

placed ventral to the costochondral junction in the area of the lateral margin of the transverse thoracic muscles. The surgeon stands on the right side of the patient for the first technique and on either side of the patient for the second technique. The telescope operator stands at the foot of the patient or across the patient from the surgeon. Placing the patient obliquely, slightly to the left 10 to 15 degrees can facilitate visualization and manipulation when both portals are placed on the right side.

A lateral intercostal approach can also be used as an alternative with the patient placed in left lateral recumbency. This approach allows better visualization of the right atrial appendage and aortic root for evaluation of tumor masses. The telescope portal is placed in the ventral third of the sixth or seventh intercostal spaces and two instrument portals are placed, one at the midpoint of the fourth intercostal space and the other at the midpoint of the eighth intercostal space (Fig. 7-50). With this technique, the pericardial window is created on the right side of the heart. The phrenic nerve is identified before incising the pericardium.

With all portals in place, the first step of the procedure is to cut the ventral mediastinum off of the sternum to get it out of the visual and manipulative field. Scissors are used to cut the mediastinum with electrosurgical assistance for

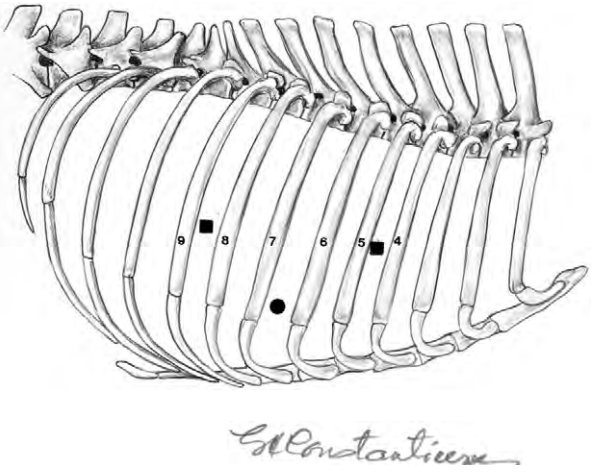



**Fig. 7-50**
Portal sites for performing a pericardial window with the patient in left lateral recumbency—a lateral intercostal telescope portal (*circle*) and operative portals (*squares*) on the right side of the chest.

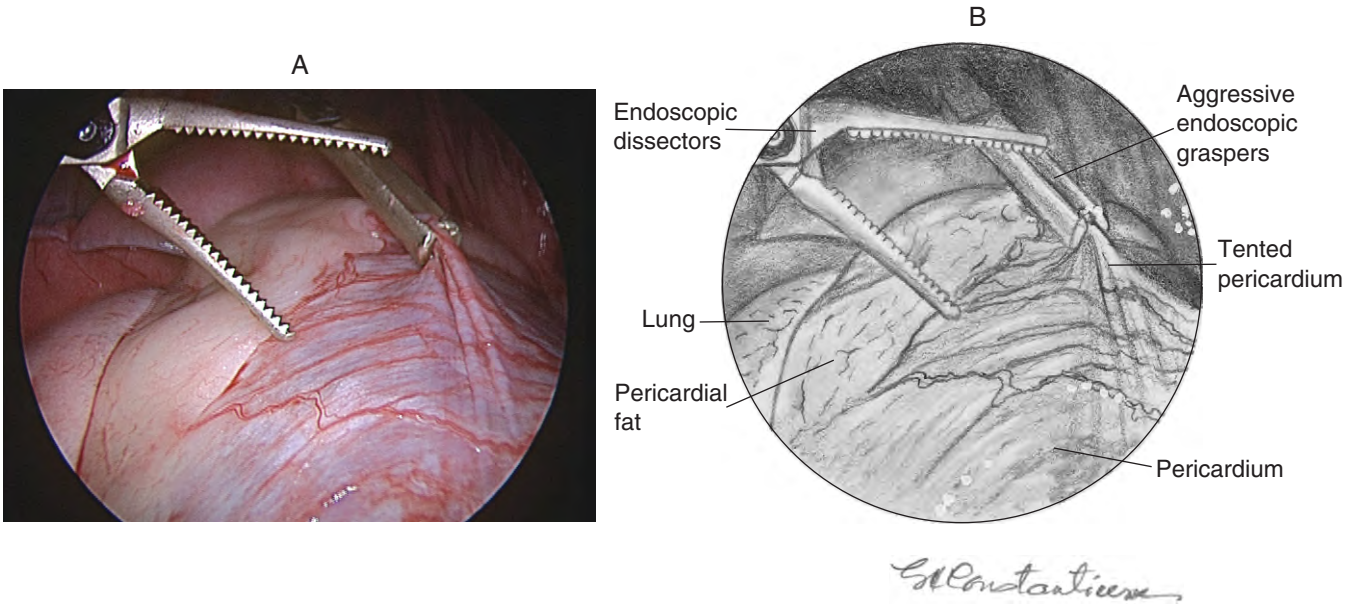



**Fig. 7-51**
Starting a pericardial window by lifting a fold of pericardium away from the heart to minimize the potential for cardiac damage. Aggressive endoscopic tissue graspers are used to grasp and elevate the pericardium. The open dissectors were used to assist in grasping the pericardium and were then removed.

control of bleeding. Inadequate control of bleeding from the mediastinal vessels interferes with the procedure by allowing blood to drip onto the telescope and obscure visualization. It is recommended to explore the cranial mediastinum for lymph node enlargement and to biopsy any suspicious lymph nodes. Biopsy of cranial mediastinal lymph nodes may establish a diagnosis of mesothelioma that may not be diagnosed with biopsies of the pericardium.

A site is selected for the pericardial window on the cranial surface of the heart. When the pneumothorax is established with the patient in dorsal recumbency, the apex of the heart falls dorsally, presenting the cranial surface of the heart to the surgeon rather than the apex that would be seen without the pneumothorax present. Babcock forceps or aggressive grasping forceps with teeth are used to pick up a fold of pericardium (Fig. 7-51) and Metzenbaum scissors are used to cut into this elevated fold of tissue (Fig. 7-52) for initial penetration of the pericardium. This technique minimizes the potential for cardiac damage. The graspers are repositioned to pick up a margin of the initial pericardial incision (Fig. 7-53). Any excess pericardial fluid that has not been previously evacuated and that interferes with visualization is removed with suction. The pericardial incision is extended to remove a patch of pericardium (Fig. 7-54), taking care not to damage the phrenic nerves, heart, lungs, or great vessels. There is no scientific data to define how much pericardium to remove. The portion removed needs to be large enough to prevent closure of the defect by the healing process and small enough to preclude herniation of the heart through the window. A 1-inch-square patch is an acceptable size. The removed patch is extracted from the chest through one of the operative portals and is inspected for size and to define pathology. Samples are submitted for histopathology and culture.

The internal surface of the pericardium (Figs. 7-27 and 7-43) and a variable area of the heart can be examined through the window. Masses are found on the heart base (Figs. 7-44 and 7-45), on the aorta (Fig. 7-55), and on the internal surface of the pericardium (Fig. 7-27).

Any residual pericardial and pleural fluid is removed with suction and the cavities are irrigated with saline. Operative portal cannulae are removed and the portals closed in layers to achieve an airtight closure. A standard lateral wall chest drain tube is placed with routine technique away from all of the portal sites. Placement of the tube through the chest wall and position of the tube within the chest can be controlled with endoscopic guidance. An alternative technique that is acceptable when pleural evacuation is needed for 24 hours or less places the tube through the paraxiphoid telescope portal. The telescope is removed, leaving the cannula in place, a chest tube is passed through the cannula, and the cannula is removed over the chest tube. Closure of deep tissues, subcutaneous tissues, and the skin achieves an airtight seal around the tube. This technique is only acceptable at the paraxiphoid

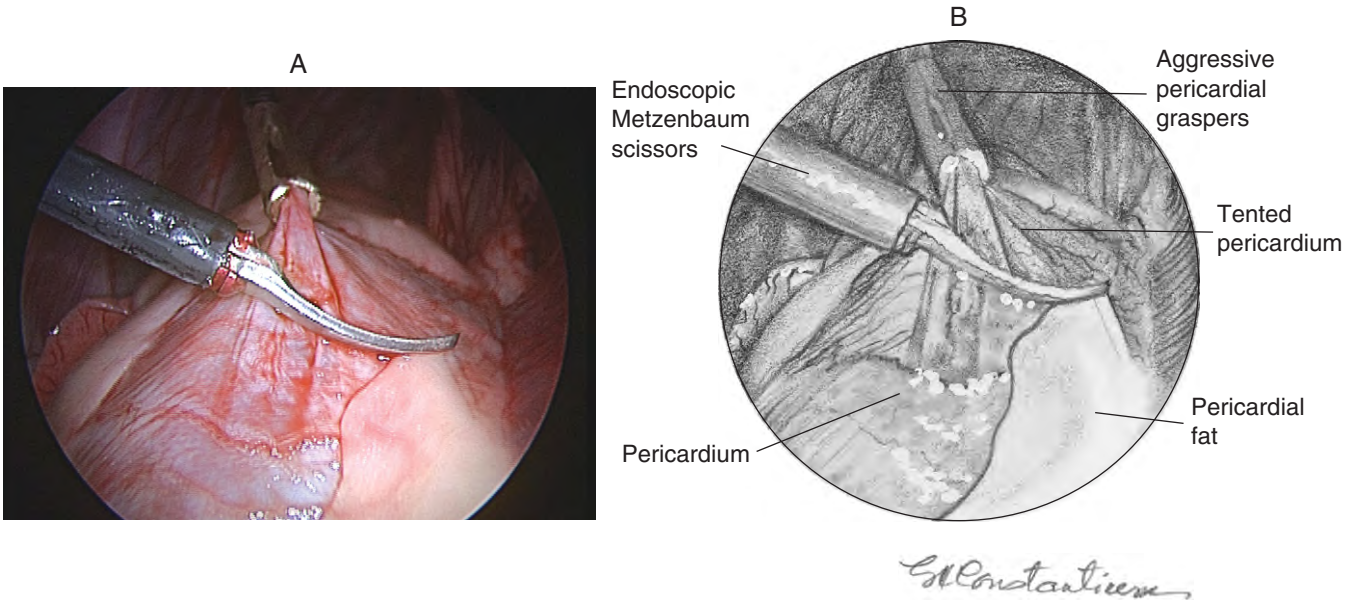



**Fig. 7-52**
The fold of tissue is cut with Metzenbaum scissors to penetrate the pericardium.

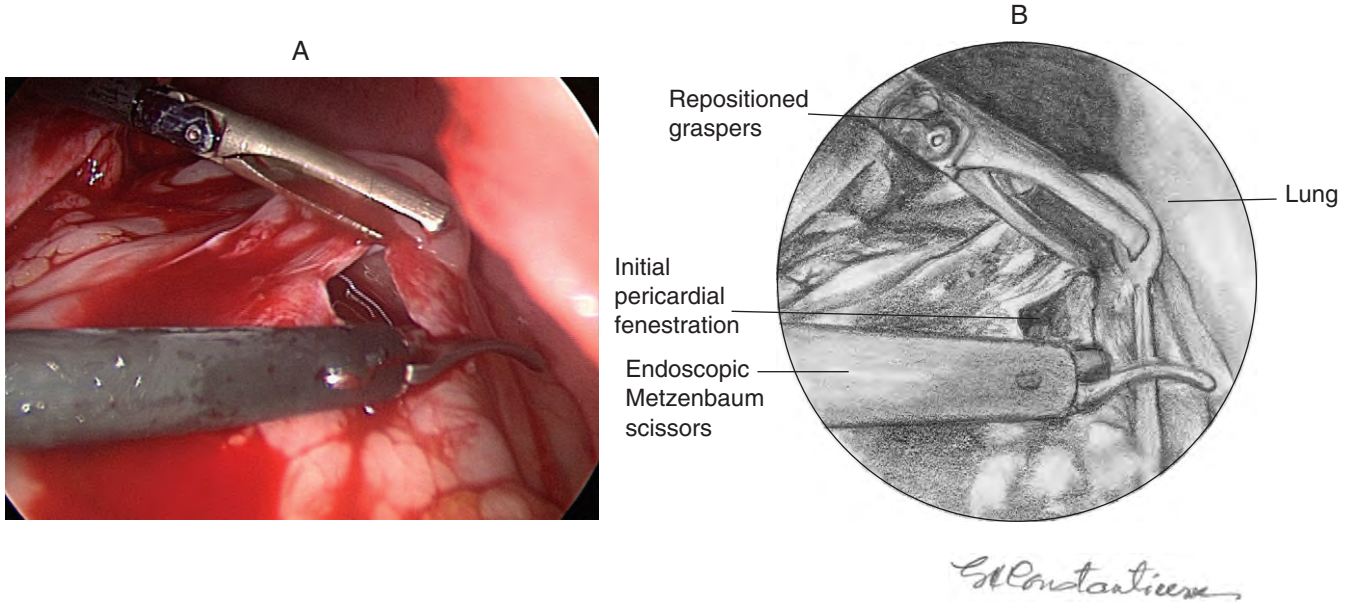



**Fig. 7-53**
After the pericardial window cut is started, the graspers are repositioned to pick up the cut edge of the pericardium and the incision is enlarged with Metzenbaum scissors and electrocautery. The incision is extended in both directions to create a flap of pericardium.

site and for tubes that will be in place for less than 24 hours. This technique is not acceptable for lateral chest wall portals or for long-term chest tubes because it is difficult to achieve an airtight seal and there is an increased risk of air leakage around the chest tube.

## Subtotal Pericardiectomy

The primary indication for subtotal pericardiectomy is constrictive pericarditis. Pericardiectomy may also be indicated for infectious processes or neoplasia involving an extensive area of the pericardium. The dissection for pericardiectomy

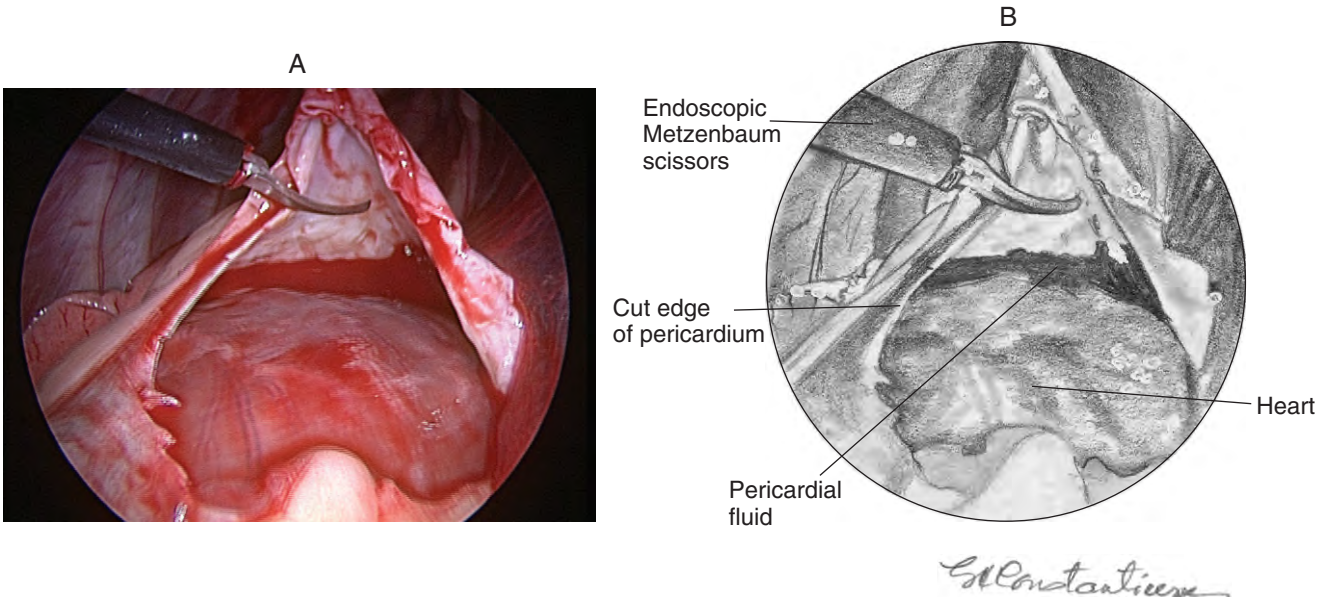



**Fig. 7-54**
The pericardial flap is enlarged to remove an approximately 1-inch-square portion of the pericardium.

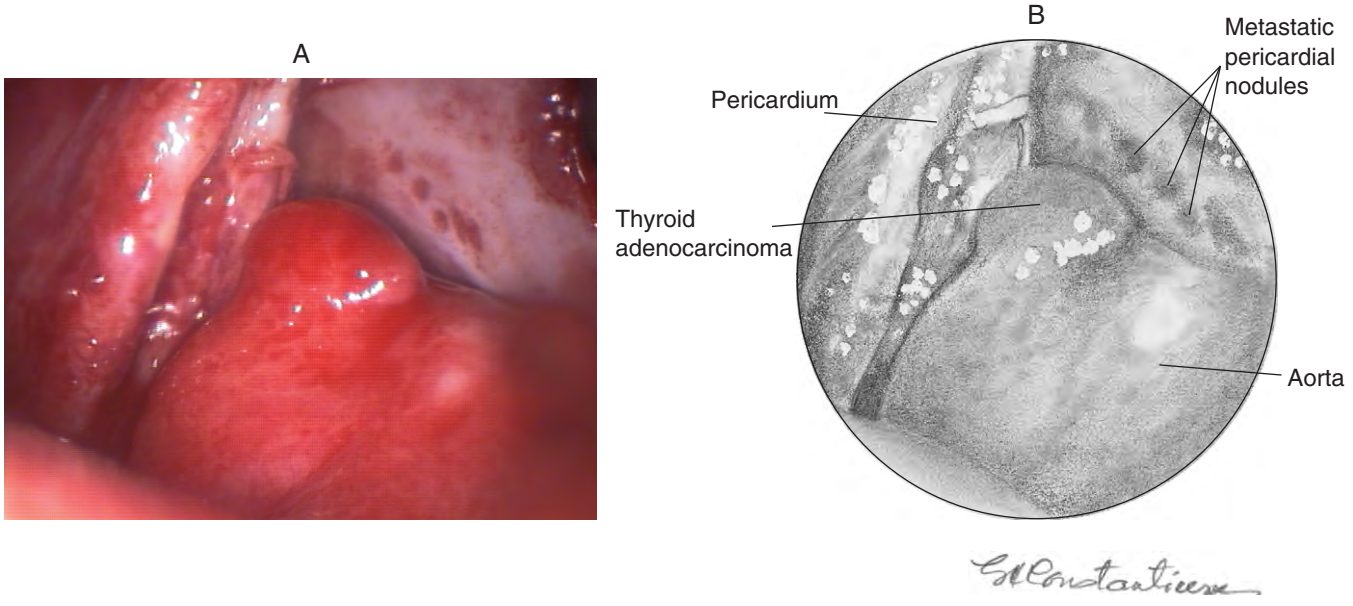



**Fig. 7-55**
A metastatic thyroid adenocarcinoma on the aorta in a dog that presented with a pericardial effusion.

is much more difficult than for creating a pericardial window and is therefore not indicated for management of pericardial effusion. Patient positioning is dorsal recumbency and portal placement is the same as for the pericardial window procedure, but two sets of portals may be required on each side of the chest for completion of dissection.[5,17] The phrenic nerves are identified before incising the pericardium (see Figs. 7-8 and 7-13). Pericardial excision is started with the same technique as for creating a pericardial window, but the pericardial incision is extended as far cranially and dorsally as possible and then circumferentially in each direction from the cranial end of the initial incision. The circumferential pericardial incision is kept ventral to the phrenic nerves in most cases. If indicated, the phrenic nerves can be elevated off of the pericardium to allow resection of more pericardium than can be accomplished if the incision is kept ventral to the nerves. Electrosurgical assistance is used as needed for hemostasis. Portal closure, chest tube placement, and postoperative management are the same as for a pericardial window.

## Partial Lung Lobectomy

Lung biopsy for chronic lung disease (see Fig. 7-47); excision of lung masses (see Fig. 7-18), lung abscesses, and emphysematous bullae (see Figs. 7-28, 7-30, and 7-31); or removal of any other localized disease process in the peripheral portions of the lung lobes can be performed quickly and effectively with minimally invasive technique. Portal placement for partial lung lobectomy is dictated by the location of the lung to be removed. Dorsal recumbency and the paraxiphoid telescope portal allow examination of both sides of the chest when the side of the pathology cannot be determined such as with spontaneous pneumothorax. If the side of involvement can be determined preoperatively with radiographs or other diagnostic techniques, then lateral recumbency provides greater unilateral access and is the preferred position. The telescope and operative portals are inserted using appropriate triangulation to access the involved pathology. For small peripheral lesions (Fig. 7-56) and for lung biopsies, a loop ligature technique can be used. The tip of the lobe to be removed is positioned through a pretied loop ligature (Endoloop), the loop is tightened, the ligated portion of the lung is transected, and the resected portion of the lung is removed (Fig. 7-57). This technique is quick and easy, and saves the significant expense of an endoscopic stapler. Larger or more central lesions require an endoscopic GIA stapling device for occlusion and transection of the portion of the lobe to be removed (Fig. 7-58). When performing partial lung lobectomy with an endoscopic stapler, the telescope and operative portals are placed, the lung lobe lesion is defined and retracted or elevated as needed, and the endoscopic stapler is placed through an additional portal to provide optimal alignment for application of the stapler (Fig. 7-59). Because of the high cost of endoscopic staple cartridges, the longest staple cartridges (65 mm) are used to minimize the chance of needing to fire two cartridges. Following transection of the lung lobe, the excised portion is removed from the chest by enlarging one of the portals to allow passage of the tissue. An endoscopic tissue pouch (Endopouch) can be used to facilitate tissue removal. The transected lung margin is observed for air leakage or bleeding before exiting the chest with the telescope (Fig. 7-60). A chest drain is placed at a site away from all portals, operative and telescope cannulae are removed, and the portals are closed.

## Lung Lobectomy

Complete lung lobectomy can also be performed with minimally invasive technique.[15,17,23] Lung lobes with small masses that are away from the hilus of the lung can be removed with minimally invasive surgical technique. Large masses and masses that are too close to the hilus impair visualization of the structures of the hilus of the lung and make manipulation for dissection and stapler placement difficult. Lateral recumbency with intercostal portal placement is the preferred technique for complete lung lobectomy. Portal placement varies depending on the lung lobe to be removed and the shape of the thorax in the individual patient, but it is generally similar to the pattern for the intercostal approach to create a pericardial window (see Fig. 7-50). One-lung ventilation is

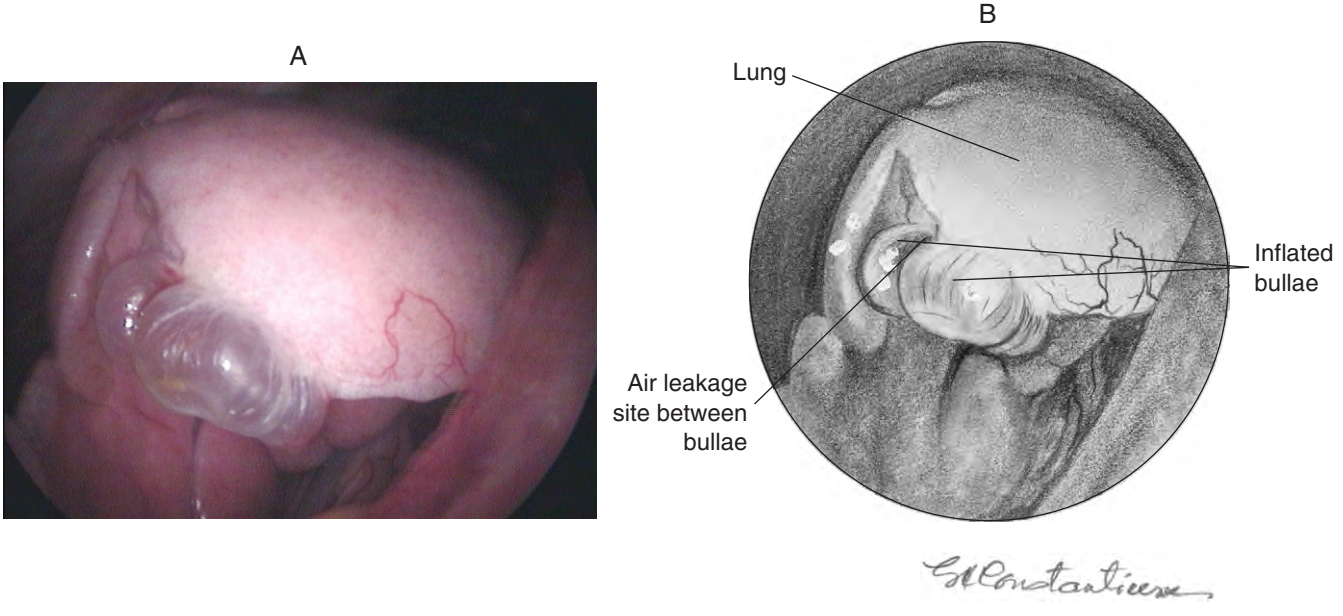



**Fig. 7-56**
Air-filled emphysematous bullae on the margin of the right middle lung lobe in a dog with spontaneous pneumothorax. The air leakage was from a ruptured bulla between the two visible, inflated bullae.

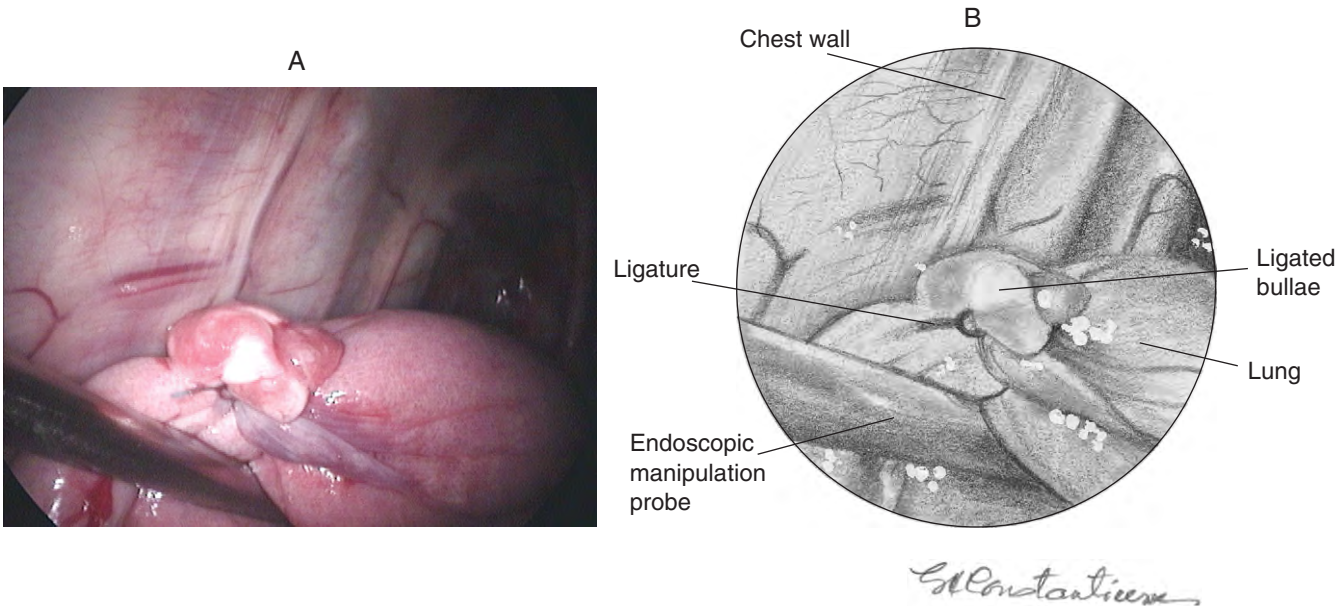



**Fig. 7-57**
The bullae in Fig. 7-56 were removed with minimally invasive technique using a pretied loop ligature.

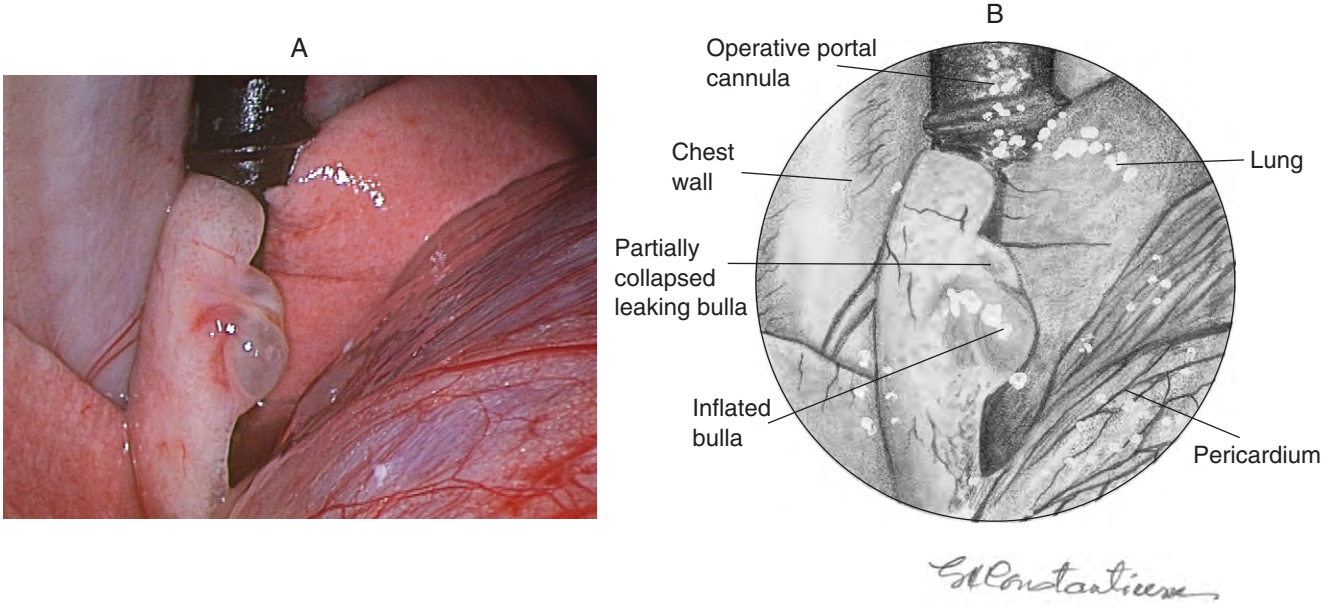



**Fig. 7-58**
A leaking collapsed bulla on the caudal margin of the right cranial lung lobe.

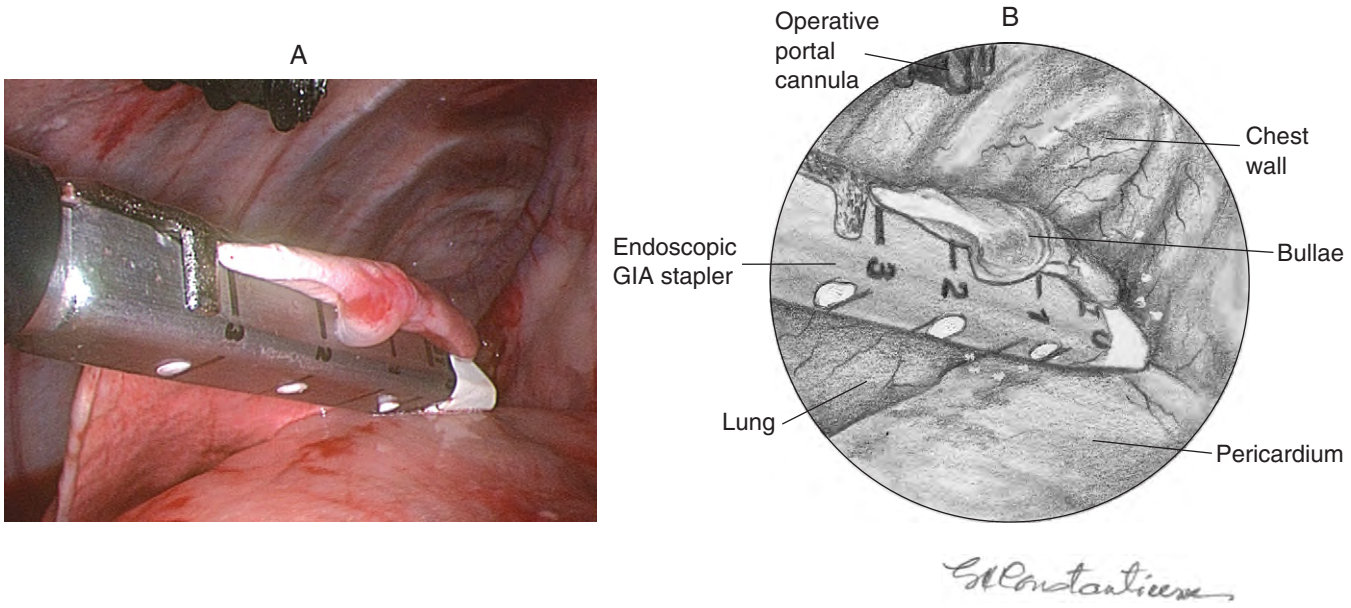



**Fig. 7-59**
An endoscopic gastrointestinal anastomosis stapler has been placed across the portion of the lung lobe containing the leaking emphysematous bulla seen in Fig. 7-58.

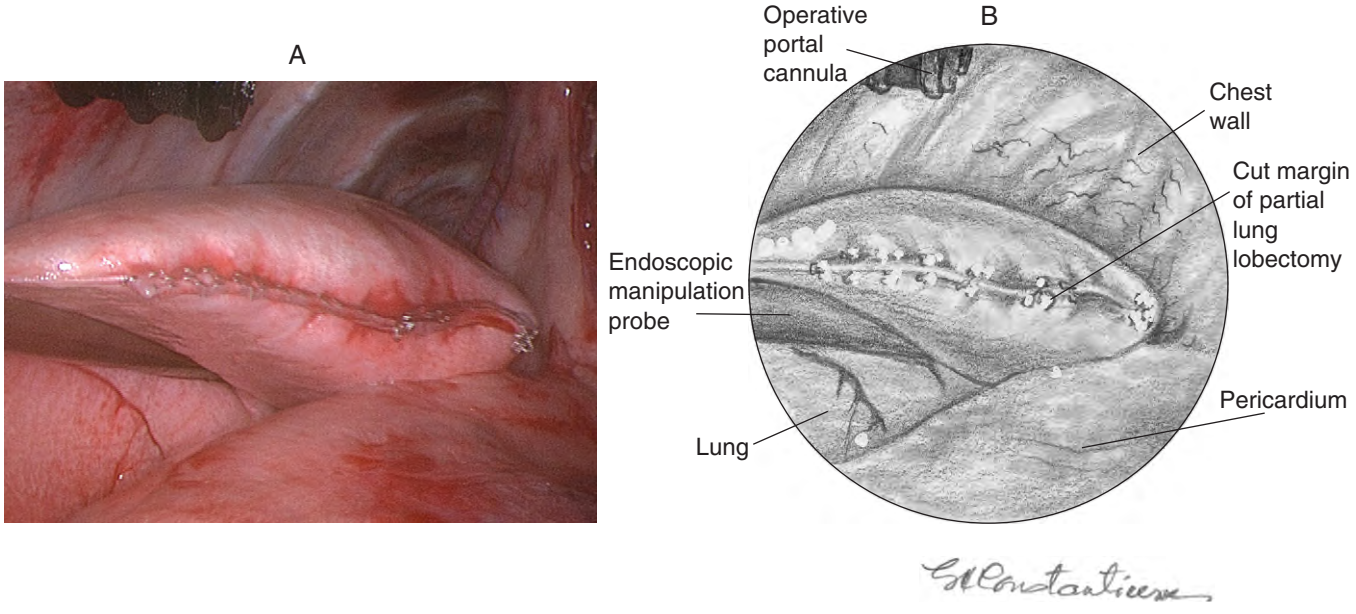



**Fig. 7-60**
The resection margin after partial lung lobectomy done with minimally invasive technique using the endoscopic gastrointestinal anastomosis stapler in the same patient as in Figs. 7-58 and 7-59.

recommended to increase the amount of space available in the thoracic cavity to manipulate the instruments and the lung lobe. A telescope portal is established, two operative portals are placed with triangulation by observation of intercostal palpation to provide optimum access to the hilus of the lung lobe to be removed, and the hilus is prepared with sharp dissection. For caudal lung lobes, the pulmonary ligament (Fig. 7-61) is divided to free the lung lobe for manipulation into position for placement of the endoscopic stapling device. Individual structures of the hilus are not isolated for minimally invasive lung lobectomy and are separated from surrounding structures only enough to place the stapling device. A 45- to 65-mm long stapling cartridge with 3.5-mm staples is placed across the hilus of the lobe to be removed through its own additional portal that is placed ventrally and caudally at a location to allow the stapler to be placed perpendicular to the bronchus and blood vessels (Fig. 7-62). The stapling

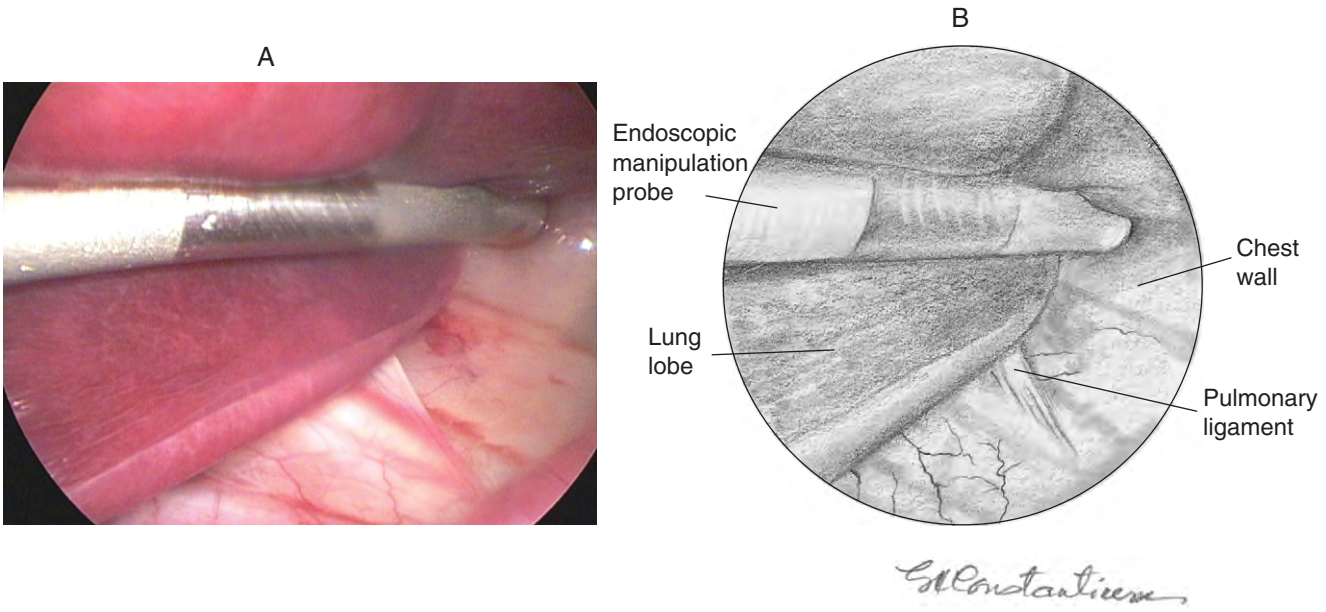



**Fig. 7-61**
Pulmonary ligament of the caudal lung lobe.

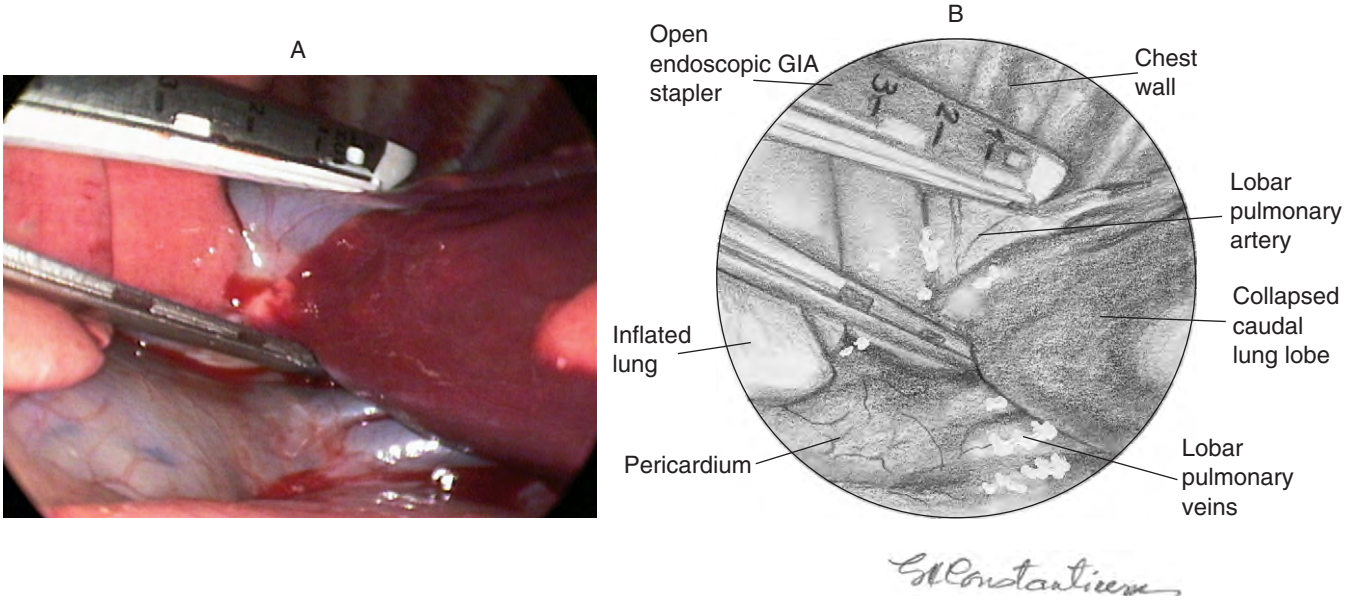



**Fig. 7-62**
Placement of an endoscopic gastrointestinal anastomosis stapler on the hilus of the lung lobe to be removed with the stapler perpendicular to the blood vessels and bronchus.

cartridge must be long enough to include the entire hilus to be stapled (Fig. 7-63). Endoscopic GIA staplers consistently achieve complete hemostasis and occlusion of the airways, but it is still wise to observe the margins of the resection at the time that the stapler is removed (Fig. 7-64). The resected lung lobe is removed from the chest through a small intercostal thoracotomy. An endoscopic tissue retrieval pouch facilitates removal of the lung lobe and decreases the potential of seeding neoplastic cells or infection to the chest wall. Enlarged hilar lymph nodes (see Fig. 7-33) can be biopsied (see Fig. 7-34) or removed with minimally invasive technique. Sharp and blunt dissection

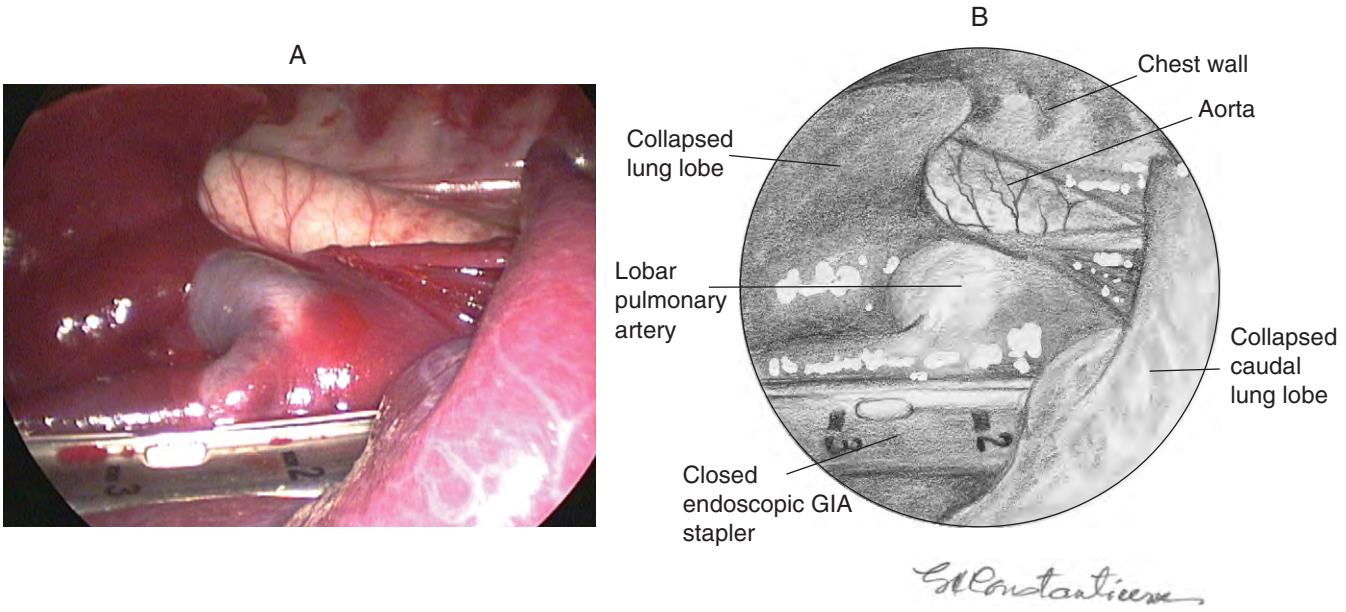



**Fig. 7-63**
The stapler cartridge must be long enough to include the entire hilus of the lung lobe being removed, and before firing the stapler it is rolled back and forth to visualize both sides to ensure that there are no other structures trapped in the stapler.

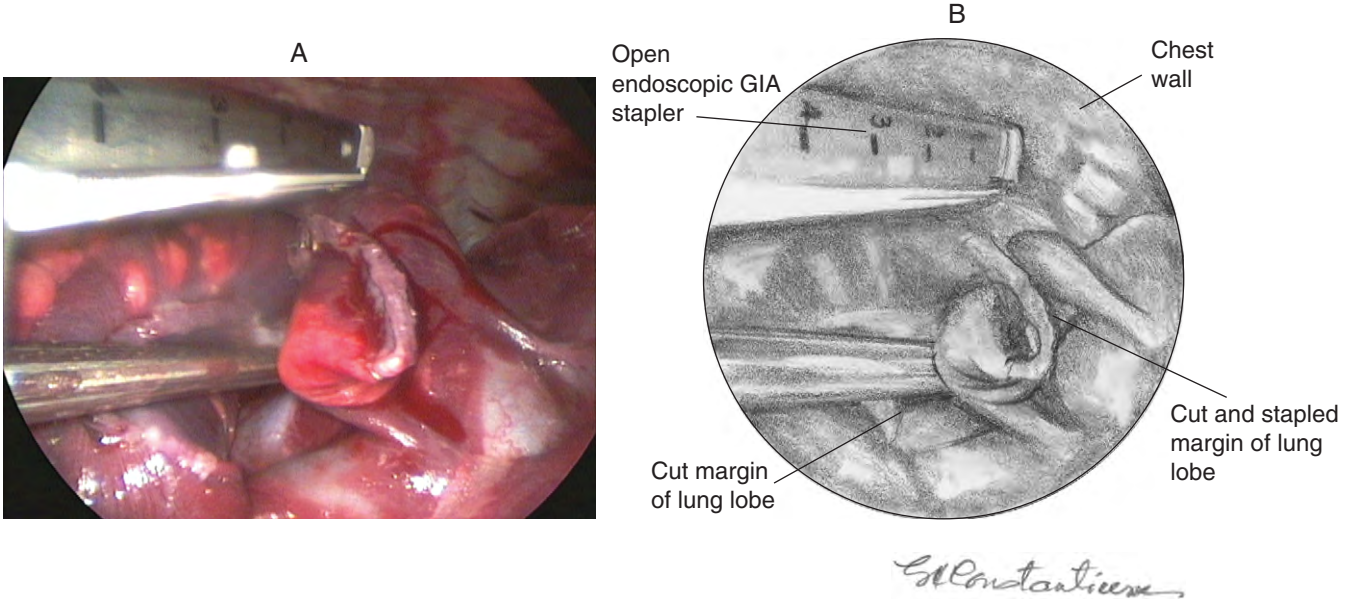



**Fig. 7-64**
Sealed lung margins observed when the endoscopic gastrointestinal anastomosis stapler is opened.

are used for lymph node removal with electrosurgical assistance and clip application for hemostasis. Before removal of the telescope, the hilus is observed for air leakage or bleeding (Fig. 7-65). A chest drain is placed at a site away from all portals, the operative and telescope cannulae are removed, and the portals are closed.

## Thoracic Duct Occlusion

Management of chylothorax by thoracic duct occlusion is far easier with minimally invasive technique than with an open surgical approach.[3] Magnification produced by the telescope and video system greatly enhances visualization of the thoracic ducts (Figs. 7-17 and 7-66), and

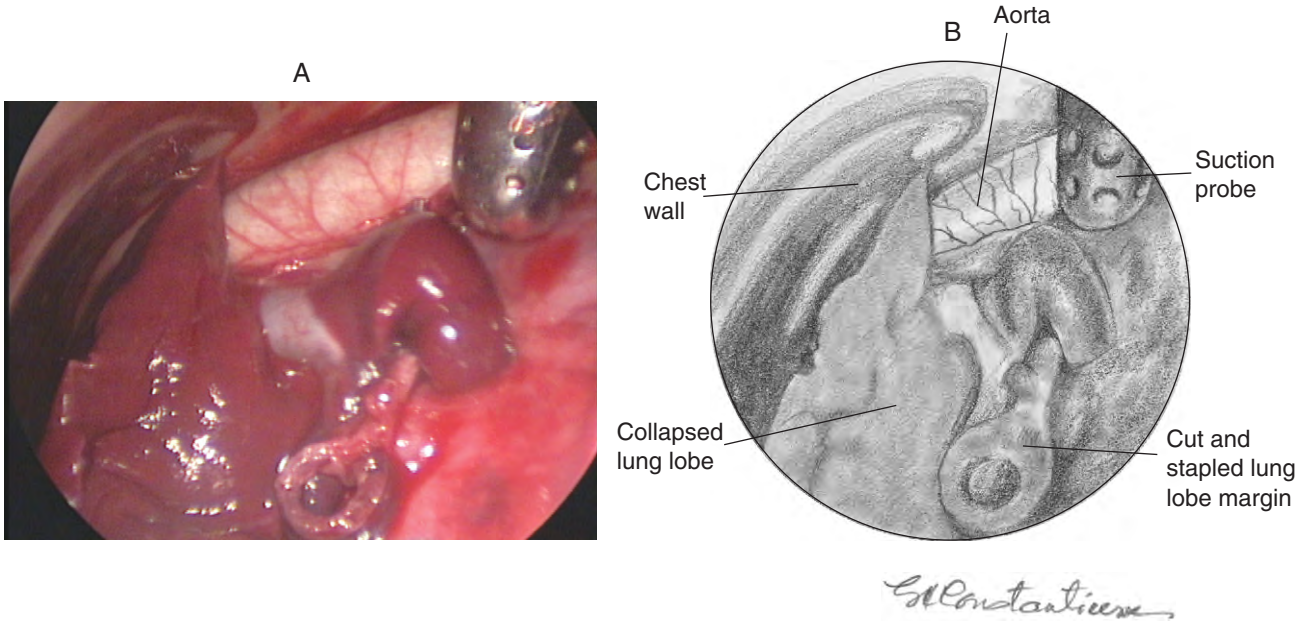



**Fig. 7-65**
The hilar staple line is checked for bleeding and air leakage before removal of the telescope. *(Courtesy Dr. Eric Monnet.)*

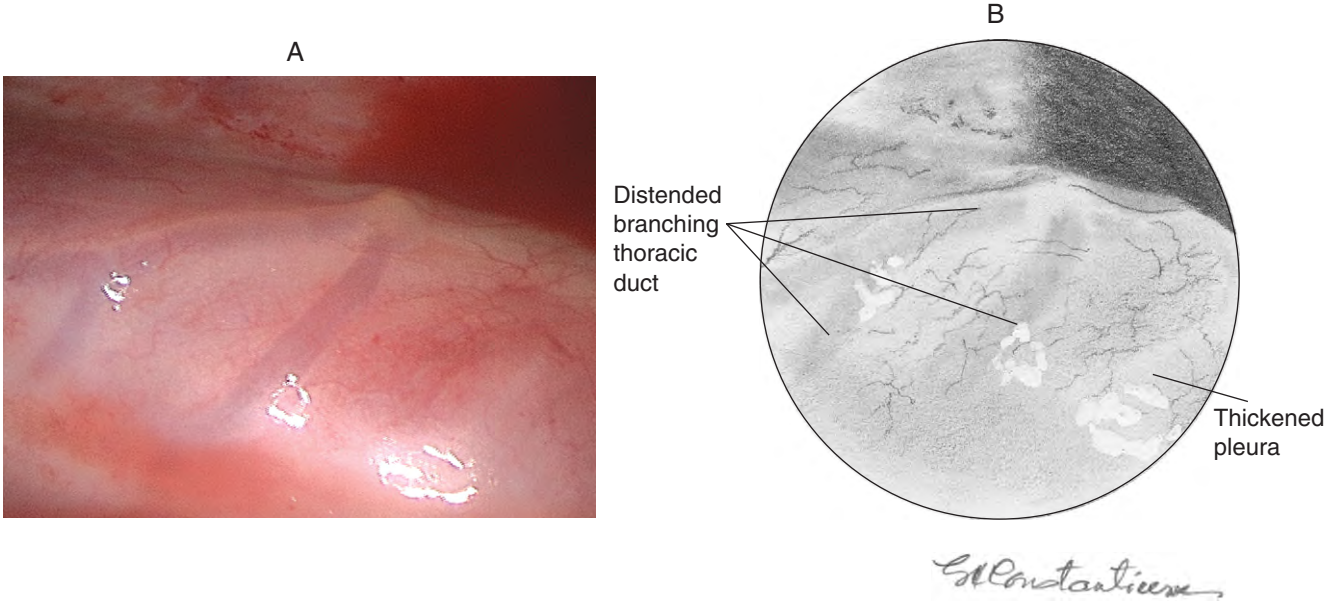



**Fig. 7-66**
Dilated thoracic duct branches in a dog with chronic nonresponsive chylothorax.

instrumentation designed for minimally invasive surgery facilitates manipulation of structures deep in the chest. Occlusion can be achieved with vascular clips specifically designed for minimally invasive surgery (Endoclips) (Fig. 7-67) or with a radiofrequency tissue ablator designed for arthroscopic thermocapsulorraphy. Clips work well in large dogs (Fig. 7-68), but they are too large to be effective in cats. Thermal duct occlusion can also be performed with a thermocouple-controlled probe that allows a preset temperature to be applied to the tissues that coagulates tissue protein without vaporizing or cutting the tissue. This effectively glues the walls of the thoracic duct together. This technique can be applied to a wide area of the chest wall in a short period of time to increase the chance of including all branches of the thoracic duct in the occlusion procedure.

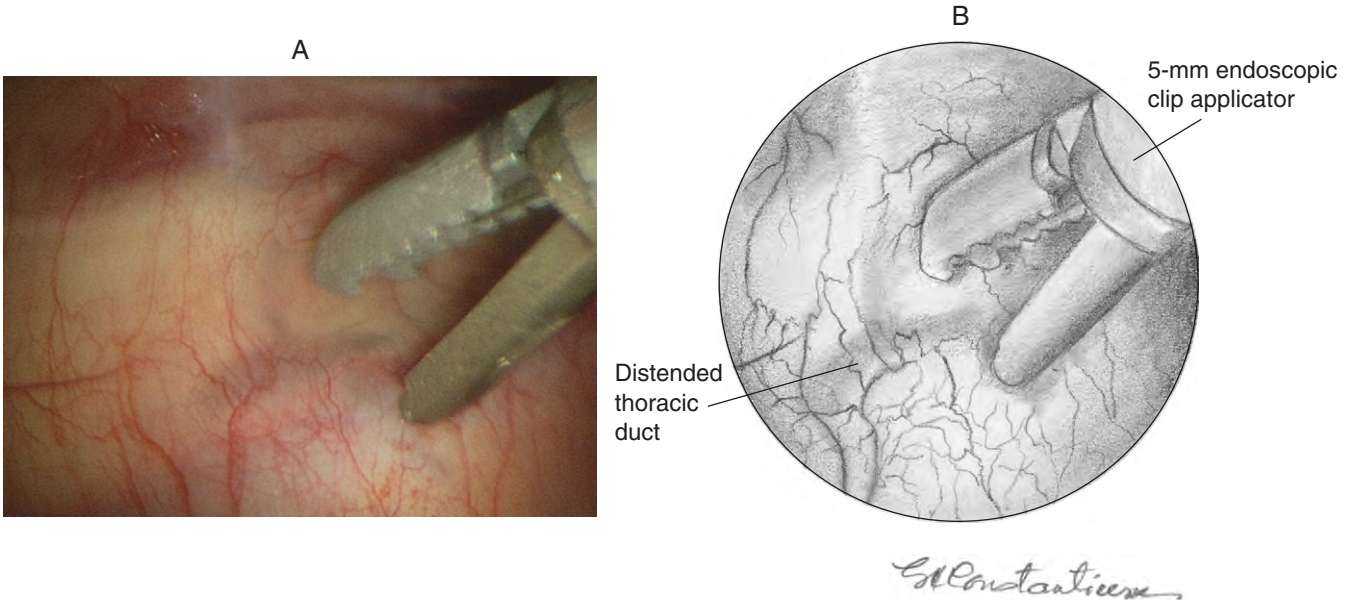



**Fig. 7-67**
Applying clips to the thoracic duct of a cat with chronic chylothorax. Endoclips work well on the thoracic duct of large dogs, but even 5-mm clips are too large to be effective in cats.

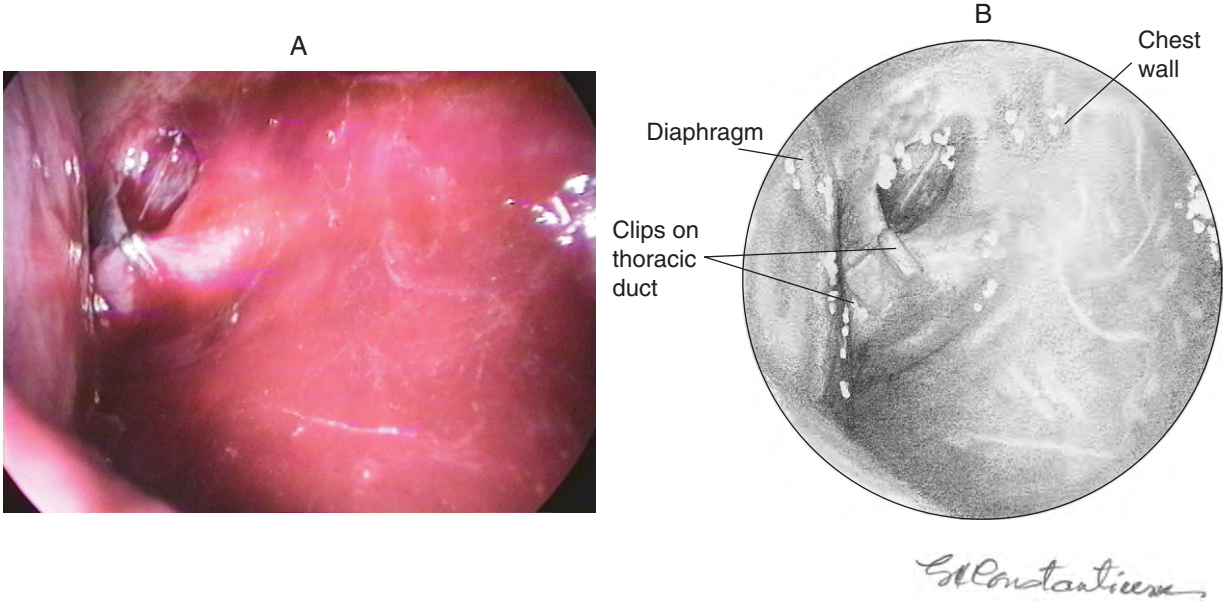



**Fig. 7-68**
Endoclips on the thoracic duct of a large dog. Multiple clips are applied to all definable branches of the thoracic duct.

Intercostal portals are placed on the right lateral chest wall with the patient in left lateral or ventral recumbency for dogs and in the left chest wall with the patient in right lateral recumbency for cats. The telescope portal is placed in the seventh intercostal space at the dorsoventral midpoint of the intercostal space and operative portals are placed midway between the telescope portal and the dorsal end of the ribs in the sixth and ninth intercostal spaces (Fig. 7-69). Injection of a popliteal lymph node or the cisterna chyli with methylene blue has been suggested to improve visualization of the thoracic duct and duct branches.[3] For clip application, the pleura is dissected to expose the thoracic ducts and multiple clips are applied to all visible branches of the duct. For thermal occlusion, pleural dissection is not required and the ducts can be effectively occluded through the pleura.

Efficacy of thoracic duct occlusion for management of chylothorax is questionable and controversial. If this method of treatment is elected or if it is indicated the substantially reduced trauma associated with a minimally invasive thoracoscopic approach is of great benefit to the patient.

## Persistent Right Aortic Arch Correction

Minimally invasive transection of the ligamentum arteriosum in cases with persistent right aortic arch (PRAA) has been shown to be an effective alternative to the open surgical approach.[33,34] To perform minimally invasive PRAA correction, the patient is placed in right lateral recumbency, the telescope portal is placed in the left fourth or fifth intercostal space at the costochondral junction, and three operative portals are placed in the third intercostal space and the sixth or seventh intercostal space at the level of the costochondral junction and at the dorsal end of the fifth intercostal space (Fig. 7-70). A retractor is placed in the sixth or seventh intercostal portal to retract the cranial lung lobe caudally. The ligamentum arteriosum is visualized with sharp and blunt dissection of the pleura (Fig. 7-71). Visualization of the ligamentum arteriosum and identification of the esophagus during dissection is facilitated by passing a stomach tube or an endoscope. A palpation probe is also used to further identify the ligamentum arteriosum, which is isolated from the esophagus with sharp and blunt dissection (Fig. 7-72). The ligamentum arteriosum is frequently patent, so endoscopic 5-mm vascular clips are placed on the isolated ligamentum arteriosum and it is transected between the clips (Fig. 7-73). Any remaining fibers are dissected off of the esophagus and divided, and the esophagus is dilated by passage of a balloon dilation catheter or esophageal bougies (Fig. 7-74). A chest tube is placed and the portals are closed. Postoperative dietary management is the same as for open surgical PRAA correction.

## Mediastinal and Pleural Mass Excision

Selected neoplastic (thymoma) and inflammatory masses can be removed effectively with minimally invasive

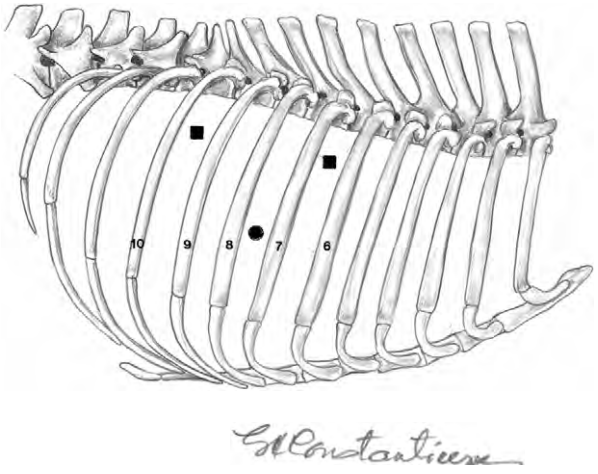



**Fig. 7-69**
Portal placement for thoracic duct occlusion in the dog with the telescope portal (*circle*) at the midpoint of the seventh intercostal space and operative portals (*squares*) halfway between the telescope portal and the dorsal ends of the ribs in the sixth and ninth intercostal spaces.

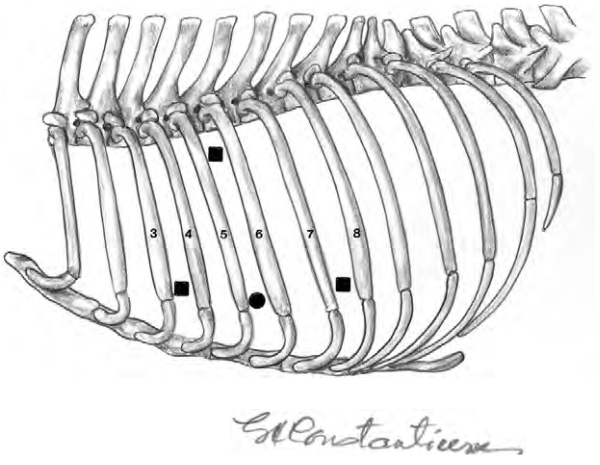



**Fig. 7-70**
Portal placement for ligamentum arteriosum division with the patient in right lateral recumbency with the telescope portal (*circle*) in the fourth or fifth intercostal space at the costochondral junction and with three operative portals (*squares*) at the costochondral junction of the third intercostal space, at the costochondral junction of the sixth or seventh intercostal space, and at the dorsal end of the fifth intercostal space.

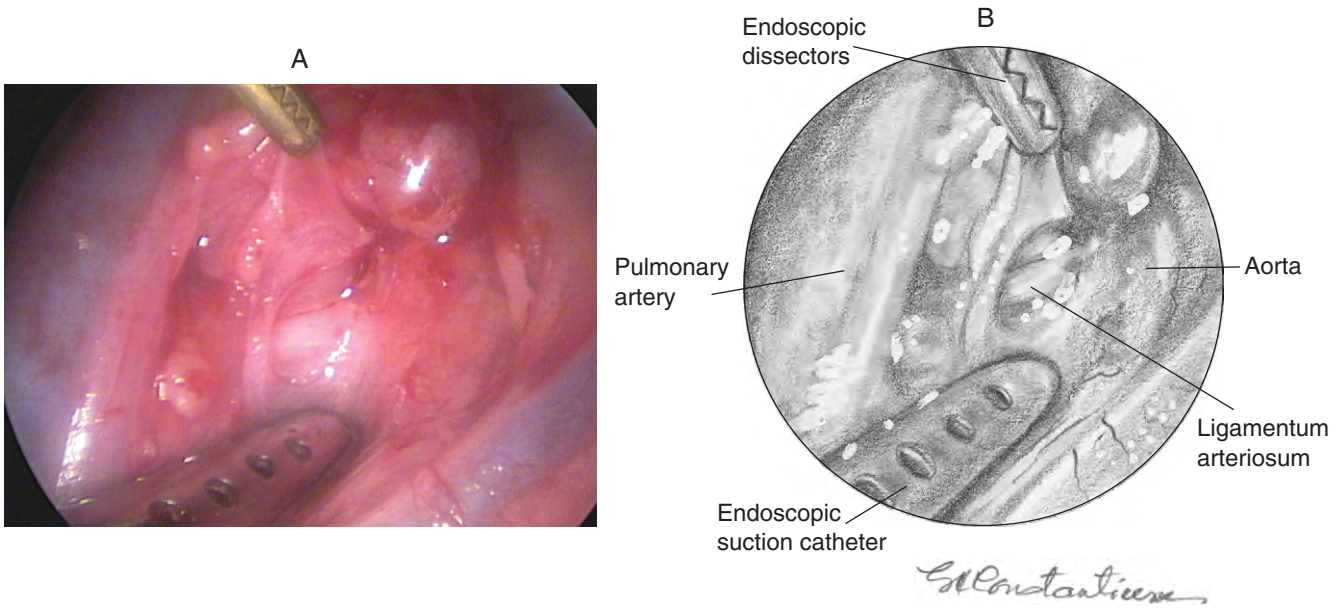



**Fig. 7-71**
The ligamentum arteriosum is identified after exposure by dissection of the pleura. Passing a stomach tube and using a palpation probe facilitate definition of the ligamentum.

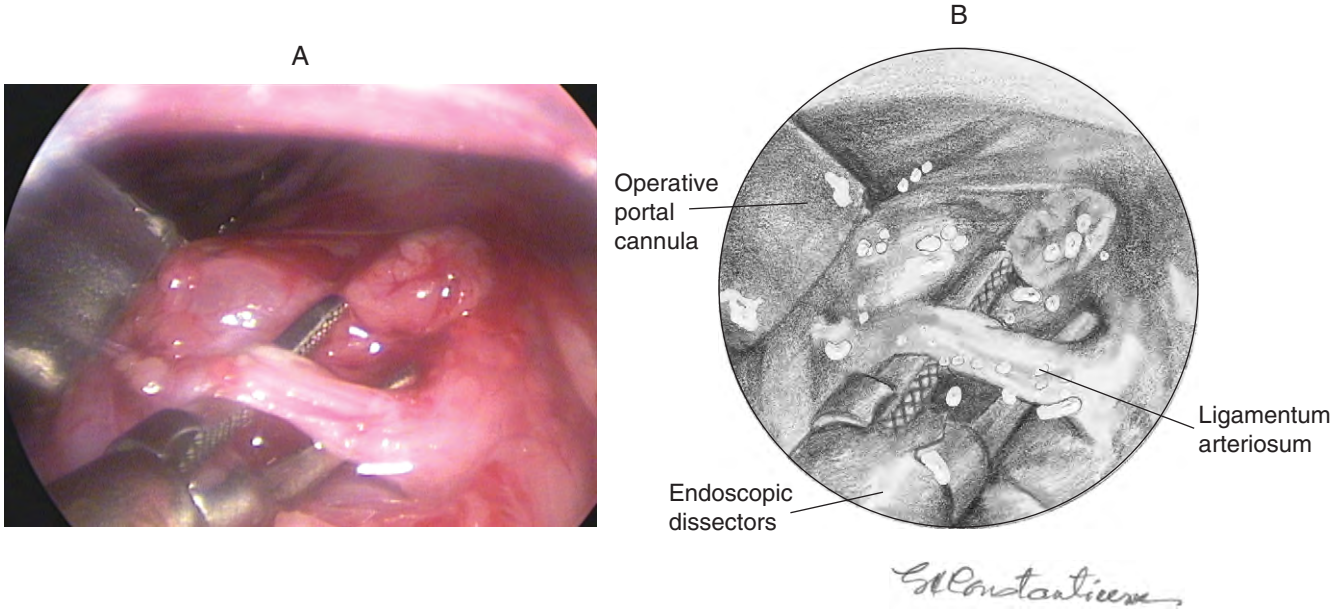



**Fig. 7-72**
The ligamentum arteriosum is isolated from the esophagus and surrounding tissues with sharp and blunt dissection.

technique. Masses that are inoperable with minimally invasive technique can be evaluated for open surgical resectability or biopsied and staged for appropriate nonsurgical treatment. Patient position and portal placement are defined by location of the mass. Cranial mediastinal masses are visualized most effectively in dorsal recumbency with a paraxiphoid telescope portal (see Fig. 7-24). Operative portals can be placed with both portals on one side of the patient or bilateral portals can be placed. Intercostal space selection for the operative portals again depends on the location and size of the cranial mediastinal mass. Portals are placed as far ventrally in the appropriate intercostal spaces as possible without traumatizing the internal thoracic artery. Cranial mediastinal masses can also be visualized and removed through a lateral intercostal approach with the patient in lateral recumbency

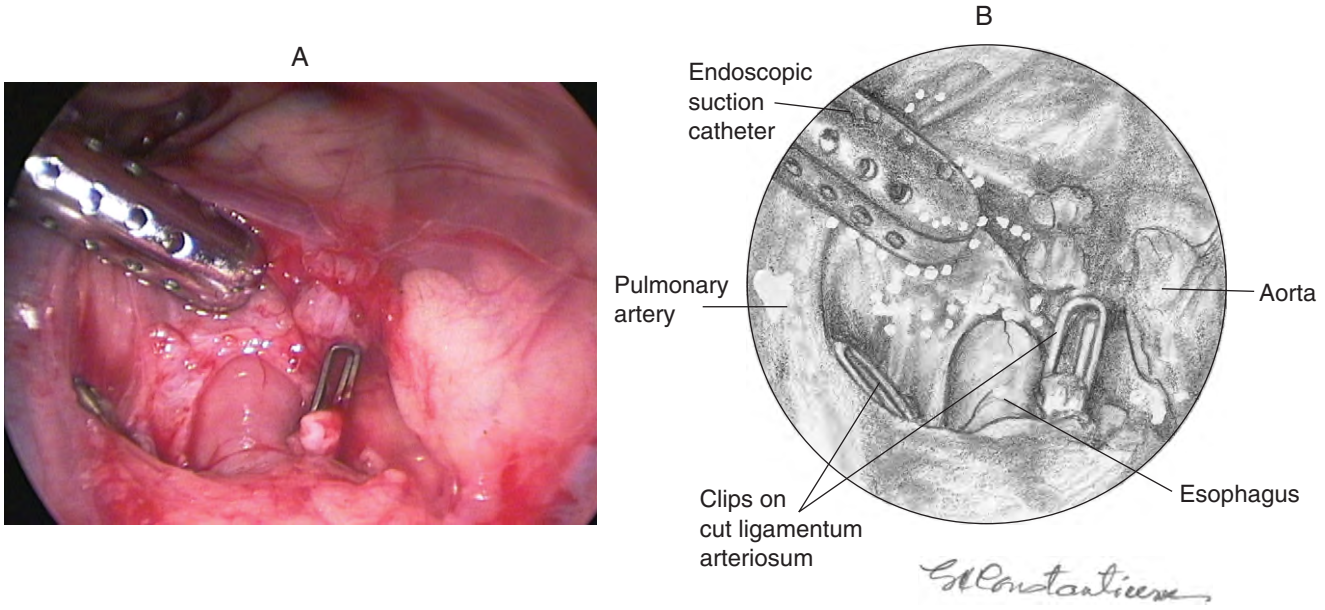



**Fig. 7-73**
Endoclips are applied to both ends of the ligamentum arteriosum, which is divided between the clips.

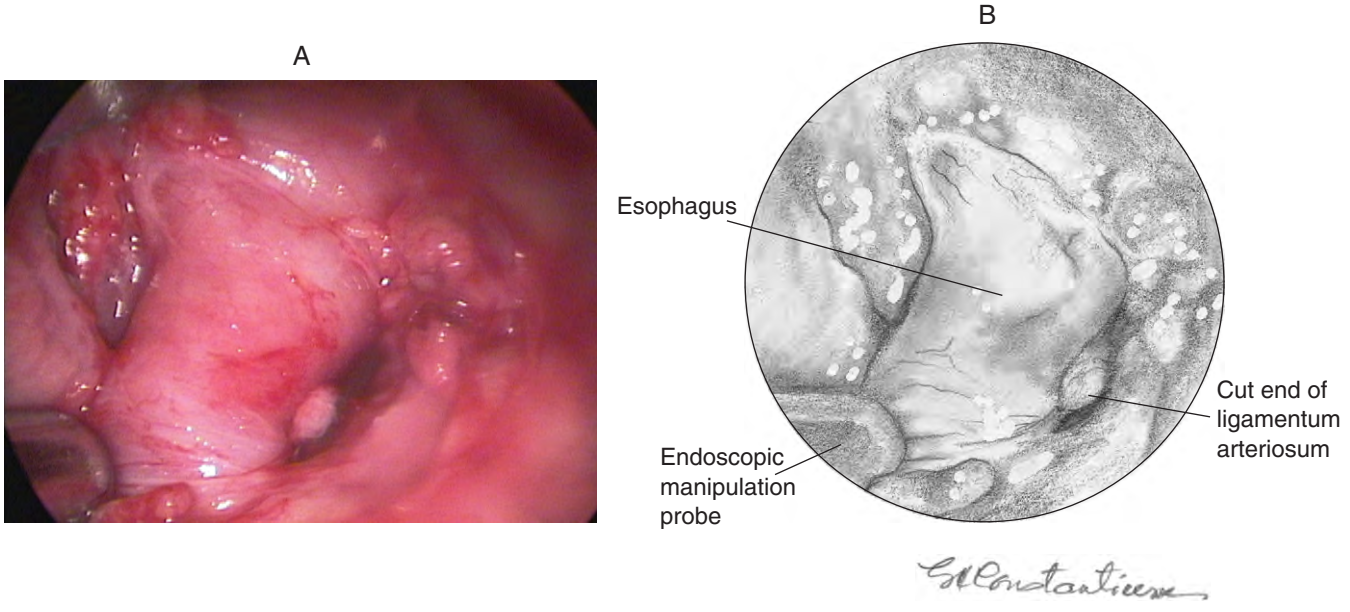



**Fig. 7-74**
After division of the ligamentum arteriosum, any remaining fibers are dissected off of the esophagus and the esophagus is dilated by passage of a balloon dilation catheter or esophageal bougies.

(Fig. 7-75). Masses are dissected with sharp and blunt dissection with ligatures, vascular clip, and electrosurgical assistance for hemostasis (Fig. 7-76).

Patient position and portal placement for approach to pleural masses in locations other than the cranial mediastinum are strictly dependent on the location of the mass (Figs. 7-77 and 7-78).

## CONTRAINDICATIONS FOR THORACOSCOPY

The primary contraindication for performing thoracoscopy or minimally invasive thoracic surgery is an inadequate level of minimally invasive surgical skills. There are few true contraindications for performing thoracoscopy

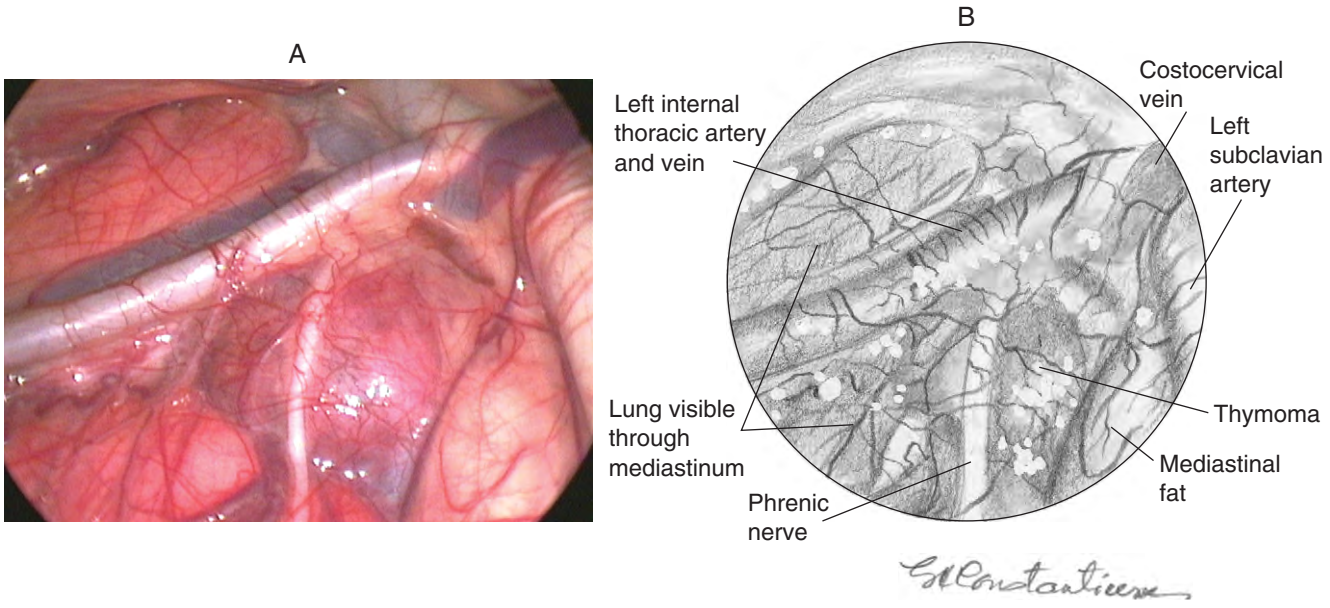



**Fig. 7-75**
A thymoma in the cranial mediastinum of a dog visualized from a left lateral intercostal telescope portal with the patient in lateral recumbency.

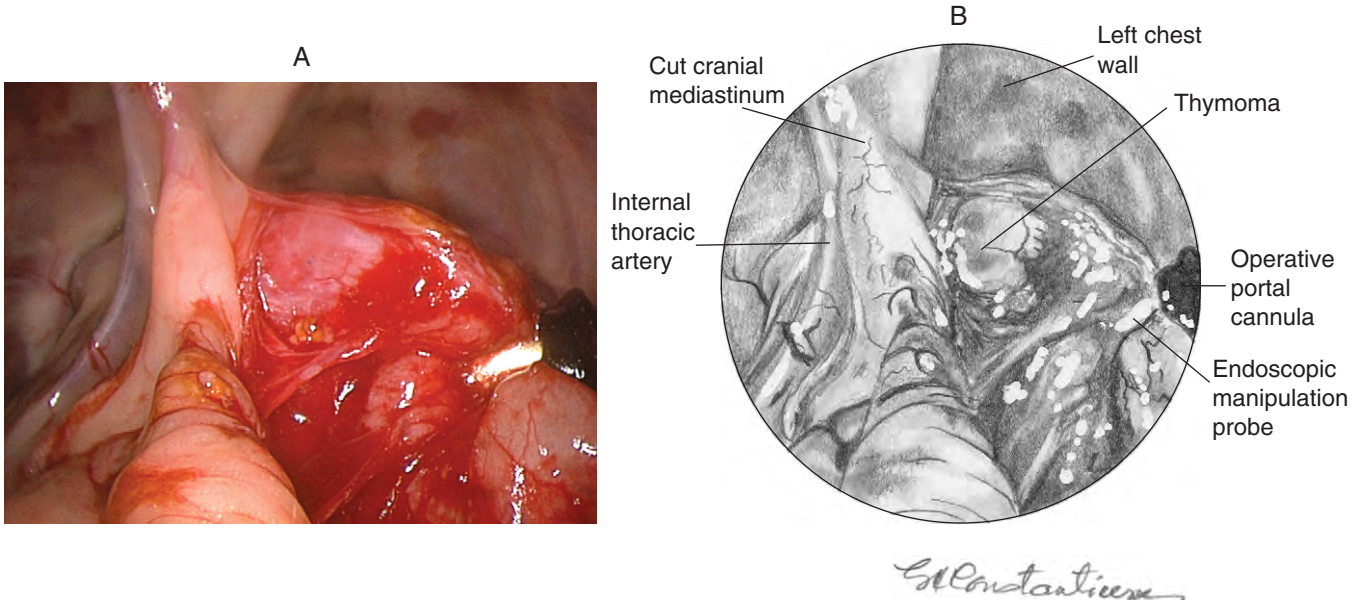



**Fig. 7-76**
The cranial mediastinal mass in Fig. 7-24 during dissection for removal.

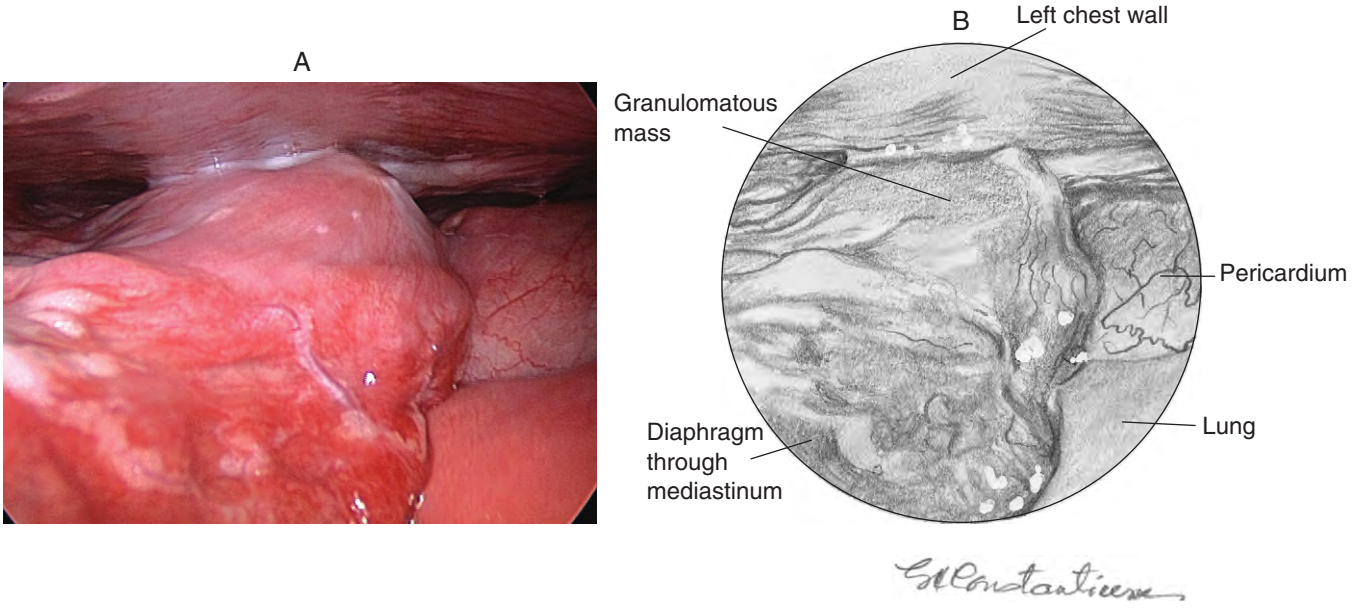



**Fig. 7-77**
A granulomatous mass in the left caudal chest of a dog with recurrent pyothorax.

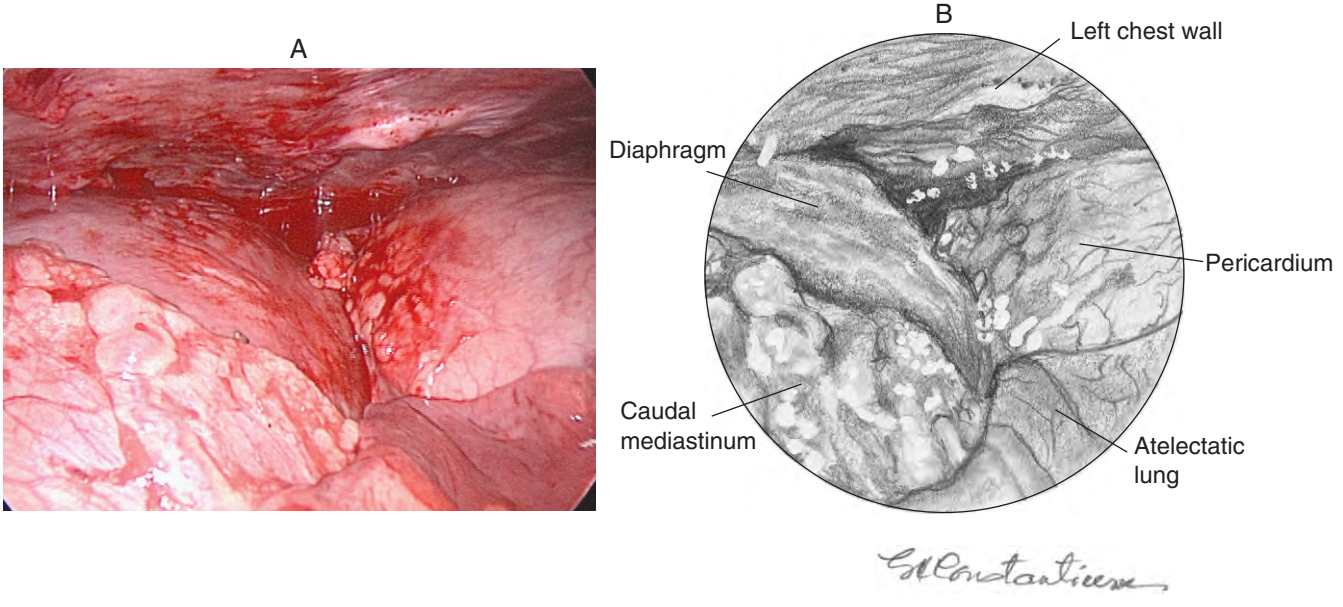



**Fig. 7-78**
Completed removal of the mass in Fig. 7-77.

in small animal practice. Many of the contraindications that are listed in the human and veterinary literature for minimally invasive thoracic surgery and for diagnostic thoracoscopy are relative contraindications and can arguably be presented as indications for these procedures. Multiple pleural adhesions that prevent creation of an adequate visual cavity, or that substantially increase the risks of establishing an adequate visual cavity, are one of the true contraindications for minimally invasive thoracic procedures in the human field. Fortunately the incidence of adhesions that are extensive enough to present a problem is very low in our patients. In an unstable case

of hemothorax that will most likely require an open thoracotomy for control of hemorrhage, thoracoscopy may delay definitive treatment and thus subject the patient to unnecessary risk. Relative contraindications include coagulopathies, obesity, and the compromised patient with systemic disease processes that substantially increase anesthetic risk. These are all reasons for additional concern, are not necessarily contraindications, and may be indications for minimally invasive procedures.

## COMPLICATIONS

Experience with complications from the human field is well documented. There are insufficient data to effectively define the complications of veterinary thoracoscopy and minimally invasive thoracic surgery. Severe or life-threatening complications associated with creation of a pneumothorax include laceration of lung, heart, or major vessels with the Veress needle or with trocar placement, perforation of the esophagus or trachea with a trocar, overinsufflation causing cardiorespiratory compromise or gas embolism, and injury to the thoracic wall or diaphragm. Additional complications related to pneumothorax that are not life threatening but that can compromise the patient and interfere with completion of the procedure include hypercapnia, hypotension, thoracic wall vascular injury, and subcutaneous emphysema. Noninsufflation-related complications include electrosurgical injuries, hemorrhage, portal air leakage, seeding of tumors at portal sites, nerve injuries, disorientation or inability to recognize anatomic structures, and lack of technical expertise.

Insufflation is not typically used for minimally invasive thoracic surgery but when it is used, it carries the same potential for complications that exists for abdominal insufflation. Complications related to thoracic wall penetration, including vascular and organ damage, are the same as for laparoscopy.

All of these complications are concerns for veterinary thoracoscopy and minimally invasive thoracic surgery, and techniques used in human surgery to avoid these problems need to be used to minimize complications and minimize defining animal complications by adverse experience. Conversion to open surgery when the procedure cannot be completed with minimally invasive technique is not considered a complication for the beginning minimally invasive surgeon; rather it is simply part of the learning curve. With proper care, attention to detail, and adequate training, the incidence of significant complications with minimally invasive thoracic procedures is very low.

## CONCLUSION

Diagnostic thoracoscopy and minimally invasive thoracic surgery are safe, effective, easy-to-perform techniques with significant applications for obtaining important diagnostic information and performing thoracic surgery with minimal invasion. There is much more to be learned about indications, advantages, disadvantages, problems, complications, and contraindications. The incidence of complications associated with thoracoscopy is very low. Significant hemorrhage or air leakage has not occurred. Animals recover quickly after thoracoscopy and typically are fully recovered, pain-free, and acting like nothing was done within a few hours after the procedure. Expanding experience with thoracoscopy in small animal practice indicates there is wide potential for its use.

My recent experience with an open intercostal thoracotomy emphasized the advantages and benefits of thoracoscopy. When compared with thoracoscopy, open thoracotomy is an inferior procedure with excessive tissue trauma, extended procedure time, and limited visualization within the chest. Postoperative pain is excessive and recovery is prolonged. Thoracoscopy is a superior procedure with dramatically reduced operative trauma, reduced operative time, dramatically reduced postoperative pain, and superior visualization.

## REFERENCES

1. Reed CE: Diagnostic and therapeutic thoracoscopy. In Green FL, Ponsky JL, editors: *Endoscopic surgery,* Philadelphia, 1994, WB Saunders.
2. Kovak JR and others: Use of thoracoscopy to determine the etiology of pleural effusion in dogs and cats: 18 cases (1998-2001), *J Am Vet Med Assoc* 221:990-994, 2002.
3. Radlinsky MG and others: Thoracoscopic visualization and ligation of the thoracic duct in dogs, *Vet Surg* 31:138-146, 2002.
4. Jackson J, Richter KP, Launer DP: Thoracoscopic partial pericardiectomy in 13 dogs, *J Vet Intern Med* 13:529-533, 1999.
5. Dupre GP, Corlouer JP, Bouvy B: Thoracoscopic pericardectomy performed without pulmonary exclusion in 9 dogs, *Vet Surg* 30:21-27, 2001.
6. Holtsinger RH, Ellison GW: Spontaneous pneumothorax, *Compendium* 17:197-210, 1995.
7. Valentine A and others: Spontaneous pneumothorax in dogs, *Compendium* 18:53-63, 1996.
8. Boutin C and others: Thoracoscopic lung biopsy: experimental and clinical preliminary study, *Chest* 82:44-48, 1982.
9. Schropp KP: Basic thoracoscopy in children. In *Pediatric laparoscopy and thoracoscopy,* Philadelphia, 1994, WB Saunders.
10. Walton RS: Thoracoscopy. In Tams TA, editor: *Small animal endoscopy*, St Louis, 1999, Mosby.
11. Faunt KK and others: Evaluation of biopsy specimens obtained during thoracoscopy from lungs of clinically normal dogs, *Am J Vet Res* 59:1499-1502, 1998.

12. Schermer CR and others: A prospective evaluation of video-assisted thoracic surgery for persistent air leak due to trauma, *Am J Surg* 177:480-484, 1999.
13. Remedios AM and others: Laparoscopic and thoracoscopic fenestration of the thoracolumbar intervertebral disks (T11-L7) in dogs, *Vet Surg* 24:439, 1995.
14. Kraenzler EJ, Hearn CJ: Anesthetic considerations for video-assisted thoracic surgery. In Brown WT, editor: *Atlas of video-assisted thoracic surgery,* Philadelphia, 1994, WB Saunders.
15. Garcia F and others: Examination of the thoracic cavity and lung lobectomy by means of thoracoscopy in dogs, *Can Vet J* 39:285-291, 1998.
16. Cohen E: One lung ventilation: prospective from an interested observer, *Minerva Anestesiol* 65:275-283, 1999.
17. Potter L, Hendrickson DA: Therapeutic video-assisted thoracic surgery. In Freeman LJ, editor: *Veterinary endosurgery*, St Louis, 1999, Mosby.
18. Cantwell SL and others: One-lung versus two-lung ventilation in the closed-chest anesthetized dog: a comparison of cardiopulmonary parameters, *Vet Surg* 29:365-373, 2000.
19. Campos JH, Massa FC: Is there a better right-sided tube for one-lung ventilation, *Anesth Analg* 86:696-700, 1998.
20. Mouton WG and others: Bronchial anatomy and single-lung ventilation in the pig, *Can J Anesth* 46:701-703, 1999.
21. Faunt KK and others: Cardiopulmonary effects of bilateral hemithorax ventilation and diagnostic thoracoscopy in dogs, *Am J Vet Res* 59:1494-1498, 1998.
22. Daly CM and others: Cardiopulmonary effects of intrathoracic insufflation in dogs, *J Am Anim Hosp Assoc* 38: 515-520, 2002.
23. Zaal MD, Kirpensteijn J, Peeters ME: Thoracoscopic approaches in the dog, *Vet Q* 19:S29, 1997.
24. Walton RS: Video-assisted thoracoscopy, *Vet Clin North Am Small Anim Pract* 31:729-759, 2001.
25. Remedios AM, Ferguson J: Minimally invasive surgery: laparoscopy and thoracoscopy in small animals, *Compendium* 18:1191-1198, 1996.
26. De Rycke LM and others: Thoracoscopic anatomy of dogs positioned in lateral recumbency, *J Am Anim Hosp Assoc* 37:543-548, 2001.
27. Lobe TE, Schropp KP: *Pediatric laparoscopy and thoracoscopy,* Philadelphia, 1994, WB Saunders.
28. Gandhi SK, Naunheim KS: The current status of thoracoscopic surgery, *Semin Laparosc Surg* 3:211-223, 1996.
29. Campbell SK and others: Chylothorax associated with constrictive pericarditis in a dog, *J Am Vet Med Assoc* 206:1561-1564, 1995.
30. Malone ED and others: Thoracoscopic-assisted diaphragmatic hernia repair using a thoracic rib resection, *Vet Surg* 30:175-178, 2001.
31. Vachon AM, Fischer AT: Thoracoscopy in the horse: diagnostic and therapeutic indications in 28 horses, *Equine Vet J* 30:467-475, 1998.
32. Walsh PW and others: Thoracoscopic versus open partial pericardiectomy in dogs: comparison of postoperative pain and morbidity, *Vet Surg* 28:472-479, 1999.
33. Isalow K, Fowler D, Walsh P: Video-assisted thoracoscopic division of the ligamentum arteriosum in two dogs with persistent right aortic arch, *J Am Vet Med Assoc* 9: 1333-1336, 2000.
34. MacPhail CM, Monnet E, Twedt DC: Thoracoscopic correction of persistent right aortic arch in a dog, *J Am Anim Hosp Assoc* 37:577-581, 2001.

# 8 Upper Gastrointestinal Endoscopy

*W. Grant Guilford*

Upper gastrointestinal endoscopy is a noninvasive, atraumatic technique that permits visual examination of esophageal, gastric, and upper small bowel lesions, and allows descriptive or photographic documentation of their severity and extent. Endoscopy provides tissue, cytologic, and fluid samples for laboratory evaluation. It allows therapeutic interventions such as foreign body retrieval, bougienage, and gastrostomy tube placement. Since its introduction into regular use in veterinary practice in the 1970s, endoscopy has revolutionized veterinary gastroenterology and is an increasingly popular procedure. The increased favor of endoscopy is due to a number of factors, including the high diagnostic yield, availability of reasonably priced endoscopy equipment designed for veterinary patients, and the financial benefit that can accrue from the procedure.

## INDICATIONS, LIMITATIONS, CONTRAINDICATIONS, AND COMPLICATIONS

### Indications

Upper gastrointestinal endoscopy is frequently used to evaluate the clinical problems listed in Box 8-1. Endoscopy is preceded by a careful history and physical examination, and by the collection of a laboratory database appropriate to the particular case under investigation. Used in this context, upper gastrointestinal endoscopy has a high diagnostic yield. At Massey University in New Zealand, gastroduodenoscopy has provided a diagnosis in more than 90% of patients in which the procedure was performed. However, automatic use of the endoscope without proper attention to clinical and laboratory examination results in a poor diagnostic return because many diseases causing chronic gastrointestinal signs can elude an endoscopic diagnosis (Box 8-2). These disorders can often be diagnosed by careful use of routine diagnostics such as dietary manipulation, complete blood counts, serum chemistry profiles, fecal flotations, and abdominal radiographs. Without the use of these essential diagnostic steps, misdiagnosis is likely. For example, the abdominal radiograph shown in Fig. 8-1 distinctly reveals a gas- and fluid-filled intestinal tract compatible with intestinal obstruction. This radiograph was obtained 4 weeks after the dog's initial presentation for chronic diarrhea and after endoscopy had been performed. On admission, a physical examination had failed to detect an ileocolic intussusception and gastroduodenoscopy was performed. Predictably, mild inflamation of lymphocytes and plasma cells was found on duodenal biopsy, and a diagnosis of lymphocytic-plasmacytic enteritis was made. Treatment with immunosuppressive agents made no impression on the diarrhea, resulting in reevaluation and discovery of the intussusception.

### Limitations

Upper gastrointestinal endoscopy is of most use for the diagnosis of esophageal, gastric, and upper small intestinal disorders with a mucosal involvement or luminal location. Lesions located in the muscular and submucosal layers of the gastrointestinal tract are more difficult to detect with an endoscope. This limitation of endoscopy has resulted in the development of endoscopic ultrasound, a technique that allows intimate evaluation of the

**Box 8-1 Principal Indications for Upper Gastrointestinal Endoscopy**

- Evaluation of dysphagia
- Evaluation of regurgitation
- Evaluation of chronic vomiting
- Evaluation of hematemesis
- Evaluation of melena
- Evaluation of chronic diarrhea
- Retrieval of esophageal foreign bodies
- Bougienage of esophageal strictures
- Retrieval of select gastric foreign bodies
- Placement of percutaneous gastrostomy tubes

**Box 8-2** Causes of Chronic Vomiting or Diarrhea Likely to Elude an Endoscopic Diagnosis

**Abdominal Diseases**
- Carcinomatosis
- Chronic pancreatitis
- Exocrine pancreatic insufficiency
- Pancreatic neoplasia

**Food Sensitivities**
- Food intolerances (e.g., lactose intolerance)
- Food allergy

**Hypersecretory Disorders**
- APUDomas (gastrinomas)
- Mast cell neoplasia
- Bacterial enterotoxins

**Mid Small Intestinal Diseases**
- Partial obstruction
- Intussusception

**Motility Disorders**
- Dumping syndromes
- Ileus (e.g., hypokalemia, hypercalcemia, dysautonomia)
- Pseudoobstruction
- Myenteric ganglionitis

**Mural Lesions**
- Neoplasia

**Subcellular Defects**
- Brush border enzyme deficiencies

**Systemic Diseases**
- Diabetes mellitus
- Hepatic failure
- Hyperthyroidism
- Hypoadrenocorticism
- Metastatic neoplasia
- Renal failure
- Toxemias

**Miscellaneous Disorders**
- Bacterial overgrowth
- Central nervous system disorders
- Drug associated
- Giardia (unless duodenal fluid is collected and analyzed)
- Heartworm (cats)
- Salmon poisoning

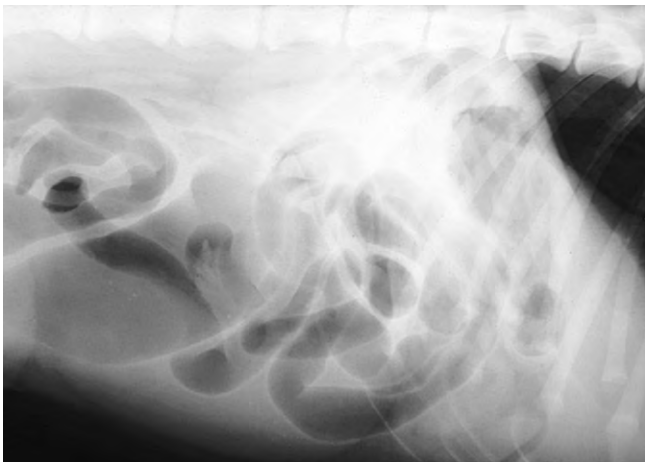


**Fig. 8-1**
Lateral radiograph of a dog with ileocolic intussusception. This Great Pyrenees had chronic diarrhea. On admission, a physical examination failed to detect the ileocolic intussusception, and gastroduodenoscopy was performed. A mild infiltration of lymphocytes and plasma cells was found on duodenal biopsy, and a diagnosis of lymphocytic-plasmacytic enteritis was made. Treatment with immunosuppressive agents made no impression on the diarrhea, resulting in reevaluation and discovery of the intussusception. This case illustrates that endoscopy is not a standalone technique and that the endoscope is not the "be all and end all" of gastrointestinal diagnosis.

full thickness of the bowel and proximate structures such as mesenteric nodes.

Endoscopy and endoscopic biopsy detect morphologic but not functional disease (see Box 8-2). It does not detect abnormal gastrointestinal motility, gastrointestinal hypersecretion disorders, or subcellular defects such as brush border enzyme deficiencies. Furthermore, because of restricted working length, the endoscopes used in veterinary practice cannot evaluate mid small intestinal disease. In contrast to exploratory celiotomy, upper gastrointestinal endoscopy provides no information about the health of abdominal organs other than the gastrointestinal tract.

## Contraindications

Upper gastrointestinal endoscopy is associated with low morbidity and mortality. Except in animals unfit for anesthesia, there are few absolute contraindications to performing gastrointestinal endoscopy. The procedure is not appropriate when bowel perforation is suspected, because contamination of the surrounding tissues may be increased as a result of the pressurization of the gastrointestinal tract by air insufflation. Endoscopy is discouraged

in patients with inadequately prepared gastrointestinal tracts and in animals with coagulation disorders.

## Complications

Serious complications of upper gastrointestinal endoscopy are rare. Those most frequently encountered are listed in Box 8-3. Of these complications, gastric overdistention due to excessive insufflation is the most common. If unrecognized, gastric dilation is potentially fatal because the overdistended stomach compresses the caudal vena cava and thoracic cavity, resulting in a rapid decrease in venous return, blood pressure, and tidal volume (Fig. 8-2). The abdomen during gastroduodenoscopy should feel distended but not tympanic. If gastric overdistention is recognized, deflation of the stomach can be readily achieved by suction of air from the stomach via the endoscope. It is for this reason that a suction pump is an essential part of the endoscopy inventory. In the absence of a suction pump, manual compression of the abdomen can be used in some animals to relieve gastric dilation by forced eructation around the endoscope. If manual compression is unsuccessful, orogastric intubation with a stomach tube is required. The endoscopist should be aware that gastric overdistention can occur during esophagoscopy or duodenoscopy as a result of leakage of air through the lower esophageal sphincter or pylorus, respectively. Gastric dilation also impedes pyloric intubation, which results in a prolonged procedure and increases the likelihood of morbidity.

Perforation of the esophagus with resultant mediastinitis and pleuritis, or of the stomach or intestine with

**Box 8-3 Most Common Complications of Gastrointestinal Endoscopy**

- Gastrointestinal perforation
- Laceration of major blood vessels
- Laceration of organs adjacent to the gastrointestinal tract
- Decreased venous return due to gastric overdistention
- Acute bradycardia
- Gastric-dilation volvulus
- Mucosal hemorrhage
- Transmission of enteropathogenic organisms
- Bacteremias (incidence uncertain in veterinary medicine)

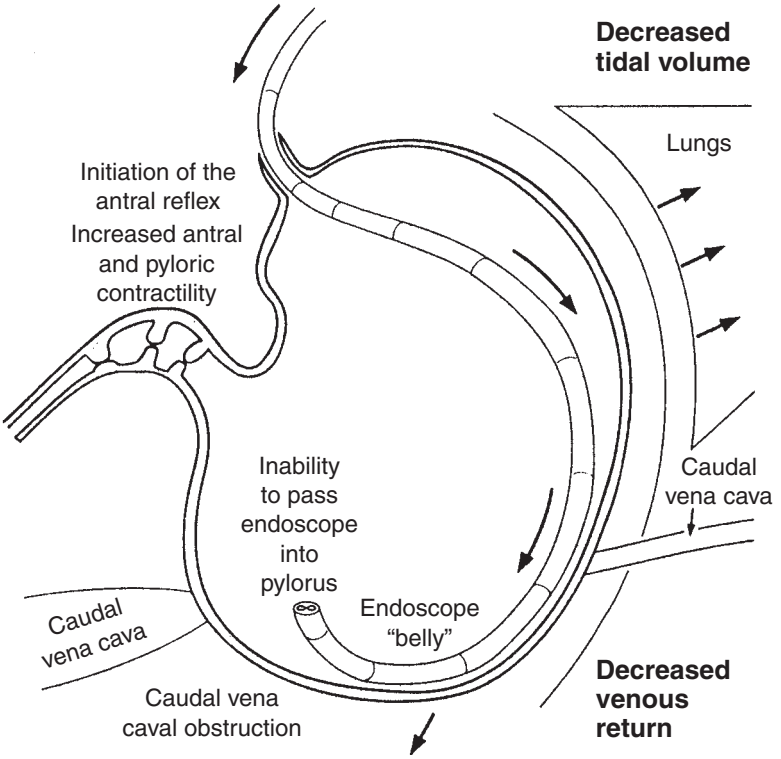



**Fig. 8-2**
Consequences of gastric overdistention. Gastric overdistention increases antral contractions and pyloric tone, compromises venous return, reduces respiratory tidal volume, and results in a "belly" in the insertion tube of the endoscope that inhibits maneuverability. *(From Strombeck DR, Guilford WG:* Small animal gastroenterology, *ed 2, Davis, Calif, 1990, Stonegate.)*

consequent peritonitis can result from forceful insertion of the endoscope, especially in the absence of vision of the lumen. Most commonly, however, perforation results from poor biopsy or retrieval technique. If a perforation is suspected, immediate radiography usually confirms the diagnosis because large quantities of air rapidly escape the viscus to enter the surrounding body cavity. Small perforations caused by endoscopy can be difficult to detect.

Gastric dilation-volvulus can occur following endoscopic procedures, perhaps partly due to inadequate removal of insufflated air. Acute bradycardia, apparently due to vagovagal reflexes, can occur during endoscopy. This phenomenon most often occurs when the instrument enters the small intestine of small breeds and is perhaps caused by overdistention of the intestinal tract or by excessive traction on the mesentery. Major blood vessels can be ruptured during removal of foreign bodies and during bougienage. Rarely, considerable hemorrhage can follow biopsy procedures. Poorly disinfected scopes can transmit enteropathogenic organisms. Following routine endoscopy, oropharyngeal organisms can be transiently cultured from the blood of a small percentage of human patients. Whether the same phenomenon occurs in dogs and cats is unknown.

## RELATIONSHIP OF UPPER GASTROINTESTINAL ENDOSCOPY TO OTHER GASTROINTESTINAL DIAGNOSTIC TECHNIQUES

### Absorption Studies

The primary function of some of the absorption tests, such as the xylose and fat absorption tests, is to detect small intestinal disease in a noninvasive manner. The necessity for these tests, therefore, has been much reduced by the use of upper gastrointestinal endoscopy.

### Contrast Radiography

The advent of endoscopy has been responsible for a decline in the use of gastrointestinal contrast radiography in both human and veterinary hospitals. However, upper gastrointestinal contrast radiography and endoscopy are complementary procedures. Contrast procedures do not require anesthesia, and they provide a better estimation of lumen diameter, mural masses, extramural compressive lesions, jejunal diseases, gastrointestinal motility, and gastric emptying. Endoscopy is more sensitive for the diagnosis of mucosal diseases of the upper gastrointestinal tract and offers the important advantage of definitive diagnosis through biopsy.

The prime function of the esophagus is one of motility. Disordered motility from esophageal neuromuscular disease is the most common cause of esophageal dysfunction. Therefore, in most cases of suspected esophageal disease, barium swallows, preferably with fluoroscopy, are performed before endoscopy.

The prime functions of the stomach and intestine are motility, secretion, and assimilation. Most disease processes that perturb these functions have a morphologic basis. Radiography is less sensitive than endoscopy for the detection of morphologic disease of the stomach in the dog. Furthermore, radiography can localize morphologic disease, but can rarely define its cause. Therefore, in most cases of suspected gastroduodenal disease, endoscopic examination precedes contrast radiographic procedures. When endoscopy was used before contrast radiography for the diagnosis of suspected upper gastrointestinal disease in a series of human patients, only five patients subsequently required barium studies. In comparison, when contrast radiography was the first procedure, 30 of the patients subsequently required endoscopy. A minimum period of 18 hours should elapse before an animal that has ingested barium undergoes endoscopy. Before this time, barium obscures visual details of the mucosa. Furthermore, dried barium is difficult to remove from biopsy instruments and the working channel of the endoscope.

### Colonoscopy

Some veterinary gastroenterologists prefer to perform both gastroduodenoscopy and colonoscopy regardless of the character of the presenting signs. The endoscopic examination of the entire gastrointestinal tract in one session has the advantage that subclinical disease in another part of the intestinal tract may be detected. This is particularly true of the inflammatory bowel diseases, disorders that are not inhibited by the pylorus or ileocecal junction as an inviolate boundary. I prefer, however, to reserve the "bi-orifice" approach for patients that manifest signs of gastrointestinal disease clearly referable to both large and small bowel dysfunction. The rationale for this "uni-orifice" approach is that subclinical disease in another part of the gastrointestinal tract only occasionally affects subsequent therapeutic approach or treatment success. I believe that the extra expense and time involved in the bi-orifice approach is therefore rarely warranted.

## EQUIPMENT FOR UPPER GASTROINTESTINAL ENDOSCOPY

Chapter 1 provides a detailed discussion of endoscopic equipment; the following section describes the features and attributes of the different types of endoscopic equipment for use in upper gastrointestinal endoscopy.

### Rigid Endoscopes

Rigid endoscopes can be used to visualize the esophagus. They are of particular value in the removal of esophageal

foreign bodies because they are of sufficient diameter to accommodate large grasping forceps. Furthermore, foreign bodies can be drawn into the lumen of the rigid scope to facilitate withdrawal of the foreign body through the upper esophageal sphincter.

### Fiberoptic Endoscopes

There is no one flexible endoscope that fulfills all the requirements of the upper gastrointestinal endoscopist in all sizes of veterinary patients. Veterinarians whose practice is predominantly feline find the narrow diameter (7.8 to 7.9 mm) of human pediatric gastroscopes valuable for the intubation of the feline pylorus. In contrast, veterinarians whose practice contains a significant proportion of large dogs need the extra length of gastroscopes designed specifically for veterinary use (see Chapter 1, Fig. 1-16), which facilitates pyloric intubation in the cavernous stomachs of the larger breeds. Endoscopes of very small diameter (e.g., 4 to 5 mm) are not usually suitable for gastroduodenoscopy because they typically have only two-way deflection capability, their flexible insertion tubes are difficult to thread around the greater curvature of the stomach to reach the pyloric antrum, and they are too flimsy to withstand significant torque. Veterinarians who have acquired human gastroscopes or colonoscopes with a diameter greater than 10 mm may use them to examine the esophagus and stomach, but they are difficult to pass through the pylorus in cats and small dogs. Advantages of larger diameter scopes are that they provide greater light intensity (useful for panoramic views of the stomach), they have significantly larger operating channels allowing retrieval of larger biopsy specimens, and they have greater durability.

Endoscopes with four-way tip deflection are essential for upper gastrointestinal endoscopy. They are considerably more maneuverable than endoscopes with tip deflection restricted to two directions. Endoscopes with two-way tip deflection are inadequate for gastrointestinal endoscopy because they require excessive torquing of the insertion tube to complete difficult maneuvers (e.g., pyloric intubation) and are too difficult to use. The maximum bending angle in each direction of deflection varies considerably with endoscope brand. In general, gastrointestinal endoscopes should have at least 180- to 210-degree deflection in one direction and a minimum of 90- to 100-degree deflection in the other three directions. The greater the tip deflection and the smaller the bending radius, the greater the maneuverability of the scope.

Good optical quality is essential in a gastrointestinal endoscope. Most scopes have a field of view of 90 to 120 degrees. A wide angle of view facilitates orientation and panoramic examination in a large viscus such as the stomach, decreasing the likelihood of missing landmarks and lesions due to tunnel vision. Endoscopes for gastrointestinal use should have a minimum focal distance less than 3 to 5 mm. This maximizes visibility when the endoscope tip comes close to the mucosa. This is particularly useful when attempting to negotiate the pylorus, because it maximizes the time in which the pyloric canal is in view as the endoscope approaches, facilitating the fine, last-minute tip deflections necessary to penetrate the more antagonistic pylorus.

### Video Endoscopes

Video endoscopes offer several advantages over fiberoptic scopes for upper gastrointestinal endoscopy. They allow better permanent documentation of lesions, create an atmosphere of team participation, facilitate coordination of biopsy and retrieval procedures, are less fatiguing, and greatly facilitate teaching. Video endoscopes are not available in as small diameters as fiberoptic scopes, and a video system is more expensive than a fiberoptic system. The latter disadvantage may be offset by greater longevity.

### Light, Insufflation, and Vacuum Sources

Light sources of 150 and preferably 300 watts are necessary to provide sufficient light intensity for detailed examination of a large viscus such as the stomach. Insufflation is required to distend the gastrointestinal tract and provide a visual space for examination. Combination light and insufflators are available, or insufflators can be obtained as a separate unit to add to an existing light source. Suction is also needed for gastrointestinal endoscopy and can be provided with a standard surgical suction pump.

## PATIENT PREPARATION

During the 12 to 24 hours before upper gastrointestinal endoscopy is done, food is withheld from the patient and symptomatic therapy is instituted to address any fluid or electrolyte abnormalities that may compromise anesthetic safety. Food is withheld for a longer period when there is evidence of delayed gastric emptying. Retained gastric material interferes with mucosal visualization, may plug the suction channel of the endoscope, and may result in inhalation of the gastric material during recovery.

### Anesthesia

Anesthesia is essential for upper gastrointestinal endoscopy. The anesthetic regimen chosen depends on the animal's general condition and the presence of any concurrent disease.

Anticholinergic premedication is an advantage to reduce gastric motility and secretion. Less secretion reduces the likelihood of foaming during prolonged procedures. Pyloric tone is not significantly increased or reduced by anticholinergics. Anticholinergics are not

used when the intention of the procedure is to collect duodenal fluid. Narcotic agents increase pyloric and cranial duodenal tone in humans, interfering with the easy passage of the scope. My clinical impression is that a similar phenomenon occurs in dogs. Therefore, if the condition of the animal allows, these drugs are best avoided during gastrointestinal endoscopy.

The anesthetist must be particularly alert for the signs of gastric overinflation, which include excessive abdominal distention, tachycardia, pale mucous membranes, and a precipitous decrease in blood pressure, and for evidence of bradycardia suggestive of vagovagal reflexes.

A reliable gag is always placed in the mouth to protect the endoscope.

## GENERAL ENDOSCOPIC TECHNIQUE

### Patient Positioning

For routine upper gastrointestinal endoscopy, the patient is positioned in left lateral recumbency. This position facilitates examination of the pylorus by bringing the pylorus to the top of the abdomen, unweighting the junction between the body and antrum and draining fluid from the antrum (Fig. 8-3). For the placement of gastrostomy tubes, the patient is placed in right lateral recumbency.

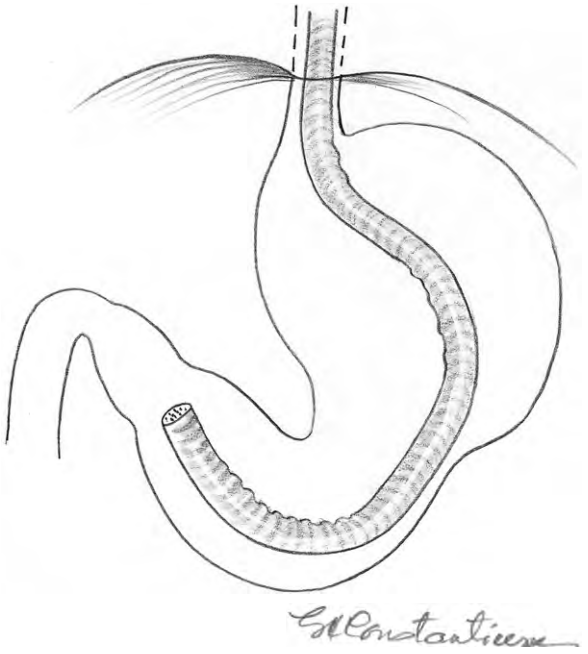


**Fig. 8–3**
A diagram of the position of stomach when a dog is placed in left lateral recumbency. This position facilitates examination of the pylorus by bringing the pylorus to the top of the abdomen, unweighting the junction between the body and antrum and draining fluid from the antrum.

### Holding the Endoscope

The endoscope is held between thumb and first finger of the left hand with the umbilical cord in contact with the dorsal surface of the hand and the control section nestled in the palm. In this manner, most endoscopists can comfortably manipulate the controls. The fingers of the left hand manage the insufflation and suction buttons, and the thumb adjusts the up-down deflection knob. The right hand is used to advance and torque the scope and to make the occasional adjustment of the left-right deflection knob. An assistant is helpful in stabilizing the instrument in a particular position in the bowel and is needed to perform efficient biopsy and retrieval procedures. Some endoscopists rely on an assistant to advance the insertion tube of the endoscope while they use both hands to manipulate the controls. This approach should be discouraged because the endoscopist cannot then use the fine, coordinated motion necessary to pass difficult pyloric canals.

### Maneuvering the Endoscope

The tip of the endoscope is maneuvered by use of the up-down and left-right deflection knobs and by torquing the insertion tube. The up-down deflection direction of most endoscopes has greater bending capability than the left-right deflection direction. Torquing allows the up-down deflection direction of the endoscope to be maneuvered to the plane that is most beneficial for the negotiation of bends requiring maximal deflection of the endoscope tip. Torquing lessens the reliance of the endoscopist on the left-right deflection knob, which is the most difficult knob to reach. Torquing is often required to negotiate the pylorus and cranial duodenum.

Torque is applied by rotating the insertion tube. The handpiece is not used to initiate torque, because its larger diameter allows generation of sufficient rotational force to damage the endoscope. Instead, the handpiece is allowed to passively follow the rotation of the insertion tube. If the handpiece and insertion tube are not rotated in the same direction and by the same degree, then excessive torsional stress is placed on the fiberoptics. Many endoscopists achieve the rotation of the handpiece and insertion tube as a unit by left or right movement of their upper body at the hips. Maximal torquing can result in impressive contortion of the endoscopist. Resistance of the endoscope to torquing increases with greater length of the insertion tube that is in the animal. It can be difficult to elicit any meaningful rotational movement of the endoscope when the tip is in the distal duodenum.

The endoscope is advanced only when the bowel lumen is in clear view. One exception to this is the “slide-by” technique (Fig. 8-4). This is done by deflection of the tip of the endoscope into the perceived direction of a flexure followed by the gentle sliding of the endoscope over the mucosa of the greater curvature of the flexure.

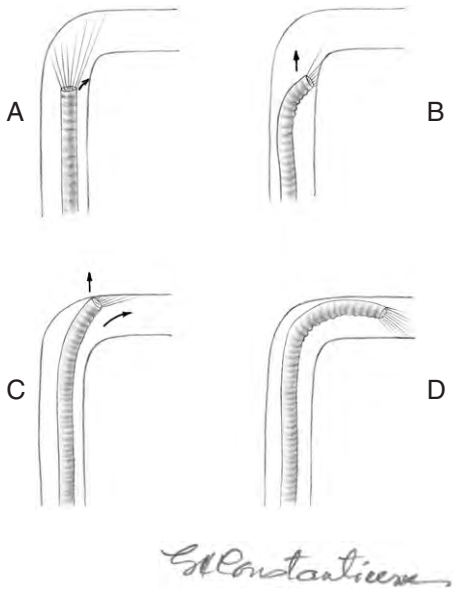



**Fig. 8-4**
Schematic diagram of the "slide-by" technique, which is used to negotiate acute flexures. **A,** The endoscopist determines what direction the flexure runs. **B,** The tip of the endoscope is deflected in the perceived direction of the flexure before further insertion of the endoscope. **C,** The deflected tip of the endoscope is pressed against the greater curvature of the flexure, resulting in a sliding of the endoscope over the mucosa. At this point, the lumen is temporarily lost to view, and a mucosal "red out" occurs. As the endoscope advances, the mucosa can be seen to be sliding by the tip of the endoscope. **D,** A tunnel view is regained once the endoscope rounds the flexure.

The lumen is temporarily lost to view, and a mucosal "red out" occurs. The impression of the mucosa sliding by the tip of the endoscope occurs and a tunnel view is not regained until the endoscope rounds the flexure. The slide-by technique is often necessary to round the cranial duodenal flexure. One disadvantage of this technique is that it occasionally results in temporary obstruction of the insufflation/flush channel by shards of mucosa.

### Frequent Causes of Damage to Endoscopes

Endoscopes are relatively fragile instruments. To prevent damage and ensure longevity, they must be handled with care. They can be damaged by bites, collision with surfaces, inappropriate coiling, excessive insertion or torquing force, forceful passage of biopsy instruments, and repeated fluoroscopy. Use of adequate anesthesia and strict placement of mouth guards can prevent bites. Collision with surfaces usually occurs when the weight of a loop of uninserted endoscope drags the tip of the endoscope out of the mouth and whips the tip of the instrument against the floor or table leg. This damage can be prevented by an assistant who gently grips the insertion tube when the endoscopist removes his or her right hand from the instrument. In general, endoscopes are not coiled greater than 360 degrees and are not forced into tight bends. The latter often inadvertently occurs when a standing endoscopist leans forward over the table. This posture can severely kink the small loop of uninserted insertion tube against the tabletop. The deflection cables of the endoscope can be stretched by overrotation of the deflection knobs. This is a frequent mistake, usually resulting from a frustrated endoscopist unfamiliar with the art of torquing. The cables also stretch when the deflection knobs are forcefully rotated against the deflection brakes. The latter problem is common when inexperienced endoscopists inadvertently set the deflection knob brakes instead of turning the deflection knob.

### Description of the Mucosa

A written description of the mucosa is a standard part of the medical record of any animal under going endoscopy. Where appropriate, photographic records are also kept. Consistent description of mucosal lesions is assisted by the use of endoscopy grading sheets for inclusion in the record. Grading sheets include a description of the size and position of any lesions such as masses or ulcers. In addition, each of the following parameters are evaluated in a semiquantitative fashion: degree of mucosal erythema, friability, granularity, and erosions; amount of mucus; and visibility of submucosal blood vessels. Of these parameters, increased mucosal erythema is least likely to correlate closely to presence of mucosal disease. Appearance of the mucosa varies considerably with degree of insufflation.

## ESOPHAGOSCOPY

### Equipment

The esophagus is best examined with a flexible endoscope, although rigid endoscopes can also be used for esophagoscopy. Rigid endoscopes often have insufficient length to visualize the intrathoracic esophagus, but they do offer advantages for the removal of sharp foreign bodies.

### Technique

To pass the endoscope into the esophagus, the animal's neck is extended dorsally and the insertion tube is introduced into the mouth, dorsal to the endotracheal tube. With firm pressure, the endoscope is then passed through the upper esophageal sphincter. Failure of the endoscope to enter the esophagus is usually due to incorrect placement of the endoscope in the mouth so that the instrument tangles with the endotracheal tube, hits the pharyngeal wall, or abuts against the larynx.

After entering the esophagus, the tip of the endoscope is drawn back until it just rests inside the upper esophageal sphincter and the esophagus is insufflated with air until sufficiently distended to visualize the lumen. As the esophagus dilates, the longitudinal mucosal folds of the proximal esophagus reduce in size and it is usually possible to see the lumen of the entire cervical esophagus. Once the esophagus is adequately distended, the endoscope is advanced. There is little resistance to movement of the endoscope in the esophagus and rapid aboral passage with a full luminal view is usually managed by minor adjustments of the up-down deflection knob in combination with small torquing movements. At the junction of the cervical and thoracic esophagus, there is a slight flexure. Once this is rounded, an uninterrupted view to the lower esophageal sphincter is usually attained.

Because of its durable epithelium, biopsy of the esophagus is more difficult than the biopsy of other parts of the gastrointestinal tract.

## Appearance of the Normal Esophagus

In the anesthetized animal, the normal esophagus appears flaccid and drapes over the trachea and thoracic vasculature, giving the false appearance of megaesophagus. The esophagus may contain small amounts of clear fluid. The presence of food is abnormal and pooling of bile is unusual but not necessarily pathologic. The normal mucosa is pale and smooth. Submucosal vessels are usually not visible in the dog esophagus but a network of superficial vessels is sometimes apparent in the esophagus of puppies and cats. There may be a redundancy of tissue at the thoracic inlet that gives the impression of a diverticulum, but this can be largely obliterated by full extension of the neck. The distal few centimeters of the cat esophagus is characterized by a series of circumferential mucosal folds termed the *herring bone* pattern. These folds are not to be confused with the radial fibrotic striations that occur in strictures. The gastroesophageal junction usually has a slitlike appearance (Figs. 8-5 and 8-6). Slight reddening may be apparent at the gastroesophageal junction in normal animals. This red coloration is due to the transition from esophageal to gastric mucosa. The lower esophageal sphincter is usually closed at the time of examination but occasionally may gape open (Fig. 8-7). Little significance is afforded such patulous lower esophageal sphincters unless the surrounding esophageal mucosa shows evidence of esophagitis.

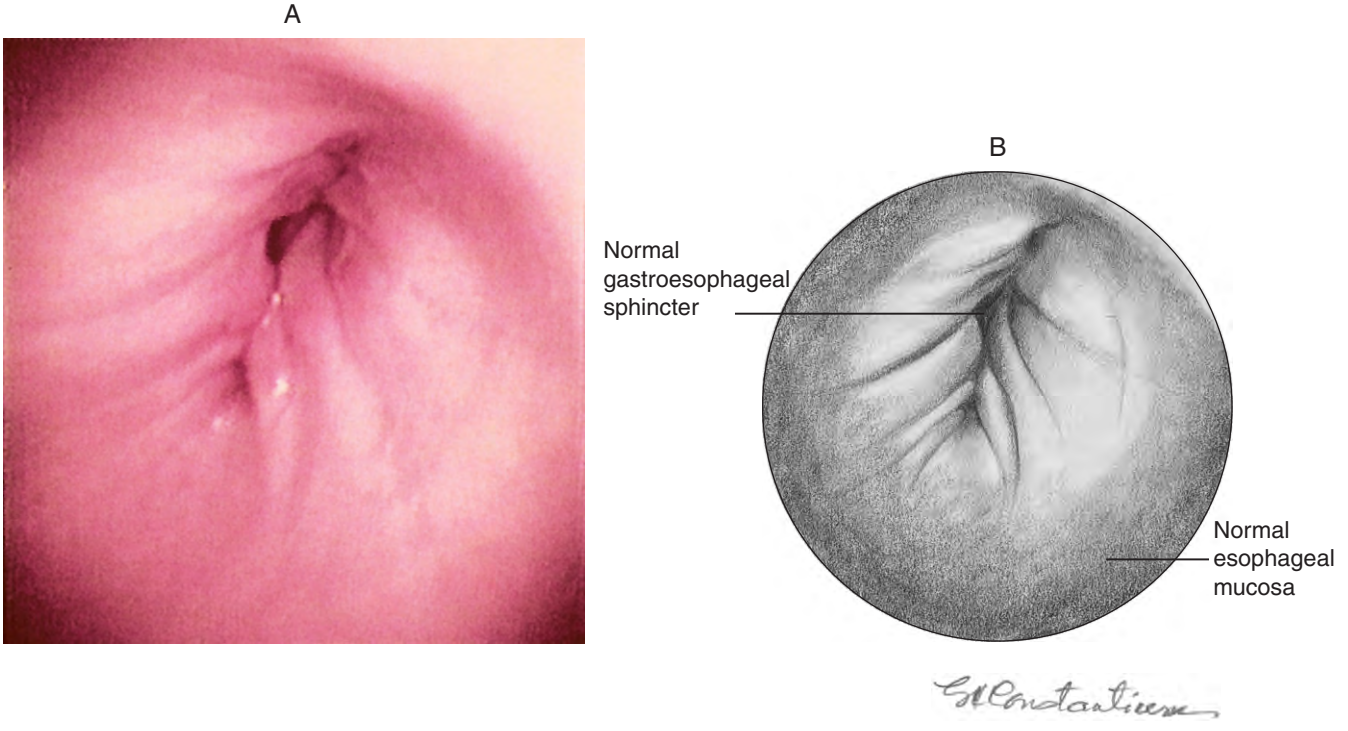



**Fig. 8–5**
Normal gastroesophageal sphincter. The gastroesophageal sphincter usually has a slitlike appearance. Slight reddening may be apparent at the gastroesophageal junction in normal animals. This red coloration is due to the transition from esophageal to gastric mucosa.

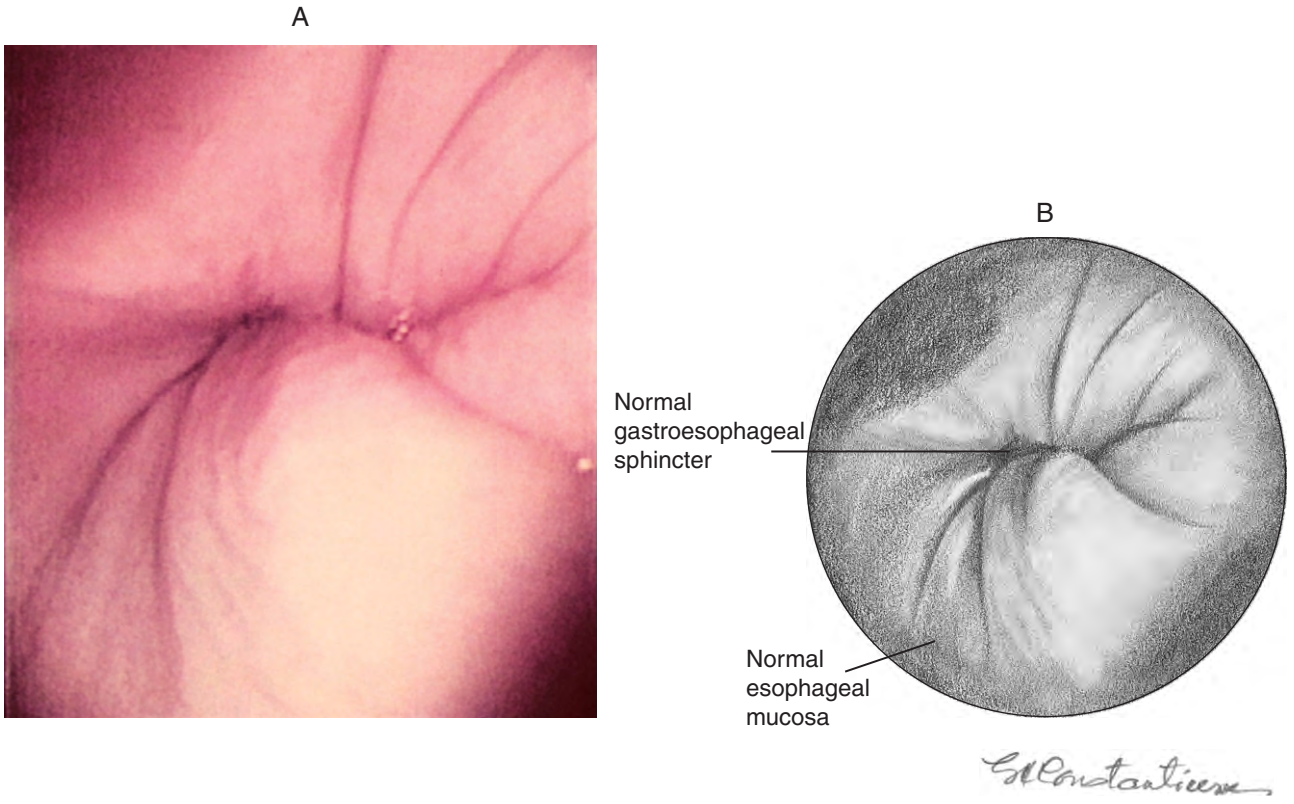



**Fig. 8–6**
Normal appearance of the gastroesophageal sphincter.

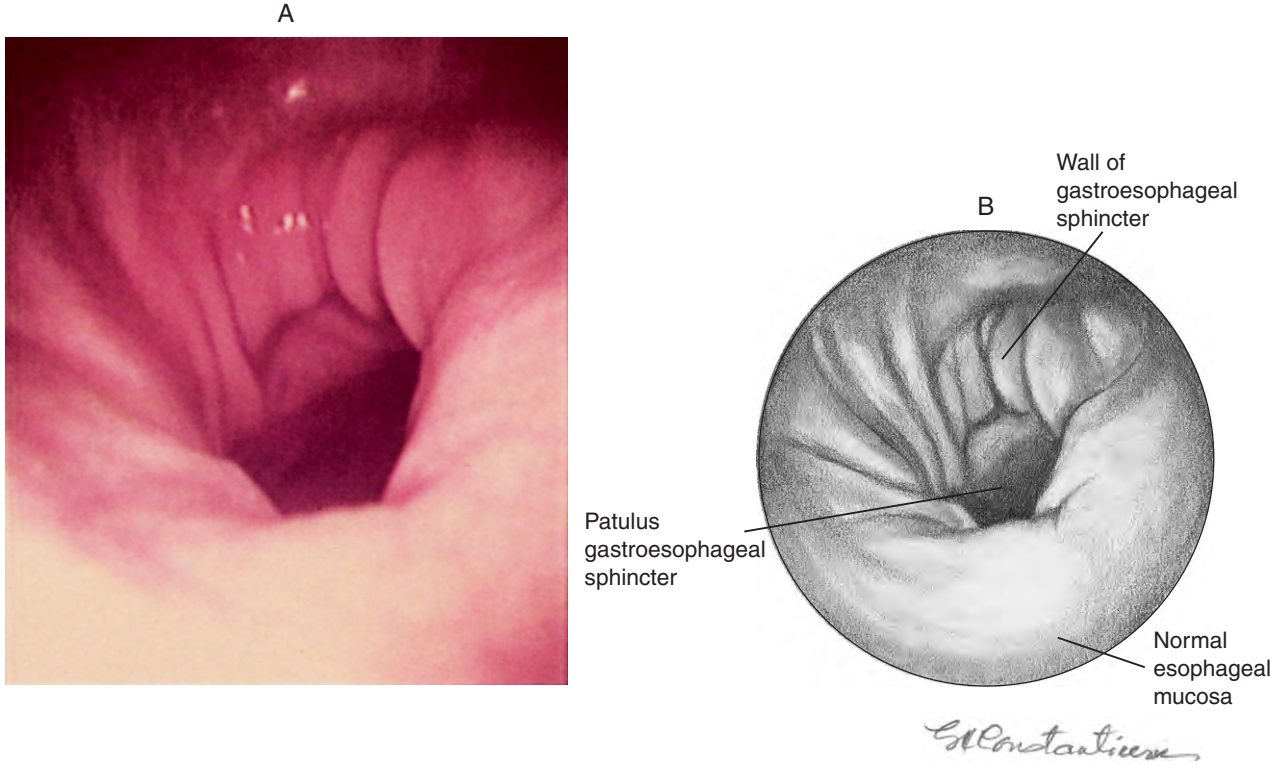



**Fig. 8–7**
Patulous gastroesophageal sphincter. The gastroesophageal sphincter is usually closed at the time of examination but occasionally may gape open. Little significance should be afforded such patulous lower esophageal sphincters unless the surrounding esophageal mucosa shows evidence of esophagitis.

## Appearance of the Abnormal Esophagus

Dogs with megaesophagus usually have fluid and fermenting food retained in their esophagus. The mucosal folds of the overdistended esophagus are often so voluminous that it is difficult to pass the endoscope to the lower esophageal sphincter. A similar problem arises with gastroesophageal intussusception, because the endoscope continually passes into blind folds caused by inversion of the stomach into the esophagus. At times, gastroesophageal intussusceptions can be reduced by insufflation of the esophagus while occluding the upper esophageal sphincter with digital pressure.

Esophagitis may or may not be visually apparent even when marked histologic changes are present. Gross abnormalities suggestive of esophagitis include erythema, erosions, irregularity, and strictures (Fig. 8-8).

Esophageal strictures appear as circumferential narrowings of the esophageal lumen (Figs. 8-9 through 8-11). There may be an associated esophagitis cranial to the stricture (see Fig. 8-10), presumably secondary to fermentation of food, or caudal to the stricture suggestive of gastroesophageal reflux. The lumen of strictures is often narrow (1 to 2 mm), and the length usually ranges from 1 to 6 cm. If the lumen is sufficiently wide, radial fibrotic striations are often apparent in the stricture wall (Fig. 8-12). Postinflammatory strictures, resulting from causes such as ingestion of caustic materials or gastroesophageal reflux during anesthesia, usually have a smooth surface devoid of erosions. Multiple strictures can occur at intervals down the esophagus. In contrast, strictures caused by neoplasia of the esophageal mucosa are usually solitary and often have a friable appearance. Biopsy specimens are taken from all strictures to assist differentiation of fibrotic and neoplastic strictures. Treatment is by bougienage or balloon catheter dilation.

Hiatal hernias are occasionally diagnosed by endoscopy. They appear as a ballooning of the distal esophageal wall into the esophageal lumen. The ballooning often occurs at the same rate as respiration. There is usually an associated esophagitis. Leiomyomas infrequently occur at the gastroesophageal junction. The growth of these masses can evert gastric mucosa into the esophagus, providing endoscopic evidence that a tumor is present (Fig. 8-13). Other esophageal tumors, such as sarcomas and carcinomas, are usually more obvious, appearing as friable and often ulcerating masses.

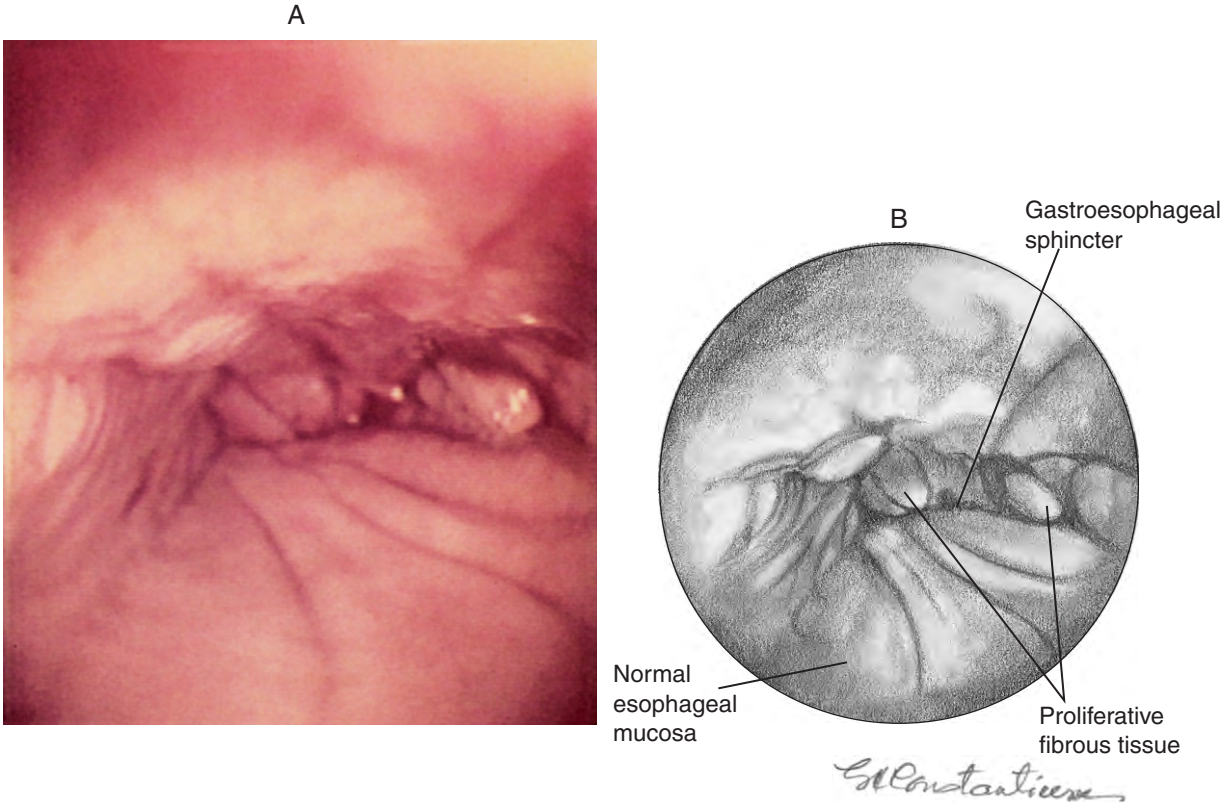



**Fig. 8-8**
Reflux esophagitis. The gastroesophageal junction of a dog with chronic and severe esophagitis. Note the prominent mucosal irregularity. *(Courtesy Dr. Kim Robinson.)*

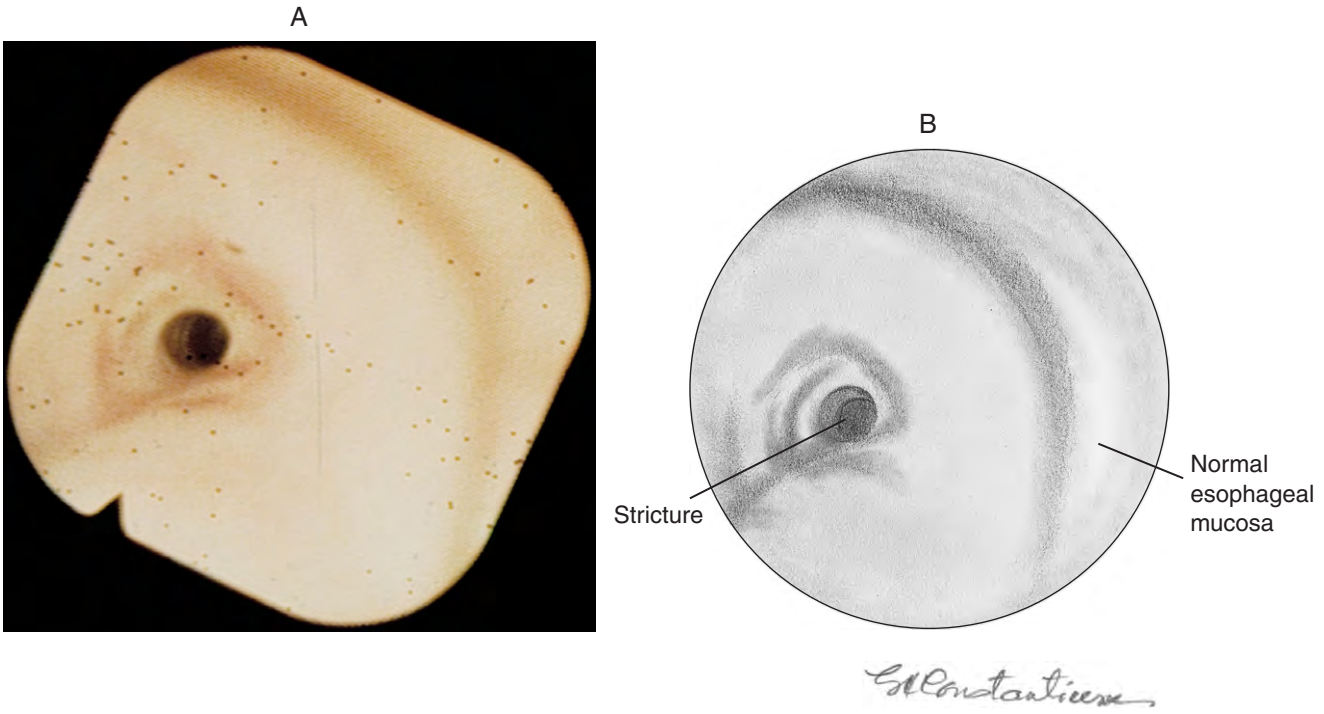



**Fig. 8-9**
Esophageal stricture without esophagitis. The lumen of the esophagus is seen to narrow markedly. The mucosa is pale, and there is no indication of a concurrent esophagitis.

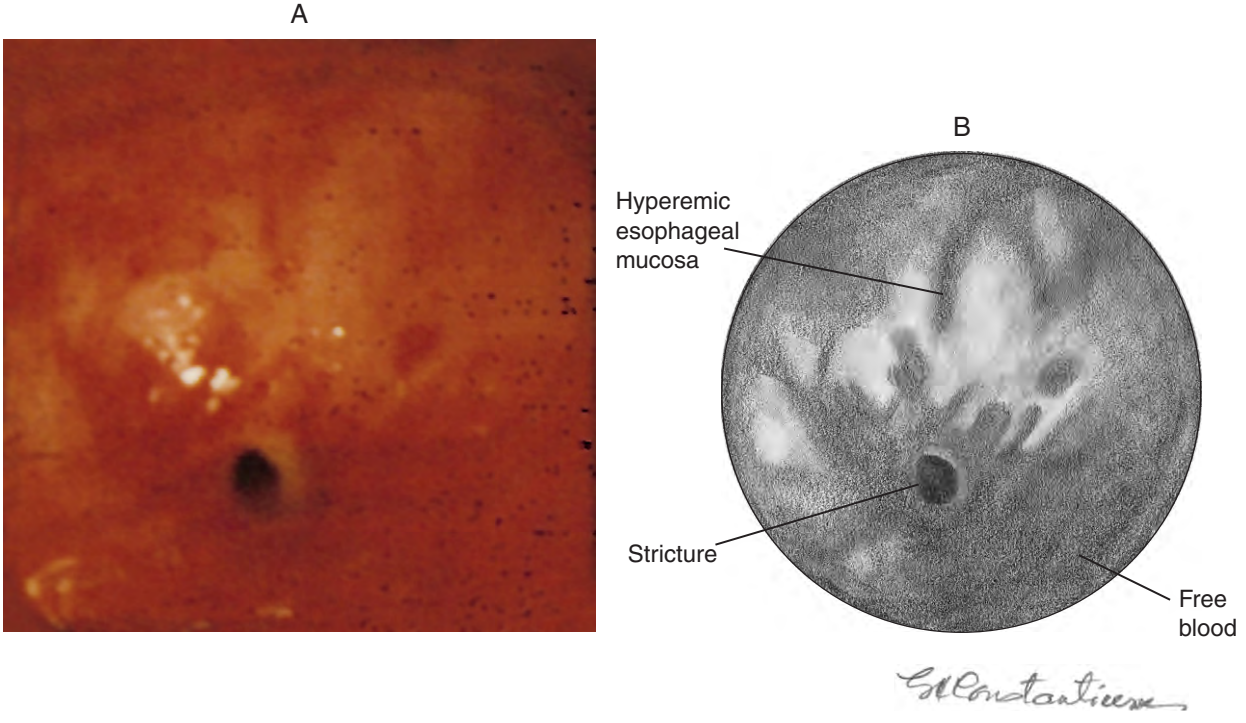



**Fig. 8-10**
Esophageal stricture with esophagitis. In contrast to Fig. 8-9, this esophageal stricture is associated with marked mucosal erythema and hemorrhage suggestive of esophagitis.

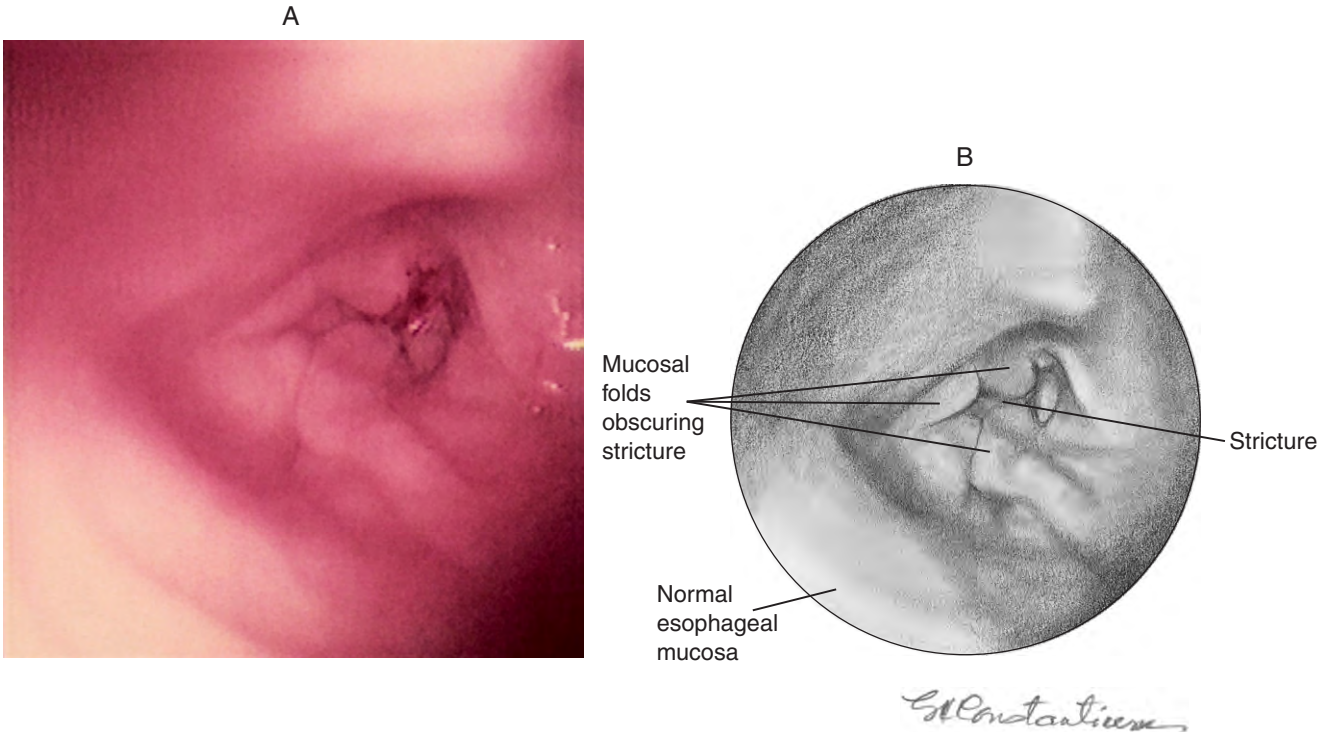



**Fig. 8-11**
Esophageal stricture before balloon dilation. This cat was presented with a history of regurgitation beginning a few weeks after a routine anesthetic was given. Endoscopy revealed this stricture in the thoracic esophagus. Folds of esophageal mucosa obscure the lumen of the stricture.

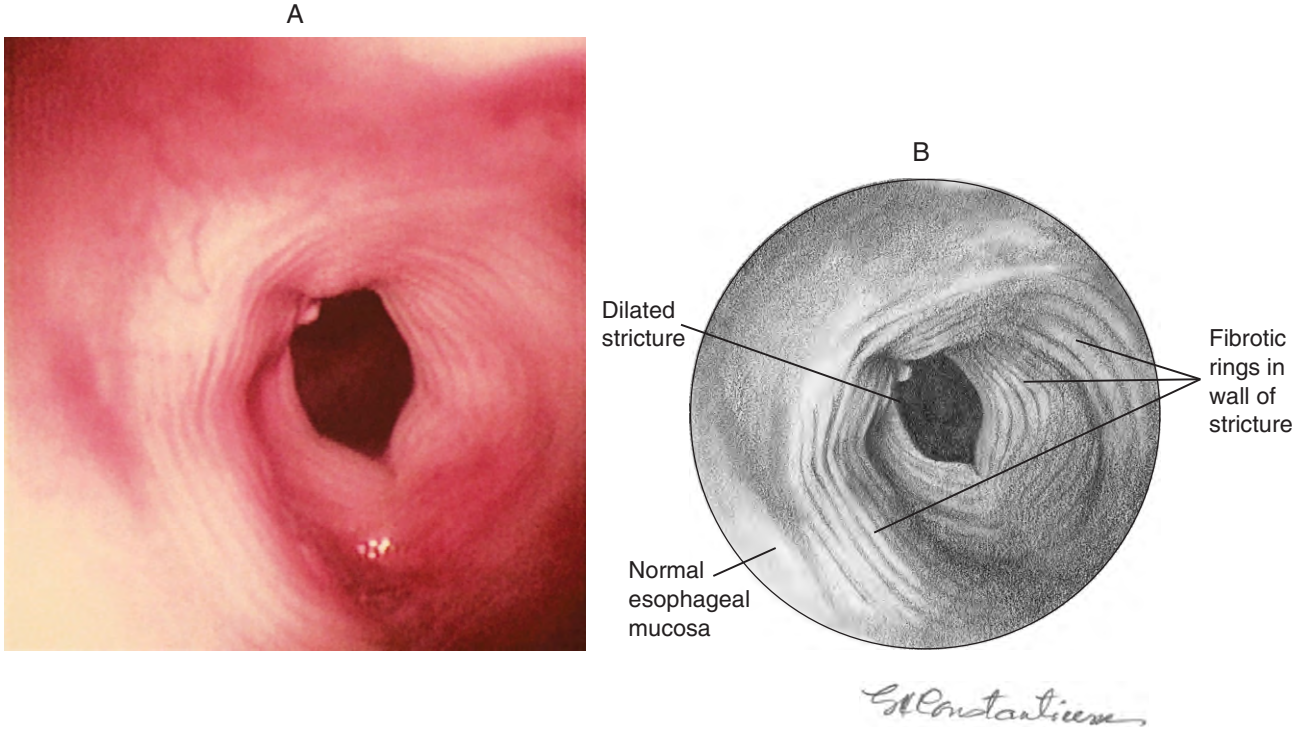



**Fig. 8-12**
A dilated stricture. The stricture shown in Fig. 8-11 has been successfully dilated. Note the radial fibrotic rings in the wall of the stricture.

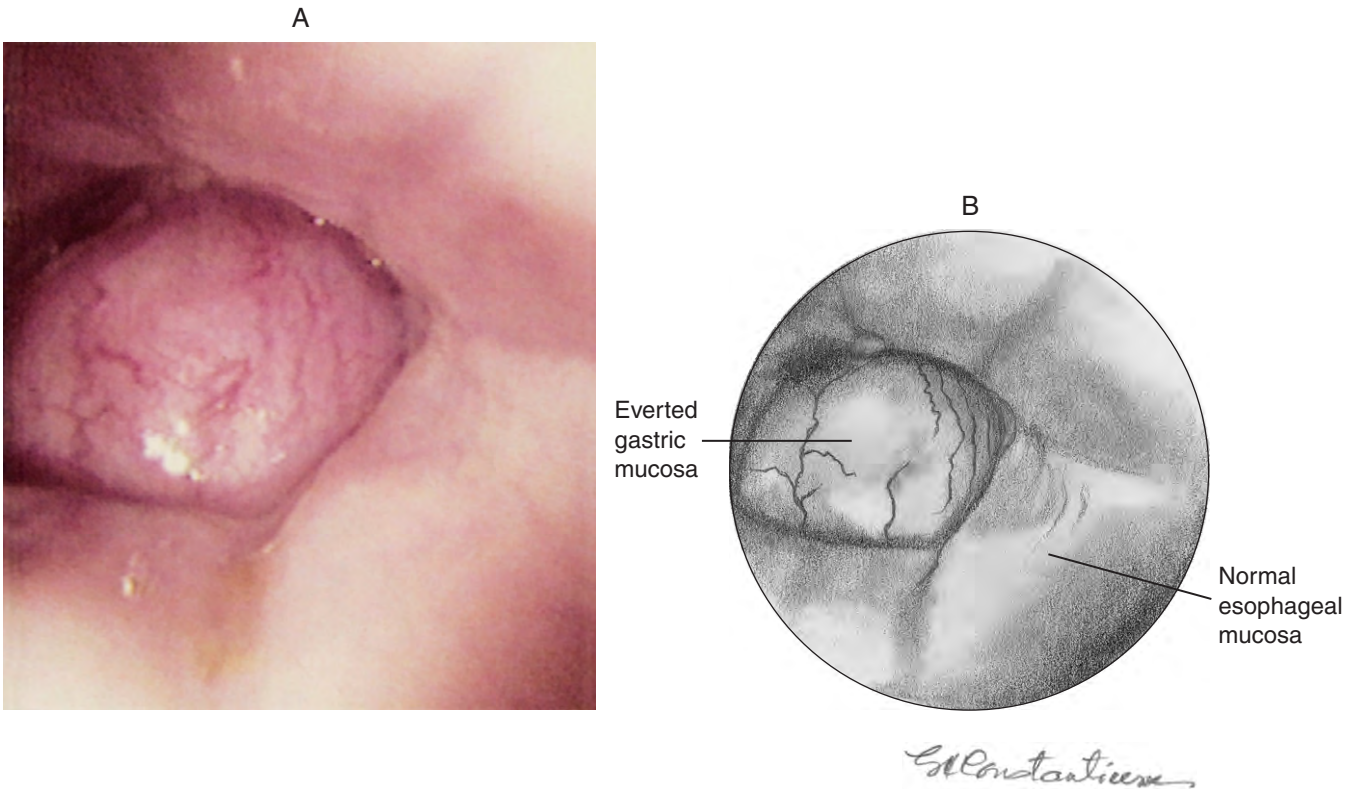



**Fig. 8-13**
Eversion of gastric mucosa into the esophagus. Gastric mucosa can be seen everted into the lumen of the esophagus. The mucosal eversion was due to a leiomyoma at the gastroesophageal junction.

## GASTROSCOPY

The large size of the stomach means that the endoscopist must develop a systematic approach to gastroscopy, otherwise lesions will be missed. The anatomy of the stomach and duodenum is depicted in Fig. 8-14.

### Examination of the Body of the Stomach

Following examination of the esophagus, the endoscope is gently advanced through the gastroesophageal sphincter into the stomach. On entry into the stomach, the mucosa of the nondistended stomach usually interferes with vision until the stomach is partially insufflated (Fig. 8-15). The first part of the stomach wall that is visualized is the junction of the fundus and body. Slight deviation of the tip of the scope away from the mucosa allows the endoscopist to obtain a panoramic view of the body of the stomach as it is inflating (Figs. 8-16 and 8-17).

The endoscopist and anesthetist need to be cognizant of the readiness with which the stomach inflates and the rugal folds disappear. If the stomach does not inflate properly, the possible causes are that air is exiting the stomach via the esophagus (firmly occlude by digital pressure if necessary), that the equipment is not insufflating correctly, or that the stomach is unable to distend due to extramural compression or an intramural lesion. Overdistention of the stomach is avoided because it impedes venous return, decreases respiratory tidal volume, allows a "belly" to develop in the insertion tube, which inhibits maneuverability of the endoscope, and increases antral and pyloric contraction frequency by way of the antral reflex, both of which make passage of the endoscope into the duodenum more difficult (see Fig. 8-2). Animals with an overdistended stomach have a tympanic abdomen and flattened rugae.

After the gastric panorama has been enjoyed, the endoscope is advanced. The natural progression of the aborally directed endoscope is along the greater curvature of the stomach toward the incisura angularis, which appears as a crescent-shaped fold at the distal end of the gastric body (see Fig. 8-17). The incisura angularis is an important landmark. It is a narrow fold that divides the pyloric antrum from the lesser curvature of the gastric body (see Fig. 8-14).

### Examination of the Lesser Curvature, Cardia, and Fundus

Particular care is taken to observe the fundus, cardia, and lesser curvature. These areas of the stomach are easily overlooked if the tip of the endoscope is single-mindedly

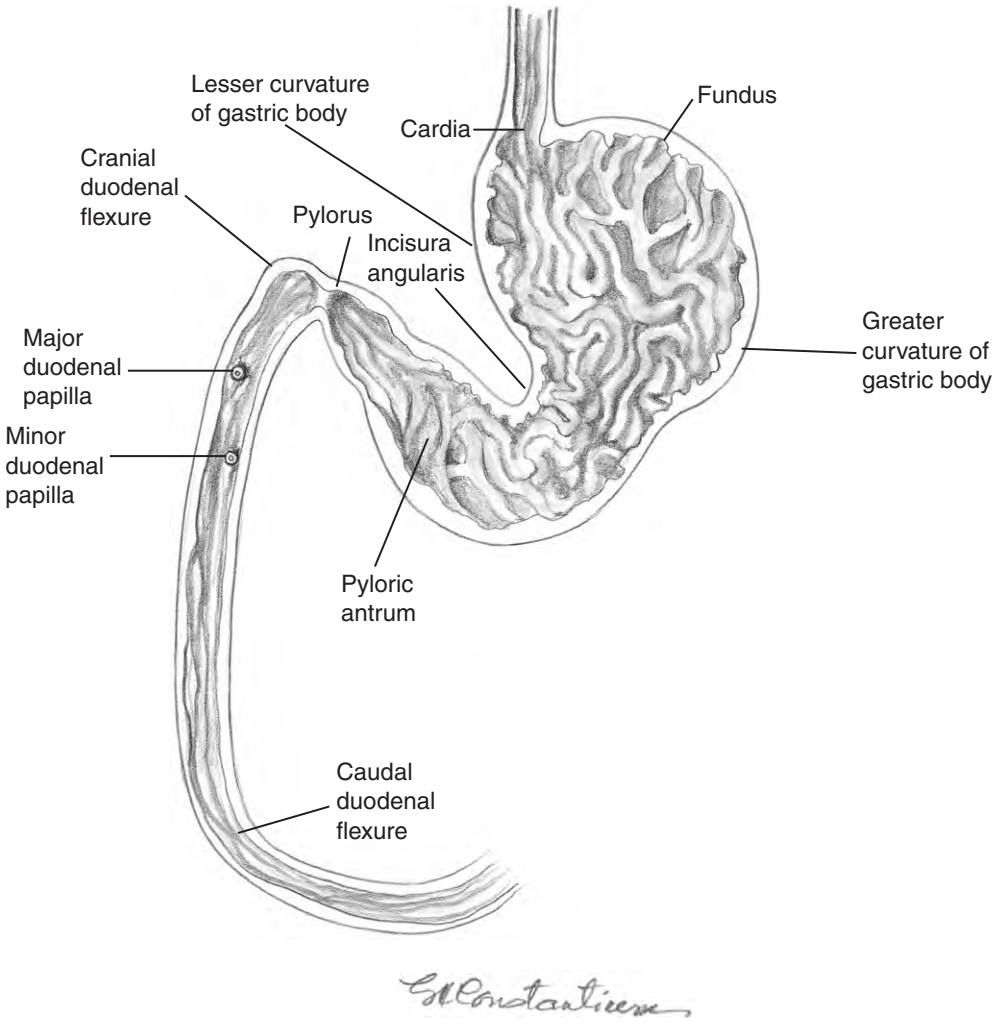



**Fig. 8-14**
Anatomy of the stomach and cranial duodenum. Endoscopists should be familiar with the anatomy of the stomach to facilitate orientation. One landmark of particular note is the incisura angularis, a mucosal fold that separates the pyloric antrum and gastric body. Also note that the rugae tend to have a longitudinal orientation toward the pyloric antrum, providing a track to follow, and that there are few rugae folds in the pyloric antrum. The acute cranial duodenal flexure can be difficult to negotiate. In dogs, the caudal duodenal flexure is usually the most distal part of the upper gastrointestinal tract that can be examined.

passed to the pylorus along the greater curvature. These areas can be visualized by firm retroflexion of the endoscope away from the greater curvature as the tip nears the pyloric antrum (Fig. 8-18). This maneuver, sometimes called the *J-maneuver*, usually necessitates counterclockwise rotation of the up-down deflection knob to its fullest extent. If the expected view is not obtained, gentle advancement of the curved tip of the endoscope into the mucosa usually guides the endoscope back on itself and achieves full retroflexion.

The J-maneuver provides a dramatic en face view of the incisura (Fig. 8-19). Once the incisura is identified, to one side is seen the pyloric antrum and to the other side is seen the lesser curvature with the cardia dimly identifiable in the distance (Fig. 8-20). Small torquing motions of the retroflexed endoscope allows the endoscopist to switch from a view of the antrum to a view of the cardia. The cardia is easily identified by the presence of the insertion tube of the endoscope (Fig. 8-21). Withdrawal of the retroflexed endoscope brings the cardia into close proximity. If the antrum is in view when the retroflexed endoscope is withdrawn, the pylorus comes clearly into view. Pyloric intubation cannot be achieved by this maneuver.

If fluid is retained in the stomach, it pools in the fundus and proximal greater curvature of the body. Pooled fluid assists identification of this area but inhibits

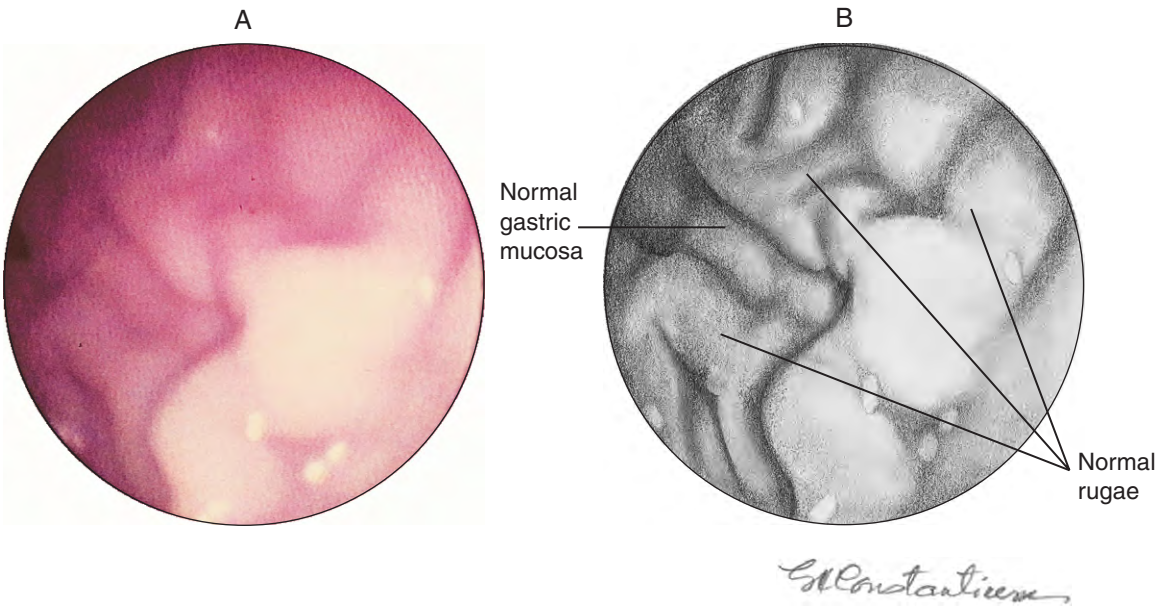



**Fig. 8-15**
Normal rugae of a partially distended stomach. The normal gastric mucosa has a pale pink color. When not distended, rugae are prominent.

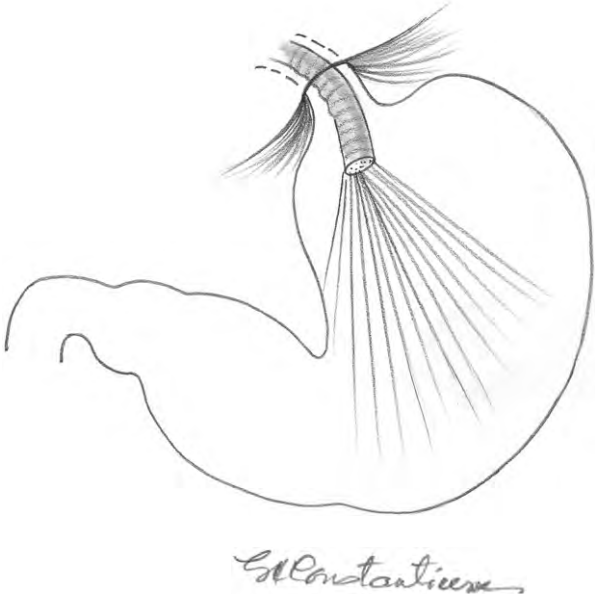


**Fig. 8-16**
Diagram of the endoscopic view from the cardia. When the tip of the endoscope is at the cardia, a panoramic view of the body of the stomach can be obtained. In the distance, the entrance to the antrum can usually be seen. From this view, the incisura angularis appears as a crescent-shaped fold on the dorsal margin of the angularis. The cardia and parts of the fundus, pyloric antrum, and lesser curvature of the gastric body cannot be visualized from this view.

visualization of the mucosa. Large volumes of retained fluid are aspirated to facilitate mucosal examination and to prevent aspiration during recovery.

## Examination of the Pyloric Antrum

Advancement of the endoscope into the pyloric antrum can sometimes present difficulties. In cats, the flexure between the body and antrum can be sufficiently acute that vision is temporarily lost as the endoscope slides into the antrum. In large dogs, particularly if their stomach is overdistended, as the endoscope is advanced there is a tendency for a loop of insertion tube to become "embedded" in the distal greater curvature of the stomach (see Fig. 8-2). As forward pressure is applied to the endoscope at the mouth, the loop is forced further into the mucosa, resulting in little forward progress and a lack of control of the movement of the tip. At times, the loop becomes the leading edge of the endoscope, stretching the greater curvature and paradoxically drawing the tip away from the pylorus as the endoscopist applies forward pressure to the insertion tube. There can also be a tendency for the tip of the endoscope to flip over the incisura toward the cardia rather than under it toward the pylorus.

These problems can usually be remedied by withdrawing the endoscope to the cardia, aspirating most of the air from the stomach, and leaving just sufficient air to provide limited vision, and then repeating the advance of the endoscope into the antrum. Inching the endoscope forward while intermittently deflecting the tip downward into the mucosa of the greater curvature can also be of

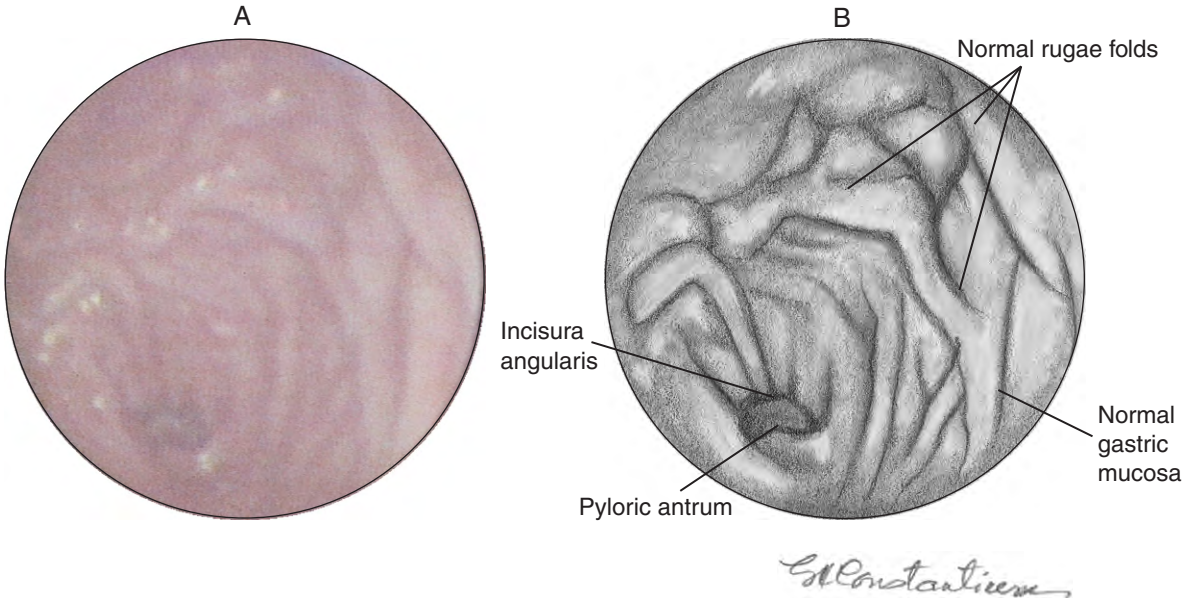



**Fig. 8–17**
Gastric panorama viewed from the cardia with partial gastric distention (endoscopic view of the diagram in Fig. 8-16). The dark lumen of the pyloric antrum can be seen at the bottom of the figure. Note the general progression of the rugae folds in the direction of the pyloric antrum.

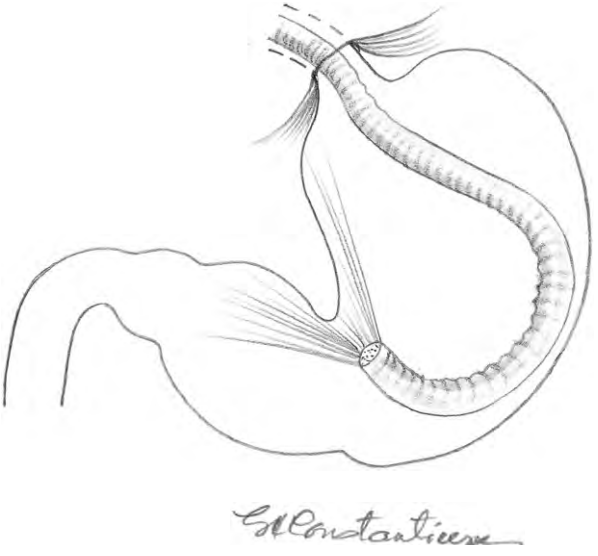


**Fig. 8–18**
Diagram of the J-maneuver. Retroflexion of the endoscope when the endoscope tip is approaching the pyloric antrum (sometimes called the *J-maneuver*) provides an en face view of the incisura angularis. Torquing the endoscope brings the pyloric antrum or lesser curvature into view. Withdrawal of the endoscope while the tip is retroflexed allows the endoscopist to closely inspect the cardia.

assistance, as can applying firm pressure to the lower right body wall with the flat of the hands. Abdominal compression appears to flatten the flexure between the antrum and body, facilitating passage of the endoscope around the flexure.

Once in the antrum (Fig. 8-22), the endoscope usually begins to move freely again and the tip of the endoscope is slowly advanced toward the pylorus. Vision may be temporarily obscured by rings of antral contraction. During this part of the procedure, the lesser curvature of the pyloric antrum is examined closely because lesions in this area can be easily missed, especially when using scopes with narrow angles of view.

## Pyloric Intubation

Adroit manipulation of the endoscope is often necessary to penetrate the pylorus. As the endoscope approaches the pylorus, the pyloric canal is maintained in the center of the field of vision. If the pylorus is in the center of the antrum, maintaining this view may simply require fine adjustments of one or both deflection knobs. If the pylorus is off-center, particularly to left-of-center, torquing of the endoscope is usually necessary. At times, even this is insufficient and the patient must be temporarily repositioned to realign the pylorus.

As the tip of the endoscope contacts the pylorus, clear vision is usually temporarily lost, but the impression of a dark space (the pyloric canal) surrounded by pale red mucosa is often retained. Firm forward pressure is applied

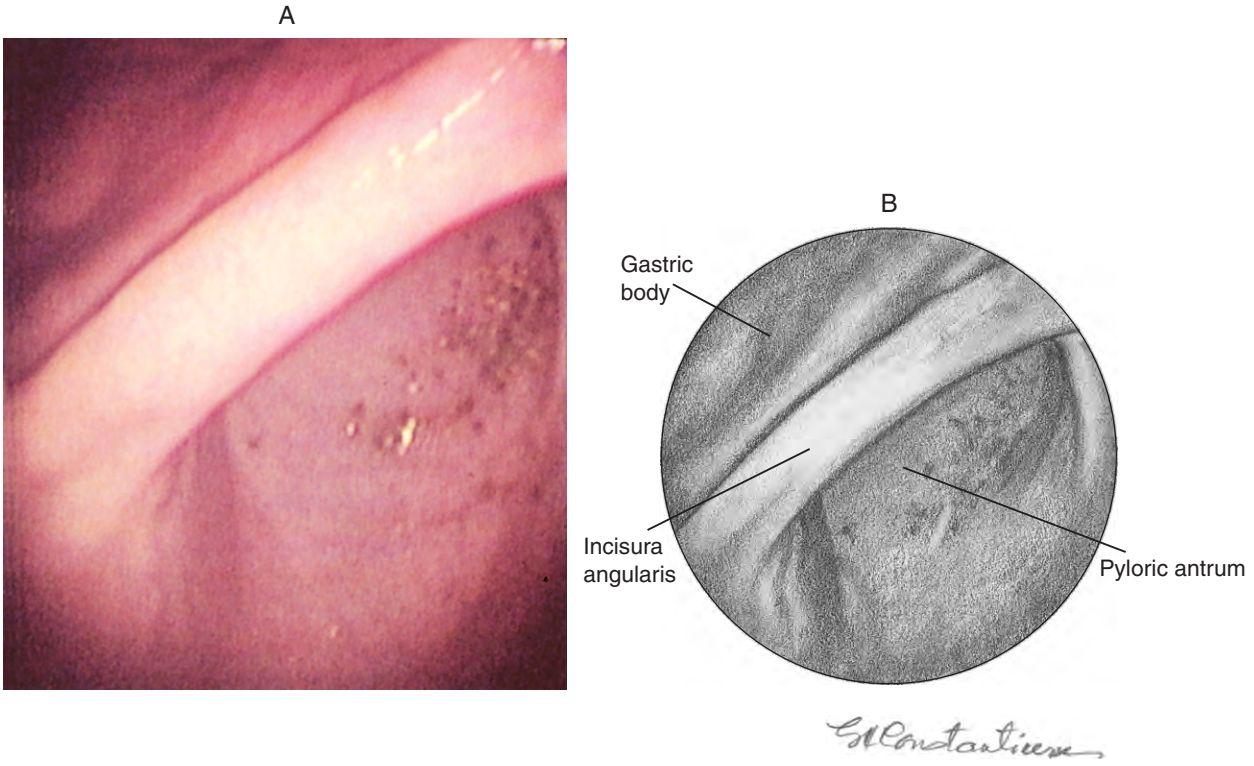



**Fig. 8–19**
En face view of the incisura angularis of the stomach. The incisura angularis is an important landmark. It divides the lesser curvature and separates the gastric body (*top left*) from the pyloric antrum (*bottom right*).

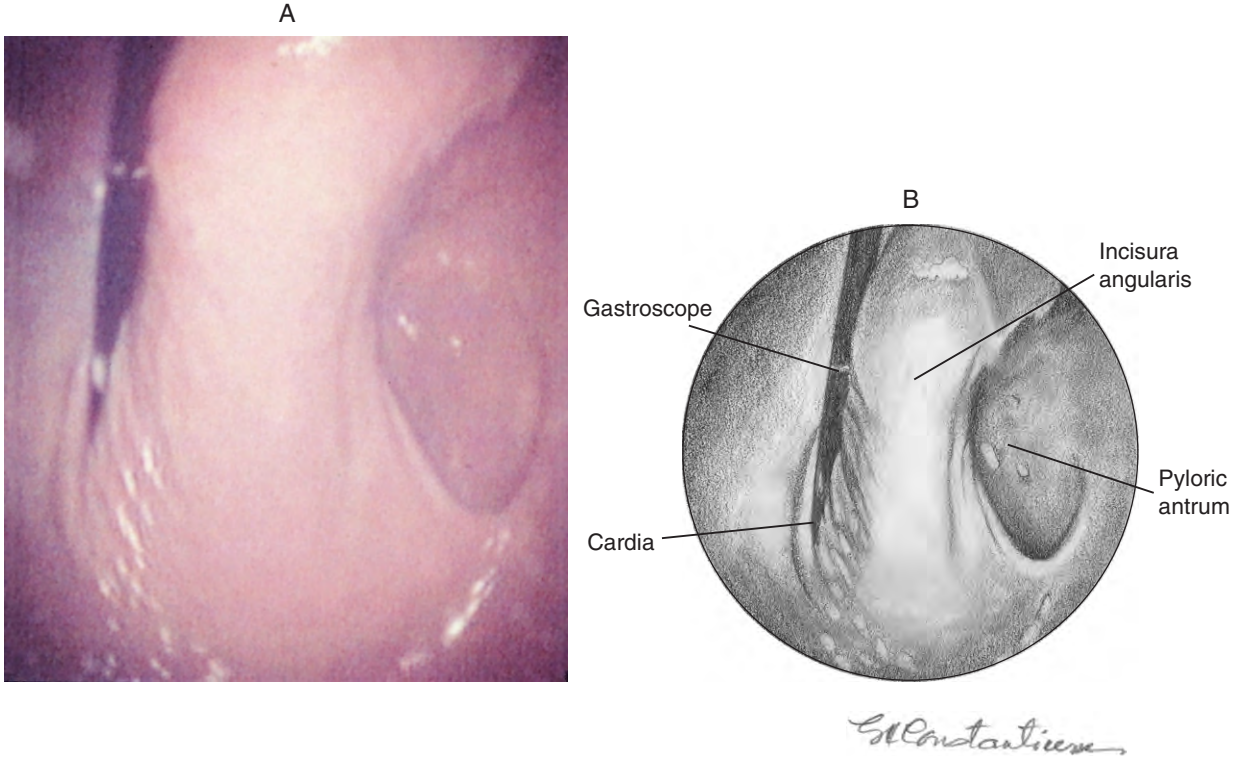



**Fig. 8–20**
Incisura angularis with cardia and antrum. An en face view of the incisura angularis. The cardia and endoscope can be seen on the left and the pyloric antrum on the right.

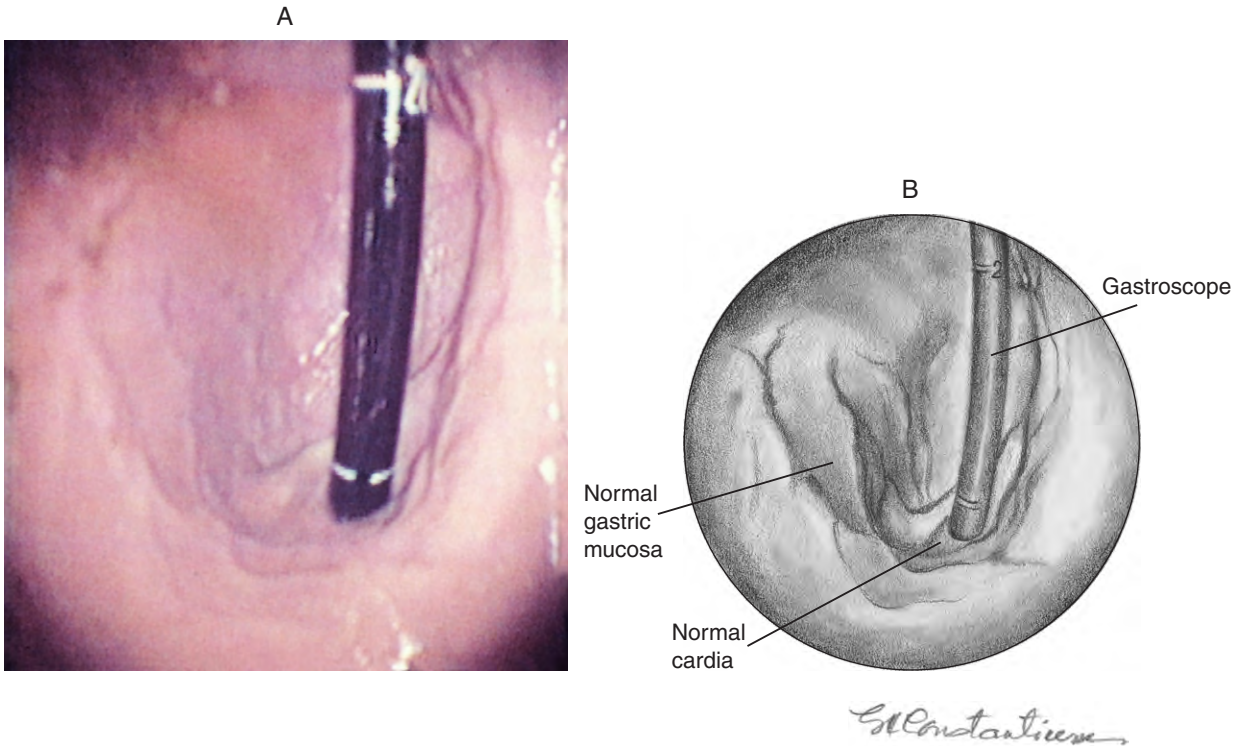



**Fig. 8-21**
Normal gastric cardia. The cardia is easily identified by the presence of the insertion tube of the endoscope.

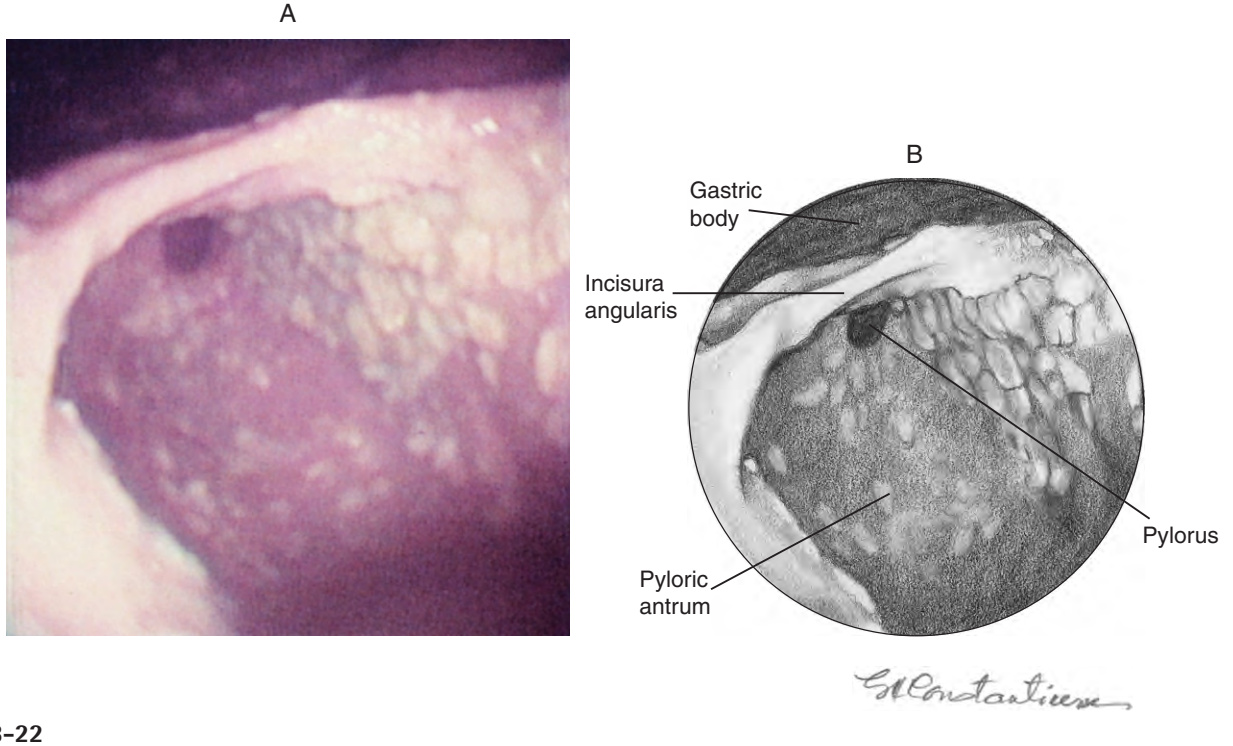



**Fig. 8-22**
Normal pyloric antrum and pylorus. In this view of the pyloric antrum, the incisura angularis can be seen at the top of the picture. The darkened area above the incisura is the cardia. Note the absence of rugae in the antrum. Partially digested food can be seen adherent to the antral wall. The pyloric canal is temporarily open.

to the insertion tube, the endoscopist continually insufflates with air and meticulously maintains the pyloric canal in the center of the field. The normal pylorus usually dilates to accommodate the endoscope. As the pylorus begins to yield, the endoscope tip is deflected downward and to the right to assist entrance into the duodenum.

As the duodenum is entered, vision is often still obscured but a change in mucosal coloration to a darker red or a yellow-tinged red (bile) may be noted. If the endoscope is freely moving, as indicated by the sliding of mucosa across the lens, forward pressure on the insertion tube is maintained for another 5 to 10 cm. Thereafter, methodical deflection of the tip of the endoscope and insufflation of air usually achieve a luminal view. If the endoscopist has successfully negotiated the pylorus, this luminal view is of the descending duodenum distal to the cranial duodenal flexure. If the endoscopist has failed to penetrate the pylorus, a disappointing picture of the stomach and insertion tube is seen. The reason for the difficulty in visualizing the lumen of the duodenum immediately after the pylorus is penetrated is because the endoscope encounters the cranial duodenal flexure (see Fig. 8-14). This is an acute flexure that can be difficult to negotiate. It arises because of the rapid change of the right-cranial angulation of the pylorus and cranial duodenum to the caudal orientation of the descending duodenum. Many inexperienced endoscopists who have difficulty passing the endoscope into the duodenum are successful in penetrating the pylorus but not in rounding the cranial duodenal flexure. This problem can usually be overcome by the slide-by technique described earlier. As the endoscopist becomes more experienced, more of the cranial duodenum is clearly visualized as the endoscope rounds the cranial duodenal flexure.

If the pylorus does not admit the endoscope, it may be relaxed with metoclopramide (0.2 mg/kg intravenously [IV]). This may assist pyloric intubation in some animals, but in others it greatly enhances antral contractions, creating a "moving target." In my experience, glucagon (0.05 mg/kg, not to exceed 1 mg, IV) has been more useful than metoclopramide for the relaxation of the antrum and pylorus. In some animals, however, glucagon induces a pronounced tachycardia.

Common problems encountered by inexperienced endoscopists during gastric examination and suggested remedies are listed in Table 8-1.

## Appearance of the Normal Stomach

The normal stomach may contain small amounts of clear or yellow-tinged fluid, but after a 12-hour fast should be devoid of food. The mucosa is smooth (see Fig. 8-15). It has a bright pink to red color and is lighter in the pyloric region. Patches of erythema are sometimes seen (Fig. 8-23). These are usually physiologic and are presumably due to variations in local blood flow. Submucosal vessels can be clearly observed in the fundus and cardia (Fig. 8-24), but are usually not visible in the normal gastric body unless the stomach is overinflated. The lesser curvature is characterized by fewer and straighter mucosal folds than the greater curvature. There are usually no rugal folds in the pyloric antrum (see Fig. 8-22). The antrum is the only part of the stomach with contractions recognizable by endoscopy.

The pylorus of normal dogs has a wide variety of appearances (Fig. 8-25). In general it has clean margins, is not obscured by excessive folds, and usually demonstrates rhythmical opening and closing. Occasionally, gastroduodenal reflux of bile or foam is noticed, which is a normal occurrence in many dogs and cats.

## Appearance of the Abnormal Stomach

Chronic gastritis is the most frequent gastric abnormality detected by endoscopy. In mild gastritis, the mucosa may appear normal and the diagnosis is made histologically. More severe gastritis is characterized by mucosal thickening, granularity, friability, erosions, and subepithelial or frank hemorrhage (Fig. 8-26).

Prominent rugal folds in the stomach body are usually due to ineffective insufflation but hypertrophic gastropathy must be considered. In hypertrophic gastropathy, the rugae often appear thickened and have prominent light reflectivity suggestive of edema. In contrast to normal rugae, full insufflation of the stomach does not result in elimination of hypertrophic mucosal folds. Furthermore, the folds may be focal and may extend into the antrum, where it is unusual in normal animals to find many rugae. Mucosal erosions or ulcers may be apparent. In contrast, atrophic gastritis is characterized by a reduction in the number and size of rugal folds and by visible submucosal blood vessels in the gastric body.

Pyloric stenosis is due to hypertrophy of the pyloric musculature. The hypertrophic pylorus usually has an enlarged, protuberant appearance with a small pyloric canal that is unable to accommodate the endoscope (Fig. 8-27). Pyloric obstruction can also occur from focal hypertrophic gastritis affecting the pylorus or pyloric antrum. Failure to intubate the pylorus is usually due to technical problems and not an abnormal pylorus. The endoscopist should only suspect pyloric obstruction if the patient's history indicates delayed gastric emptying, if the pylorus has an abnormal appearance, and if retained gastric ingesta or rugal hypertrophy are observed.

Gastric erosions are shallow areas of mucosal disruption. The bed of the erosion usually has a red or brown color from accumulated blood. Erosions are most often seen in association with inflammatory diseases of the stomach but may also result from stress or drugs such as nonsteroidal antiinflammatory drugs (NSAIDs). Foreign bodies often excoriate the mucosa, producing erosions.

*Table* 8-1 Gastric Examination, Trouble Shooting

| Problem | Reason | Remedy |
|---|---|---|
| Inability to visualize the gastric lumen. | Inadequate insufflation. Can be due to rapid loss of air through the esophagus or pylorus; equipment failure or depression of the aspiration button on the handpiece instead of or along with the insufflation button; extragastric compression; gastric mural disease. | Manually occlude the esophagus; check equipment function; continually depress insufflation button to keep pace with rapid, ongoing losses. |
| Pyloric antrum and pylorus in view but scope does not advance into the antrum. The endoscope may "flip" over the angularis toward the cardia or appear to move away from the pylorus when forward pressure is applied. | Gastric overdistention or laxity in the greater curvature, creating a "belly" in the endoscope. | Withdraw scope to cardia, partially deflate stomach and try again. Reduce compliance of greater curvature by compressing lower abdominal wall with flat of hand. Inch endoscope forward while intermittently deflecting the tip downward (into the mucosa of the greater curvature). |
| Unable to negotiate pylorus. | Increased pyloric tone due to gastric overdistention or narcotic administration; lateral placement of the pylorus in the antrum; anatomic pyloric obstruction. | Partially deflate stomach; torque endoscope to allow utilization of the maximum deflection capability; metoclopramide or glucagon to reduce pyloric tone. |
| Insufficient working length to reach the pylorus. | Human pediatric endoscope in a large dog. | Position endoscope tip in the pyloric antrum and slowly deflate stomach while attempting to keep the pylorus in view. Eventually the deflation reduces the length of insertion tube necessary to traverse the gastric body and provides sufficient length to intubate the pylorus. |

Gastric ulcers are mucosal disruptions that penetrate into the submucosa or deeper. They often have a raised, thickened margin. The bed of the ulcer is usually dark brown, due to accumulated blood, or dirty yellow or white, due to accumulation of necrotic tissue. The first indication that an ulcer is present may be accumulation of digested (brown) blood in the gastric fundus. Most ulcers I have observed via endoscopy have been due to gastric adenocarcinoma, leiomyoma, or leiomyosarcoma. Ulcers resulting from gastric adenocarcinoma are usually associated with broad areas of induration (Fig. 8-28). Ulcers due to leiomyomas are usually crater-like with raised margins. Drug-induced ulcers resulting from administration of NSAIDs or glucocorticoids are also common. Ulcers associated with NSAIDs are usually located in the antrum. Benign stress-associated ulcers are not common in dogs or cats.

Gastric polyps are benign protuberances of the gastric mucosa. They are rare in dogs and cats, and are usually not associated with clinical signs unless they are sufficiently large to obstruct gastric outflow.

Gastric neoplasms can have a variety of appearances. They may ulcerate, as described earlier, or appear as raised plaques or masses (see Fig. 8-28). Infiltrative neoplasms, such as lymphosarcoma, usually appear as diffusely thickened mucosa. The indurated mucosa often feels heavy and yields little as the endoscope or biopsy forceps contacts it.

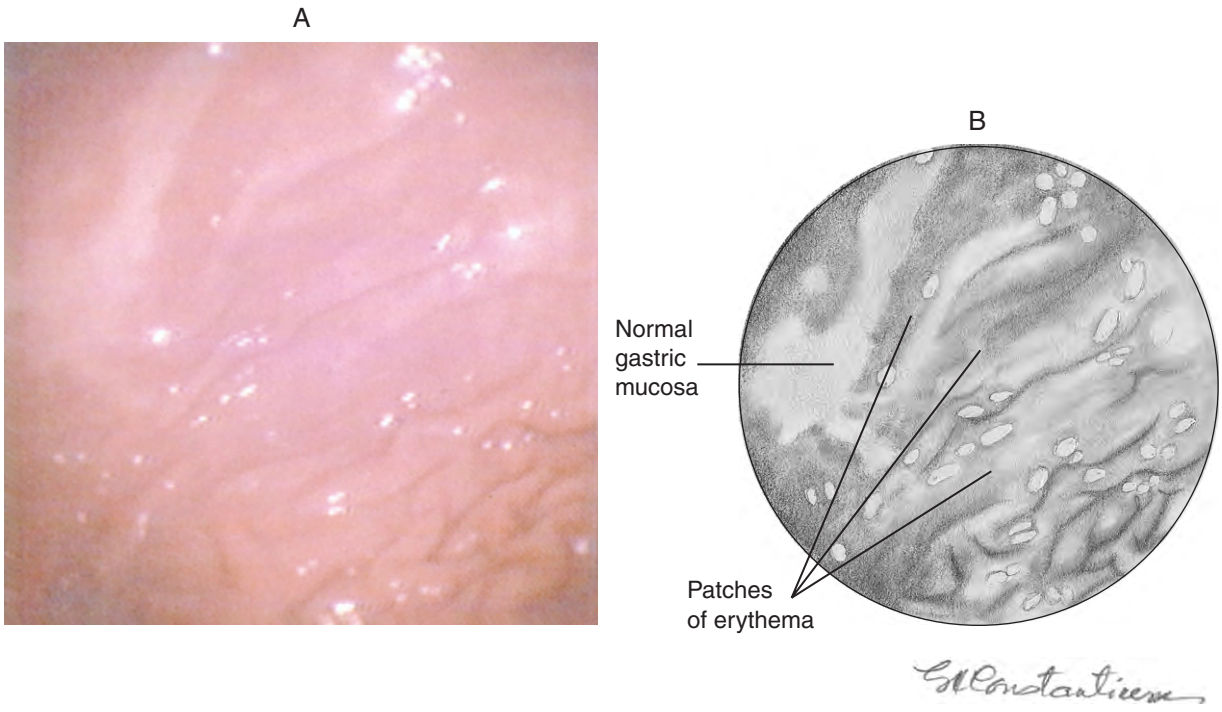



**Fig. 8-23**
Patchy gastric mucosal erythema. Patches of mucosal erythema are sometimes seen in the stomach. These are usually physiologic and are presumably due to variations in local blood flow.

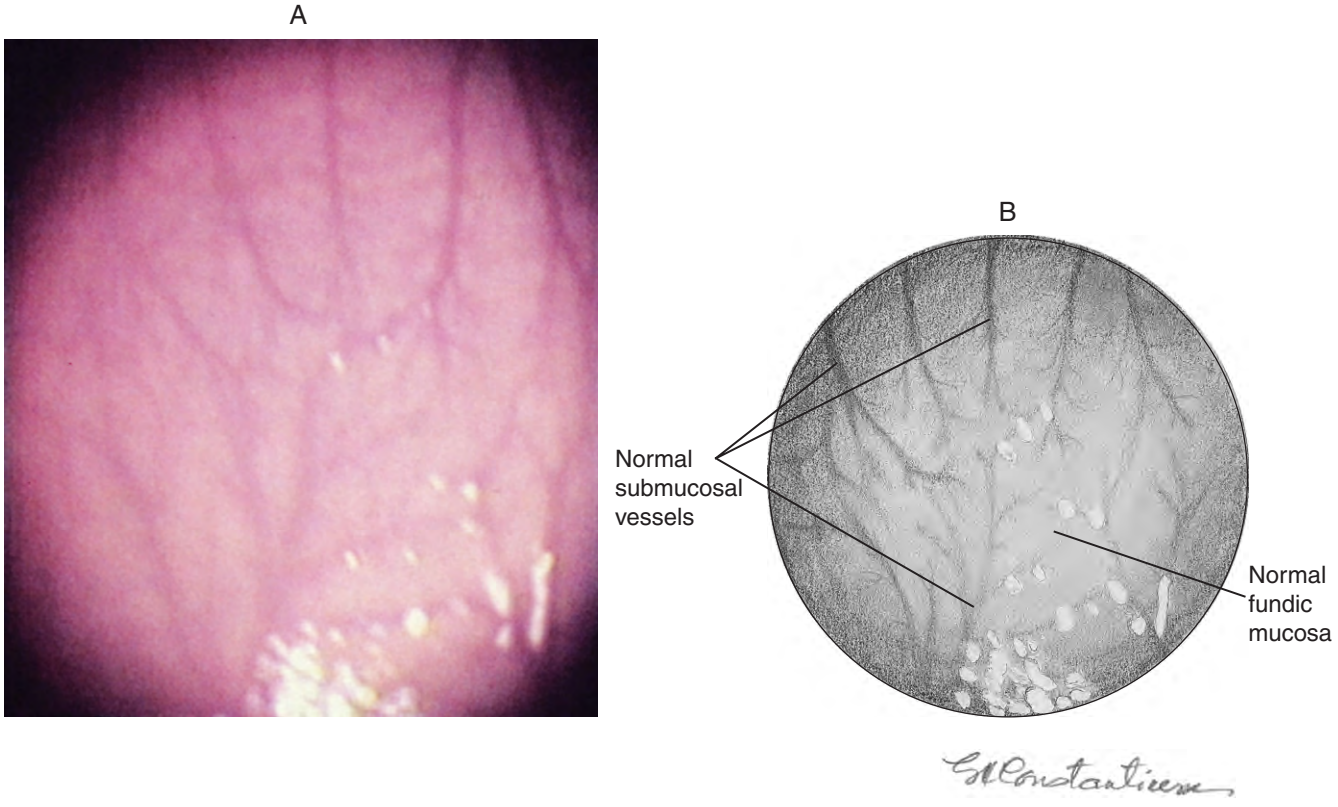
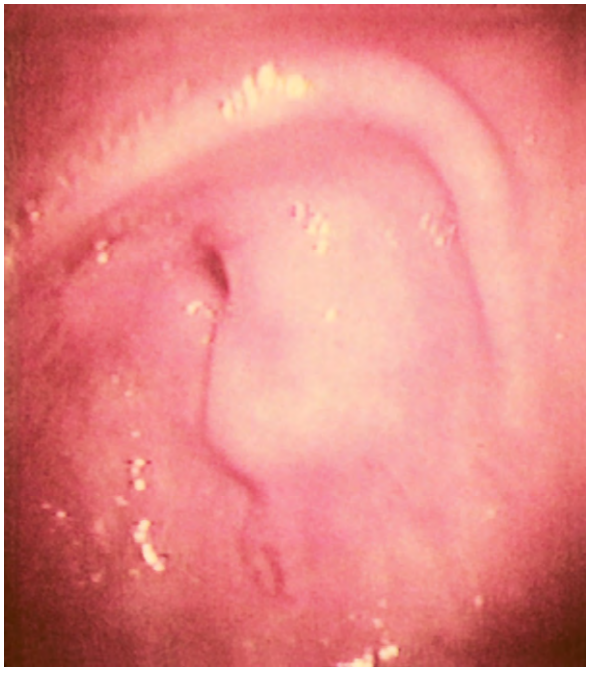
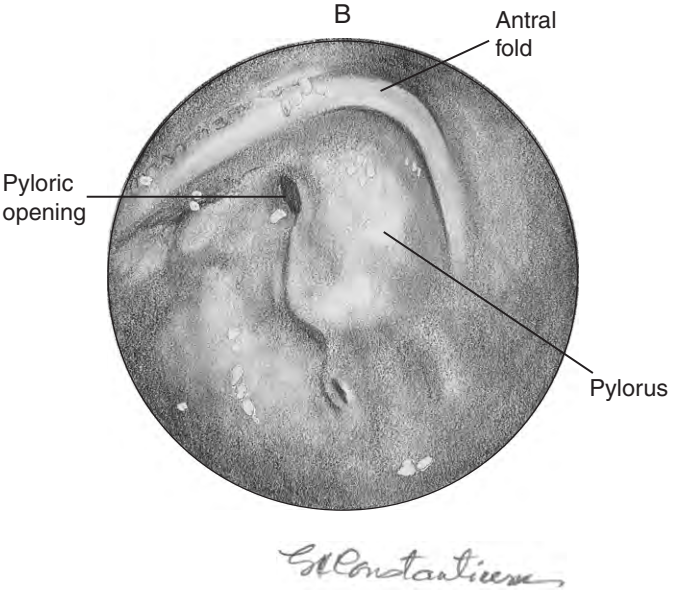



**Fig. 8-24**
Submucosal blood vessels of the normal gastric fundus. Submucosal vessels can be clearly observed in the fundus and cardia, but are usually not visible in the normal gastric body unless the stomach is overinflated.

A



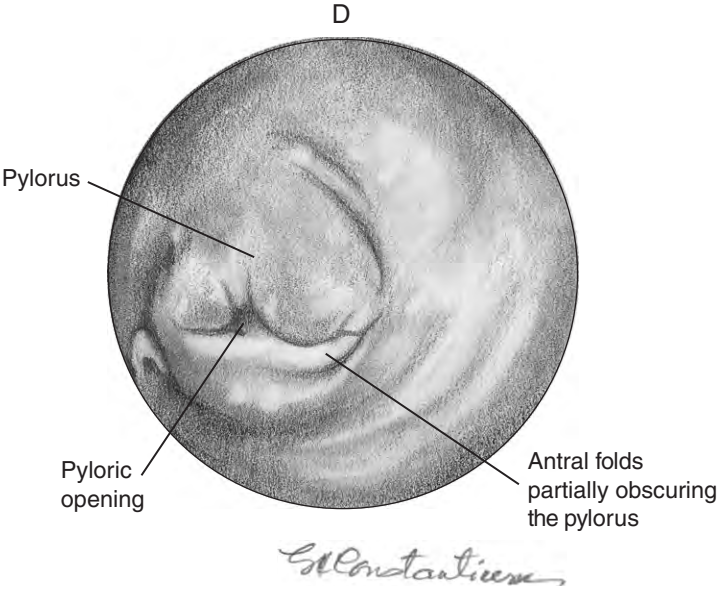
B


Antral fold
Pyloric opening
Pylorus

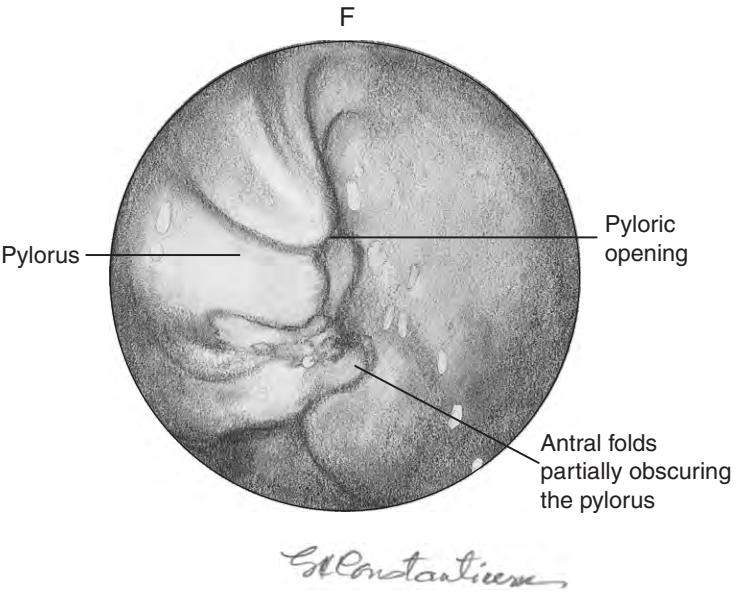
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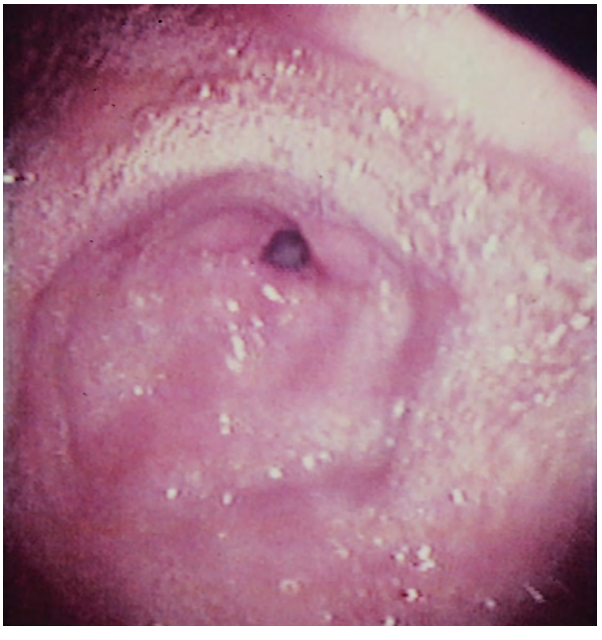


D


Pylorus
Pyloric opening
Antral folds partially obscuring the pylorus



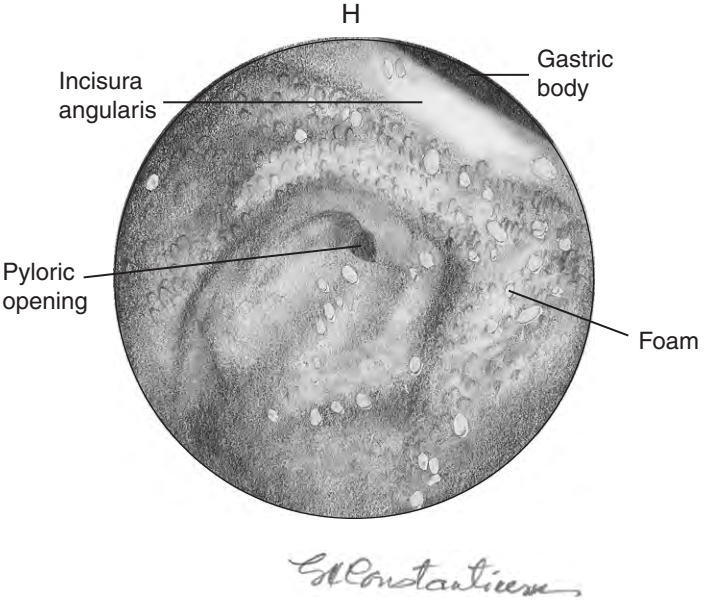




**Fig. 8-25**
Variations of the normal pylorus. The pylorus of normal dogs has a wide variety of appearances. **A and B,** In general, it has clean margins and is not obscured by excessive folds. **C, D, E, and F,** The occasional fold positioned above or below the pylorus is not abnormal. **G and H,** A small amount of foam is often adherent to the antrum in the region of the pylorus.

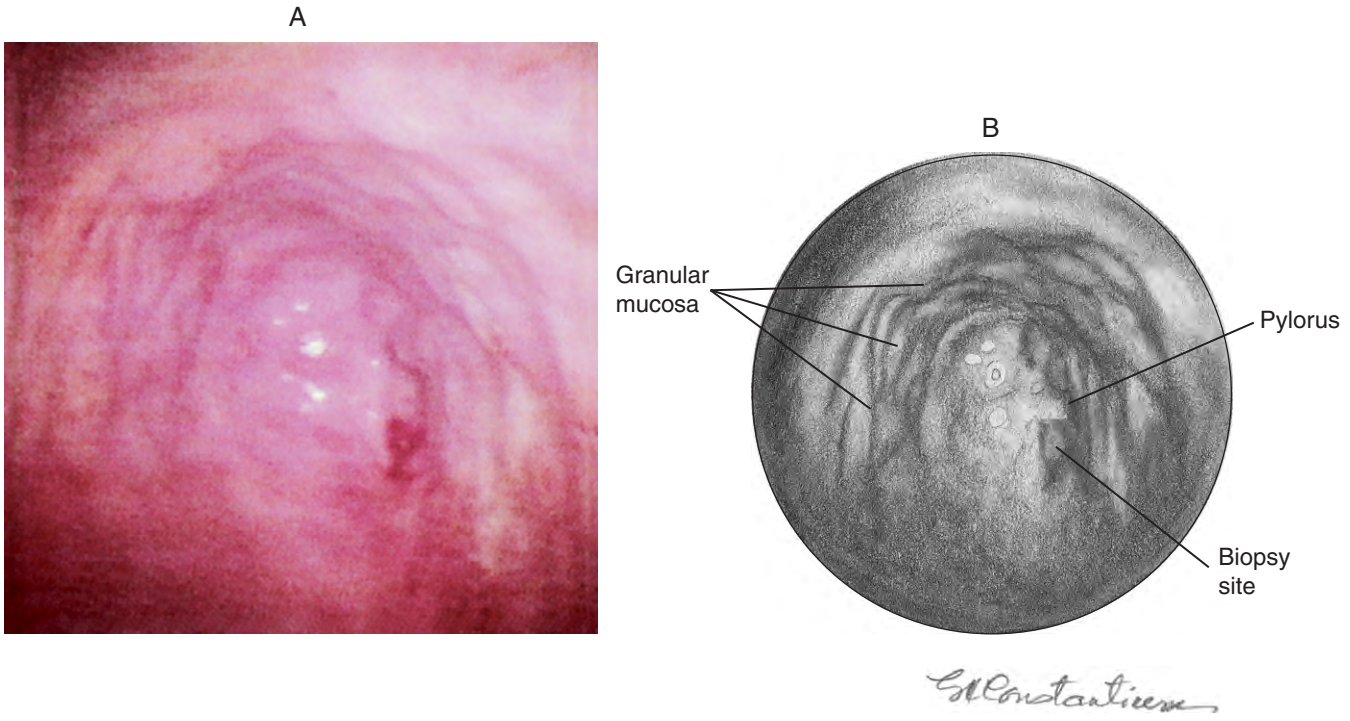



**Fig. 8-26**
Gastric granularity associated with chronic gastritis. The smooth mucosa of the normal pyloric antrum is replaced in this dog by a granular mucosa suggestive of chronic gastritis.

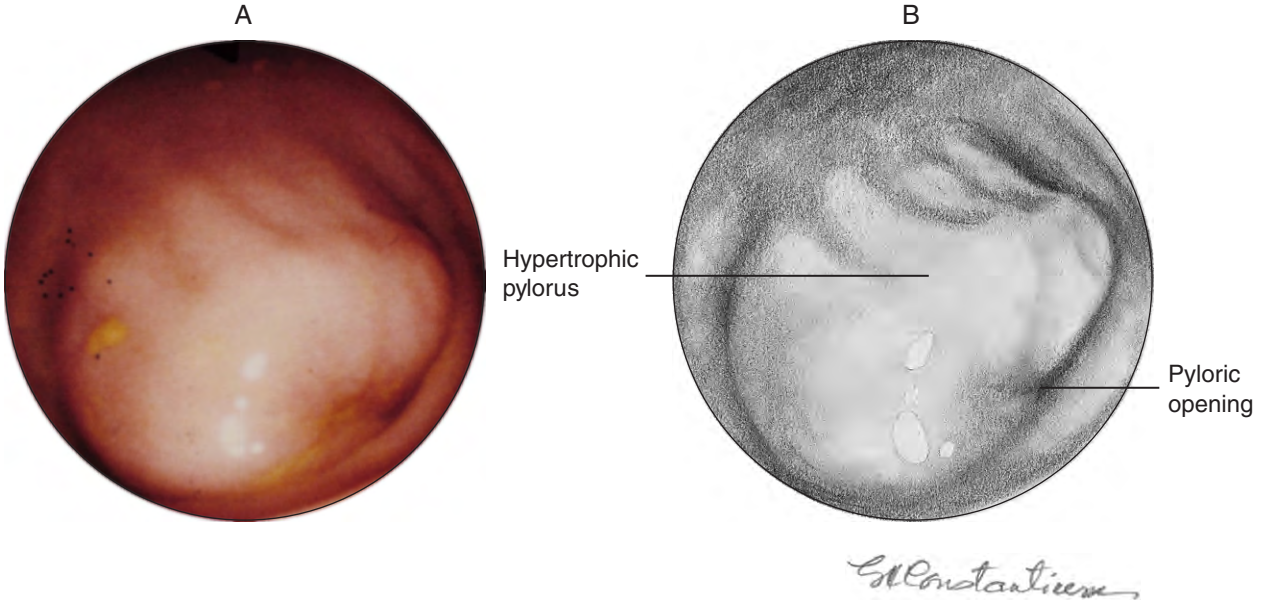



**Fig. 8-27**
Pyloric hypertrophy. Note the protuberant and muscular appearance of this hypertrophic pylorus.
*(Courtesy Dr. Brent Jones.)*

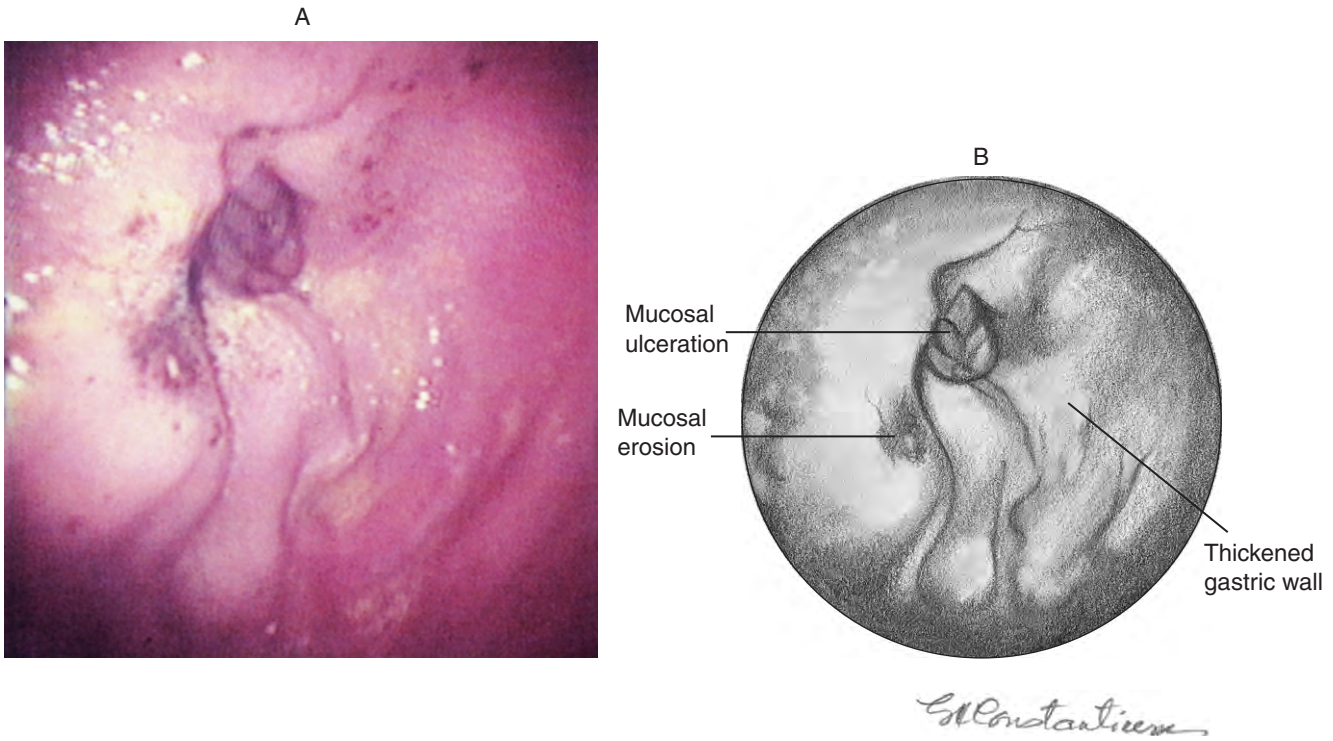



**Fig. 8-28**
Gastric adenocarcinoma. The entire incisura angularis has been invaded by an ulcerated adenocarcinoma. *(Courtesy Dr. Sherri Wilson.)*

Parasites are occasionally encountered in the stomach. The most commonly recognized is Physaloptera, a short, stout nematode. The parasite can be snared and removed after a short rodeo.

## DUODENOSCOPY

After passing the pylorus and rounding the cranial duodenal flexure, the endoscopist should obtain a luminal view of the descending duodenum (Figs. 8-29 and 8-30). Careful examination of the proximal duodenum may reveal the duodenal papillae (two in the dog, one in the cat). Because the papillae are positioned immediately after the cranial duodenal flexure, they are often overlooked. They usually appear as small, white, relatively flat protuberances (Fig. 8-31).

The endoscope is slowly advanced down the descending duodenum until the majority of the working length is used. It is usually possible to reach the caudal duodenal flexure (Fig. 8-32). In some patients, this flexure can be negotiated and the short ascending duodenum and the proximal jejunum examined. The mobility of the tip of the endoscope is reduced in the duodenum by the convolutions of the insertion tube in the stomach. As a result, the slide-by technique (see Fig. 8-4) is usually required to negotiate flexures in the duodenum and jejunum. Torquing the instrument at this point is also difficult, particularly if there is excess belly in the insertion tube as it rounds the greater curvature.

The normal duodenal mucosa is redder than the stomach and may have a yellow tinge (Fig. 8-33). Submucosal vessels are not apparent. The mucosa has a fine granular appearance due to the duodenal villi. It is more friable than that of the stomach. As a result, linear mucosal erosions are frequently left in normal mucosa by the passage of the endoscope around flexures (Fig. 8-34). Peyer's patches may be observed in the duodenum of dogs. They appear as large oval depressions in the mucosa up to several centimeters in length (Figs. 8-35 and 8-36). They are often multiple.

Abnormal duodenal mucosa usually develops a pronounced granularity and friability (Figs. 8-37 and 8-38). These abnormalities are most commonly associated with inflammatory bowel disease. Care must be taken in the assessment of duodenal granularity because this feature of the duodenum is markedly influenced by the degree of distention. The author prefers to distend the duodenum to its full extent before judging granularity. The diseased duodenal mucosa usually bleeds freely when contacted by the endoscope. Passage of the endoscope around bends may leave deep excoriations. Infiltrative neoplasms such as lymphosarcoma usually result in marked

*Text continued on p. 309.*

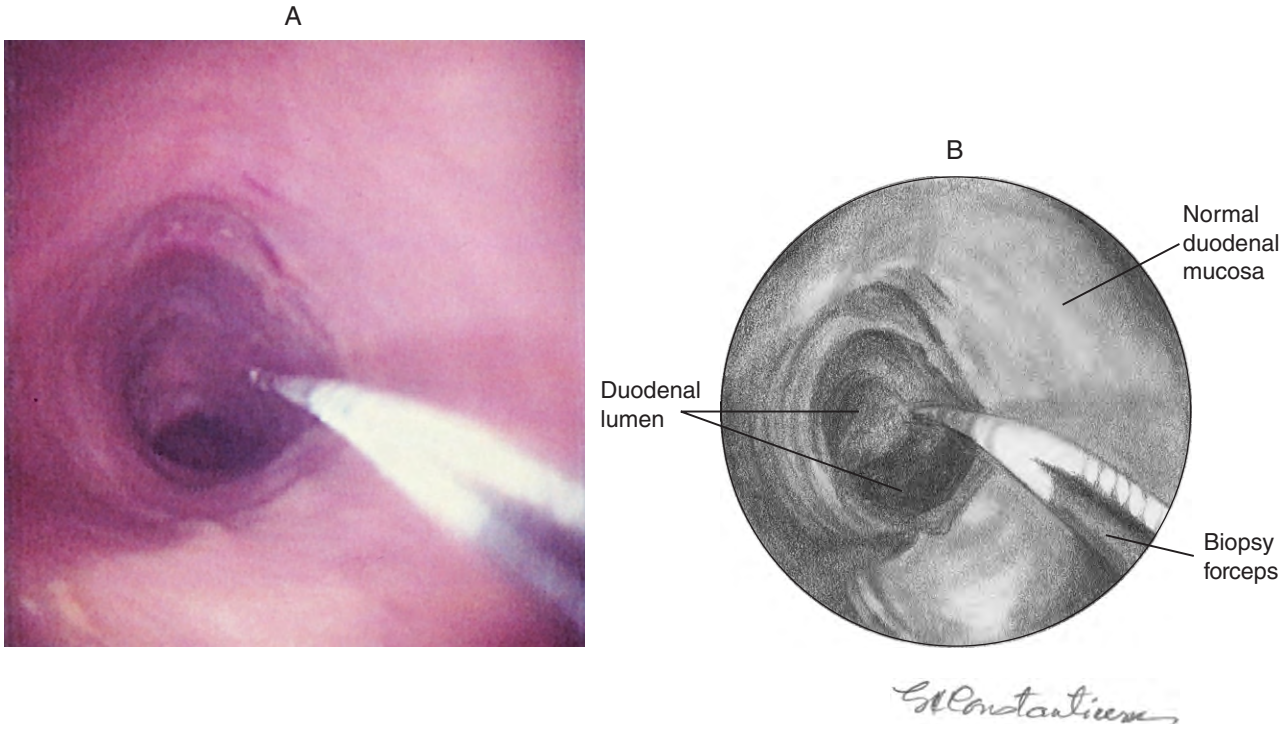



**Fig. 8-29**
Luminal view of the normal descending duodenum. Note the smooth appearance of the mucosa.

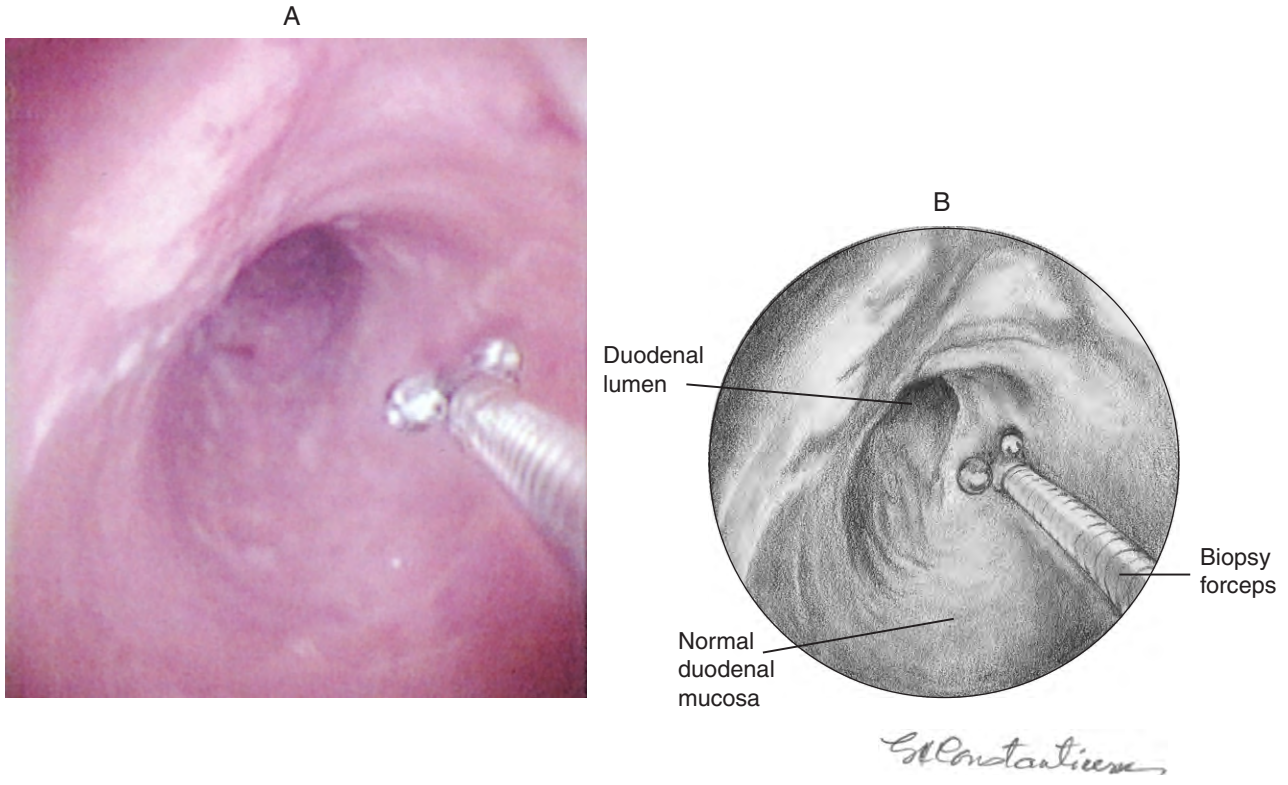



**Fig. 8-30**
Luminal view of the normal descending duodenum. The mucosa is relatively smooth. Small quantities of mucus are adherent to the duodenal wall.

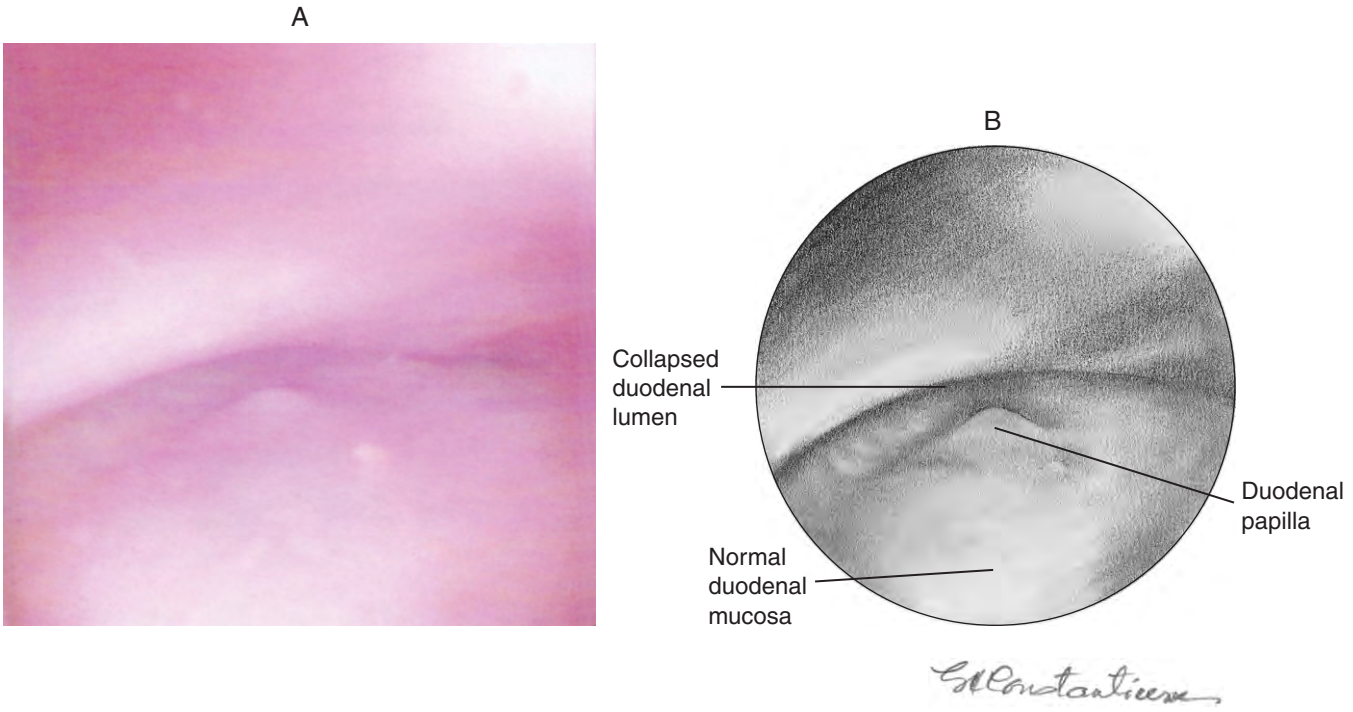



**Fig. 8-31**
Duodenal papilla. The duodenal papillae usually appear as small, white, relatively flat protuberances.

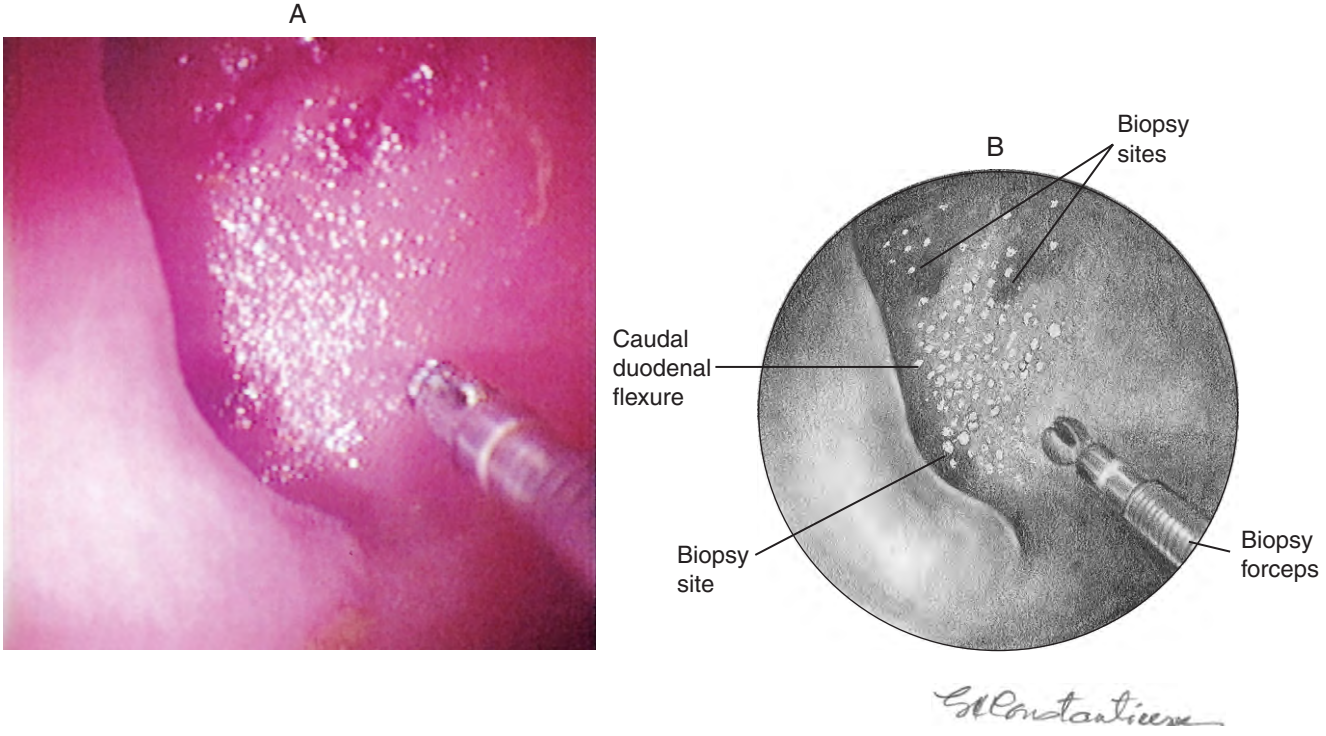



**Fig. 8-32**
Caudal duodenal flexure. The caudal flexure of the duodenum is the most distal part of the gastrointestinal tract examined in most dogs. It is a good site from whence to obtain biopsy samples. Note the fine granularity of the mucosa.

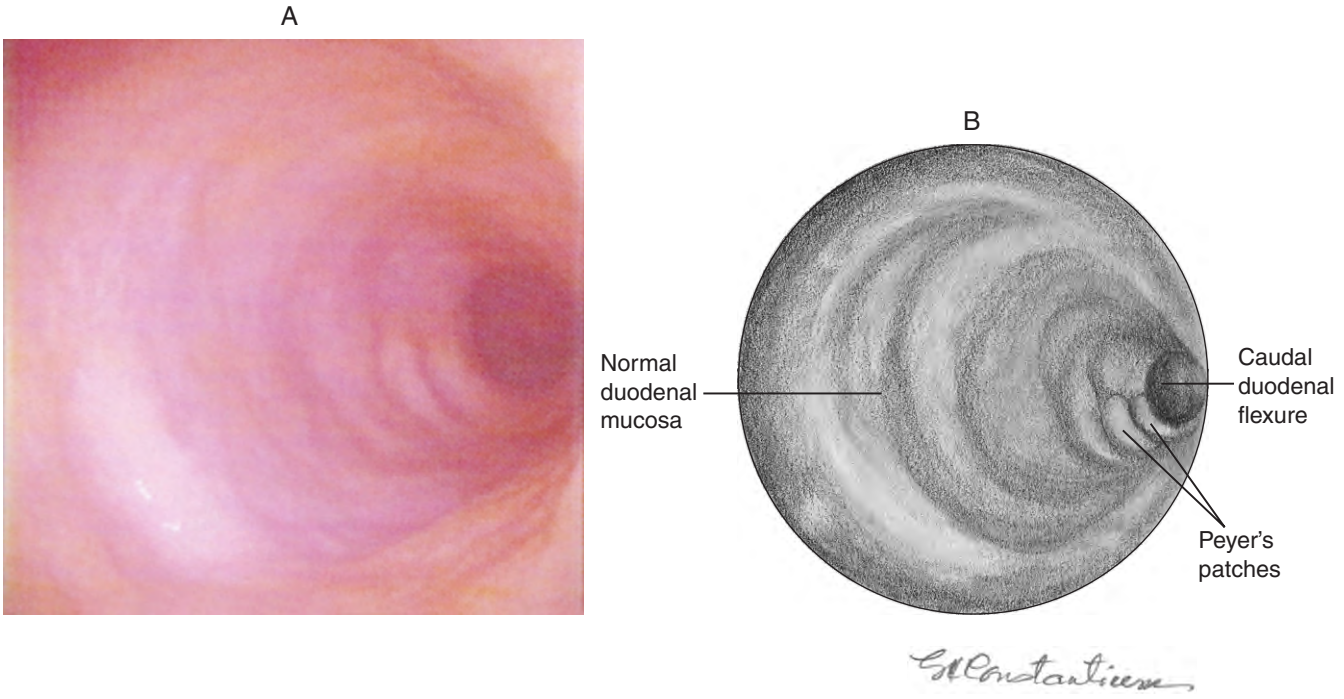



**Fig. 8-33**
Luminal view of the normal descending duodenum. Note the yellow-tinged color and the pseudoulcers (Peyer's patches).

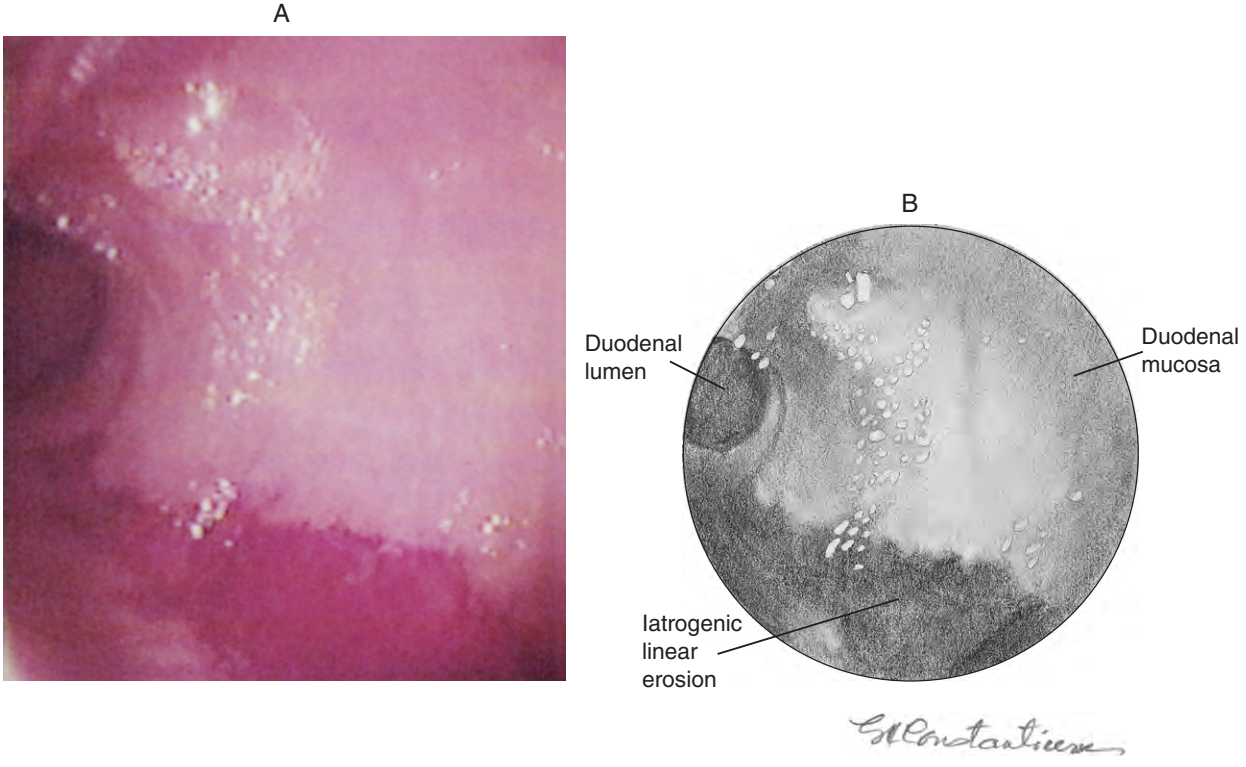



**Fig. 8-34**
Mucosal trauma due to the passage of the endoscope. The linear shape of the mucosal erosions seen in this figure suggests these erosions were caused by shearing forces exerted by the endoscope. Abnormal mucosa shears more easily than normal mucosa, but extensive lesions can be created in normal animals by rough endoscopic technique. Despite their appearance, these undesirable lesions do not result in any permanent harm.

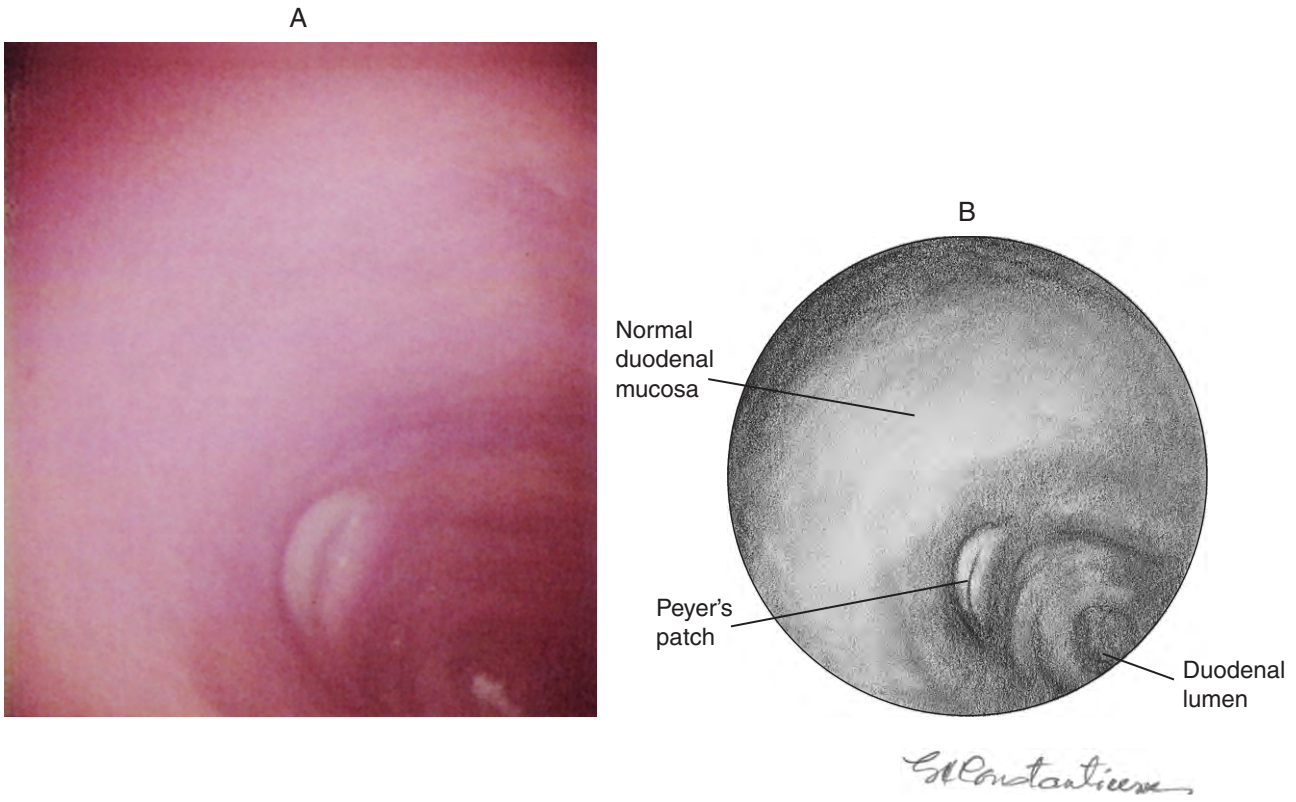



**Fig. 8-35**
A single Peyer's patch is pictured. Peyer's patches usually appear as pale depressions in the mucosa of the descending duodenum.

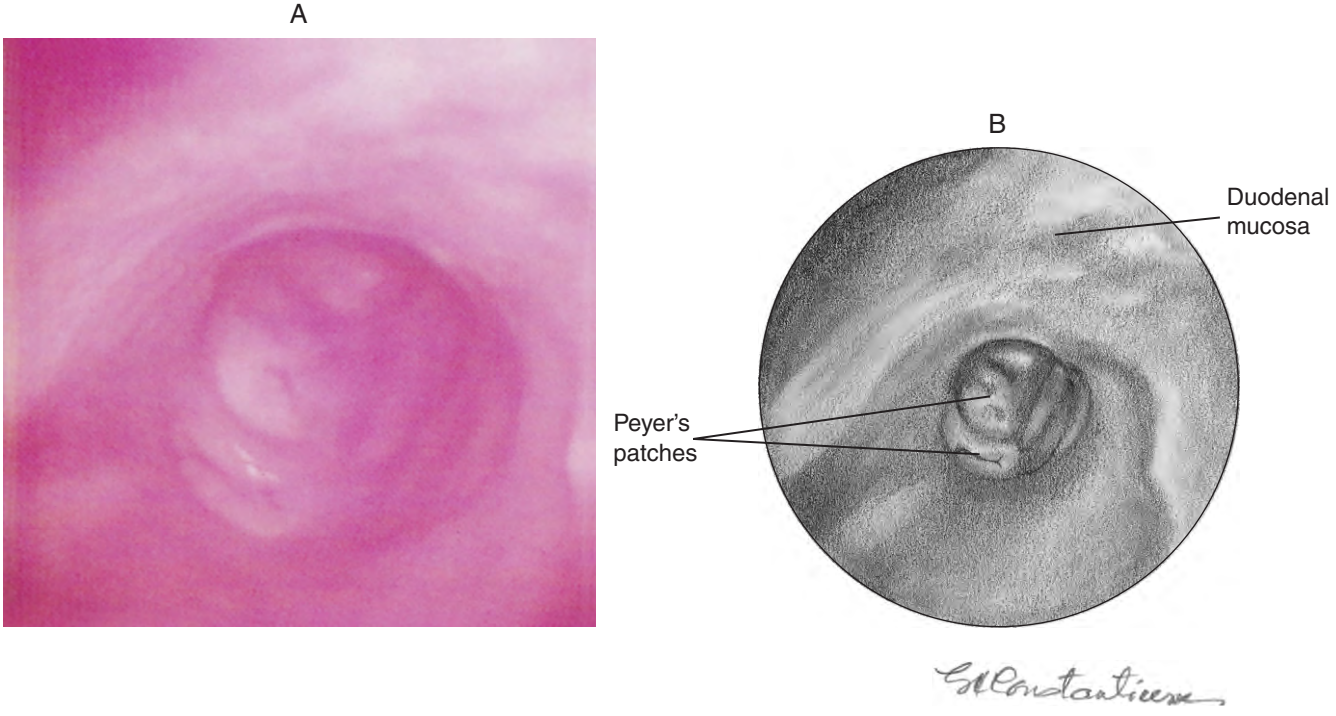



**Fig. 8-36**
Two Peyer's patches side by side.

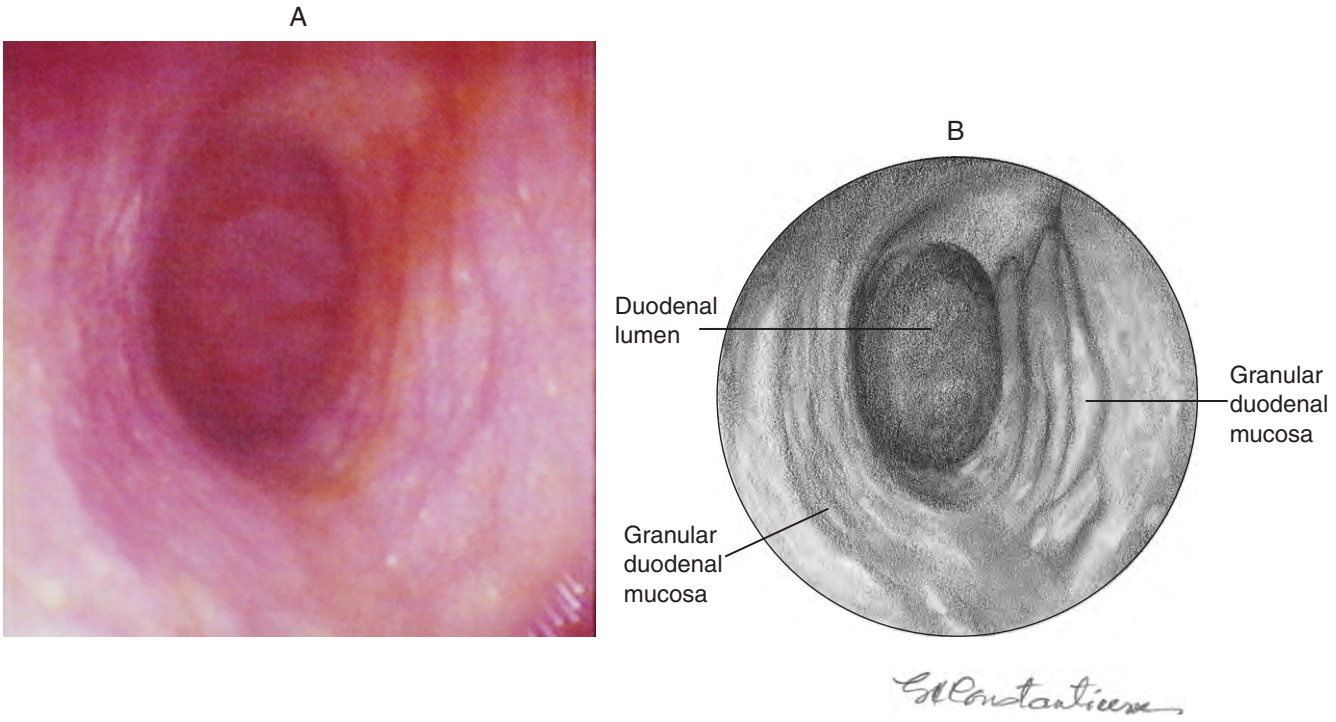



**Fig. 8–37**
Duodenal mucosal granularity. The mucosa of this duodenum shows a mild increase in granularity suggestive of inflammatory bowel disease.

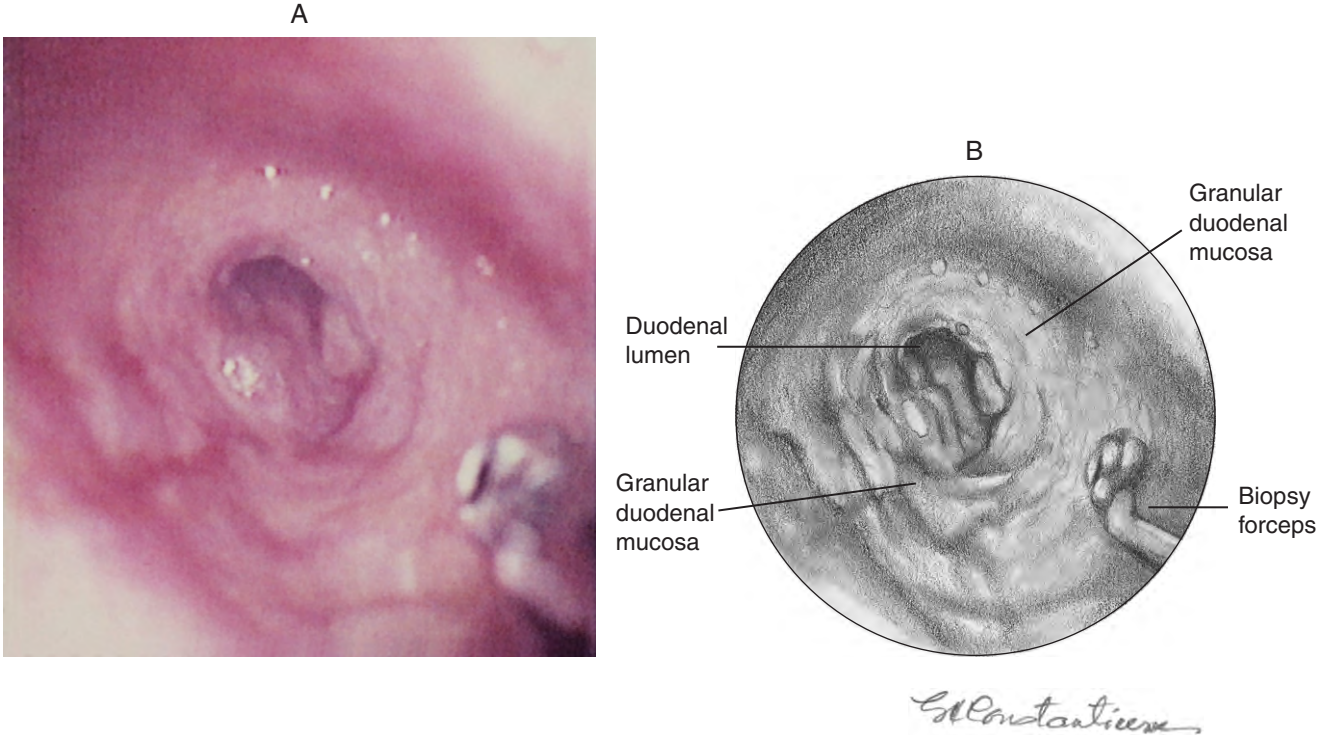



**Fig. 8–38**
Duodenal mucosal granularity. The mucosa of this duodenum is markedly more granular than normal duodenal mucosa. Inflammatory bowel disease was diagnosed.

duodenal thickening and irregularity. Adenocarcinoma may be infiltrative in behavior or result in annular obstructive lesions (Fig. 8-39). Occasionally, patches of coarse duodenal granularity or lipid-laden villi may be observed, which are characteristic of lymphangiectasia (Figs. 8-40 and 8-41). Ascarid parasites are sometimes encountered (Fig. 8-42).

## COMPLETION OF THE ENDOSCOPIC EXAMINATION

After the endoscope reaches its full working length, it is slowly retracted. Biopsy specimens, brush cytology samples, and fluid aspirates are taken as indicated. It is during retrograde passage of the endoscope that the best views of the gastrointestinal tract are obtained, but the endoscopist must always be cognizant that observed lesions may have been caused by the endoscope. Lesions with a linear shape are usually iatrogenic. Particular care must be taken to observe the cranial duodenal flexure, where lesions may have been overlooked during pyloric intubation. All air is aspirated from the gastrointestinal lumen before the endoscope is withdrawn. The animal is then recovered from anesthesia and closely observed for any complications.

## ANCILLARY ENDOSCOPIC TECHNIQUES

### Brush Cytology

Brush cytology is a useful adjunct to endoscopic biopsy. It may improve diagnostic yield because superficial material, which otherwise may be lost during processing, is sampled. Thus organisms such as protozoa that reside in the mucus of the gastrointestinal tract may occasionally be detected by brush cytology but not be seen on biopsy. Furthermore the brush ranges over a wider area than that examined by biopsy, and cytologic specimens may be rapidly evaluated. Brush cytology has been shown to improve the diagnostic yield in some forms of gastrointestinal cancer in humans. A tentative diagnosis made by brush cytology should not be summarily dismissed if not supported by biopsy results. Instead, repeated biopsies may be prudent.

### Aspiration of Duodenal Fluid

Duodenal fluid for culture and cytology is obtained by threading sterile plastic tubing down the endoscope and into the duodenum. The duodenal lumen is then collapsed and the tubing slowly drawn back to the endoscope tip as gentle suction is applied by way of a large volume syringe. On most occasions, this technique provides 0.5 to 2 ml of duodenal fluid. The fluid is quickly transferred to a suitable anaerobic container for transfer to the microbiology laboratory.

Quantitative culture of duodenal fluid is an effective way to diagnose bacterial overgrowth of the small intestine. Colony counts of greater than 105 per milliliter are considered diagnostic of bacterial overgrowth. Cytology of duodenal fluid is an accurate technique for the diagnosis of giardiasis. Occasionally, cytology reveals neoplastic cells. This is particularly true in cases of lymphosarcoma.

### Endoscopic Biopsy

Biopsy of the stomach and duodenum is performed with a pinch biopsy instrument. The tissue samples are small (2 to 3 mm) but guided (i.e., not "blind"), in that they are obtained under endoscopic vision. In view of their small size, good technique is essential to acquire tissue samples of diagnostic value. The instrument must be sharp to avoid crush artifacts. Where possible, the long axis of the biopsy instrument is directed at a 90-degree angle to the mucosal surface to be sampled. This lessens the likelihood of obtaining only villus tips, a common result when the biopsy forceps are directed parallel or tangential to the mucosal surface. In featureless lumens such as the small bowel, attaining a perpendicular orientation with the biopsy forceps is easier when the tip of the endoscope is extended until it encounters a flexure, or when the bowel is partially collapsed by the aspiration of the majority of luminal air. Overdistended stomachs are also harder to biopsy. It is useful to obtain more than one pinch biopsy specimen from the same site to increase the depth of the tissue sampled. This is particularly important when biopsying masses because of the inflammatory reaction that commonly surrounds neoplasms. Biopsy of ulcerating lesions is best performed at their periphery to avoid the sampling of necrotic tissue. Because histologic anatomy varies within regions of the bowel, obtaining biopsy specimens at consistent sites is likely to improve the ability of pathologists to differentiate normal from abnormal histology. For this reason, it is recommended to obtain biopsy specimens from any visible lesions and from the descending duodenum, pylorus, incisura angularis, mid greater curvature, and cardia as a routine practice. At each site in the stomach, a minimum of three to four biopsy specimens are suggested and at least eight biopsy specimens are obtained from the duodenum. A good site to biopsy in the duodenum is the caudal duodenal flexure. If the pylorus cannot be negotiated, it is possible to obtain duodenal biopsy specimens in a blind manner by passing the biopsy forceps through the pylorus while the endoscopic tip remains in the antrum.

#### Handling of Biopsies

Endoscopic biopsy yields pieces of tissue that are small and easily damaged. They are handled gently, are not allowed to dry, and are placed on or in some support such

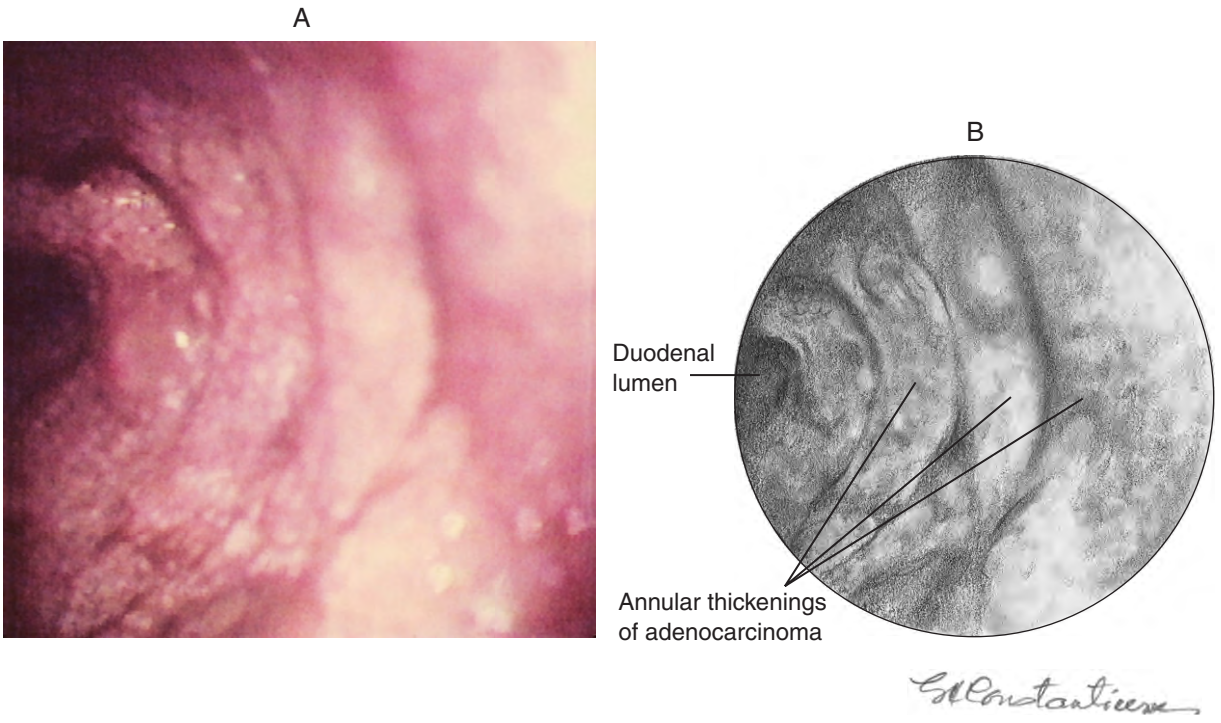



**Fig. 8-39**
Duodenal adenocarcinoma. The increased granularity and the annular constrictions of the mucosa of this duodenum were due to annular adenocarcinoma. *(Courtesy Dr. Jory Olsen.)*

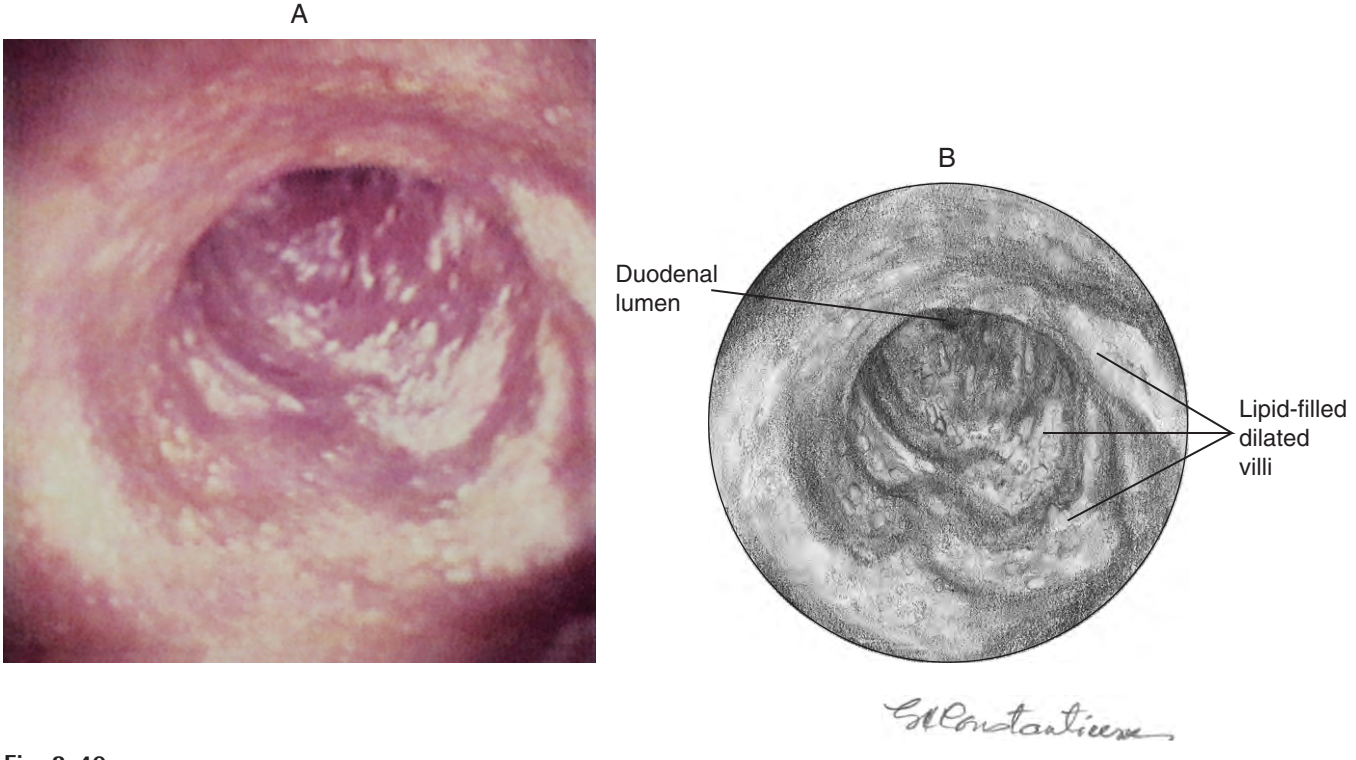



**Fig. 8-40**
Lymphangiectasia. The duodenum of this 4-year-old Terrier cross has prominent, circular, white patches that correspond to areas of lipid-filled dilated intestinal villi. This patient was fed only a few hours before the endoscopy.

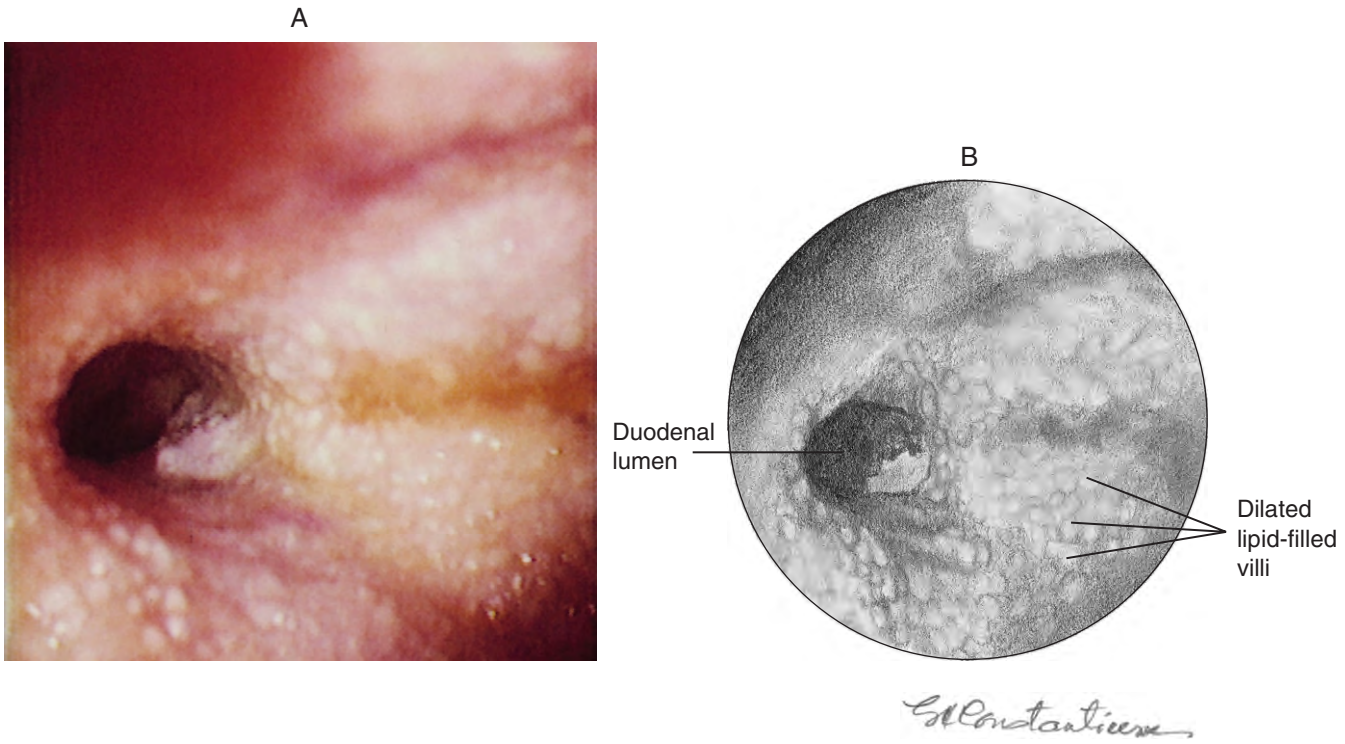



**Fig. 8-41**
Lymphangiectasia. The dilated villi due to lymphangiectasia can be seen more clearly in this close-up view of the mucosal surface.

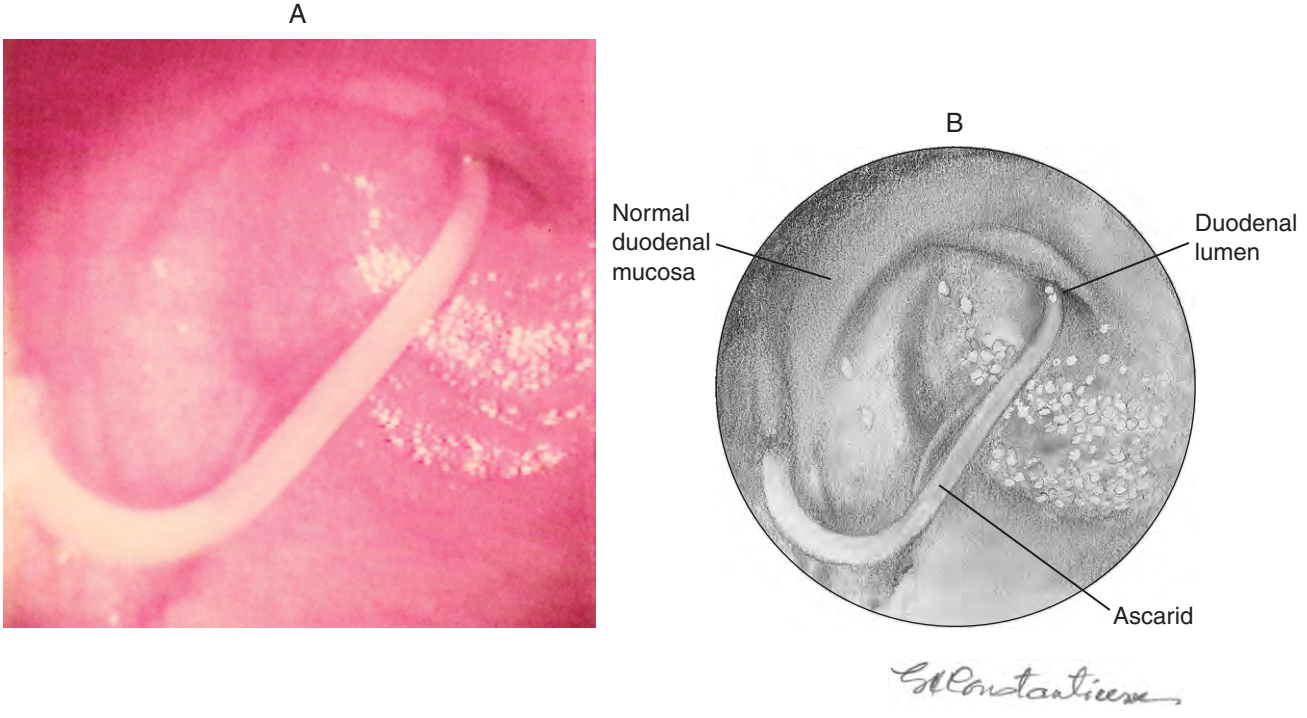



**Fig. 8-42**
Ascarid in the duodenum of a dog. The endoscopist occasionally encounters parasites such as Physaloptera or Ascarids in the gastrointestinal tract. The Ascarids are usually incidental findings.

as a piece of foam, a biopsy cassette, or folded coverslip paper to minimize contraction and preserve orientation.

### Discordance of Biopsy Results and Clinical Signs

Discordant results between clinical signs, endoscopic examination, and biopsy results are sometimes observed. For the clinician, it is most disturbing to receive a normal biopsy report when the clinical signs or gross appearance of the mucosa are suggestive of significant gastrointestinal disease. Some suggested causes for this discordance are provided in Box 8-4. In about two thirds of cases, endoscopic abnormalities are associated with histologic abnormalities. Endoscopically observed mucosal hemorrhage and erythema holds the least predictive value for histologic abnormality. Excess mucosal friability is associated with histologic abnormality in 80% of cases. Reasons for discordance include inexperience of clinicians, endoscopists, and pathologists; the presence of functional rather than morphologic bowel diseases; patchy distribution of mucosal lesions; and failure to place sufficient significance on mild morphologic changes.

**Box 8-4 Reasons for Discordance of Biopsy Results with Clinical and Endoscopic Findings**

- Incorrect localization of disease process by clinician
  - Failure to separate large and small bowel diarrheas
- Incorrect endoscopic assessment of gastrointestinal mucosa
  - Inexperience
  - Inadequate insufflation misread as mucosal thickening, mucosal granularity, or obscured submucosal blood vessels
  - Scope-induced trauma misread as spontaneous disease
- Incorrect biopsy evaluation by pathologist
  - Inexperience
  - The unknown significance of mild inflammation
  - Sample handling error
- Nonrepresentative biopsies
  - Poor biopsy technique
  - Biopsied incorrect aspect of a lesion (e.g., necrotic center)
  - Patchy mucosal lesions
- Presence of functional rather than morphologic disease
  - Brush border defects
  - Motility abnormalities
  - Secretory diarrheas
  - Permeability defects

*From Srombeck DR, Guilford WG:* Small animal gastroenterology, *ed 2, Davis, Calif, 1989, Stonegate.*

### Posttreatment Biopsies

Some veterinarians recommend follow-up biopsies of the intestinal mucosa of all patients with moderate to severe inflammatory bowel disease. Follow-up biopsies are most helpful in patients whose clinical signs are not responsive to therapy, because as they provide an objective assessment of the response of the intestinal inflammation to the therapeutic regimen. If the endoscopic appearance and follow-up intestinal biopsy suggest a reduction in inflammation, maintaining clinically nonresponsive patients on the same therapy is indicated with the advice to allow more time for the disease to resolve. Clinically nonresponsive patients whose gross or microscopic morphology show no improvement are changed to a different therapeutic protocol, usually involving another controlled diet and more aggressive immunosuppression.

The question of whether it is justified to rebiopsy patients in clinical remission is open to debate. There is no doubt that many of these patients have evidence of persistent intestinal inflammation despite clinical remission. Furthermore, it is not uncommon for patients with subclinical gastrointestinal inflammation to have recurrence of their clinical signs after the conclusion of the medical therapy. It is possible that, in the long term, this residual inflammation will lead to intestinal fibrosis and eventually a recurrence of untreatable clinical signs. Unfortunately, however, the significance of such residual inflammation is often difficult to judge and the value of routine follow-up endoscopy remains to be established.

## FOREIGN BODY RETRIEVAL

### Retrieval Equipment

Retrieval equipment includes through-the-endoscope equipment such as a basket retrieval instrument, a snare, a three- or four-pronged grasper, and a rat-tooth grasper (Fig. 8-43). In addition, it is helpful to obtain a long, semirigid or rigid grasping instrument for the removal of proximal esophageal foreign bodies. Suitable rigid retrieval instruments are available from most major surgical equipment manufacturers but are expensive. An economical alternative designed for retrieval of objects lost in plumbing and engines can be found at local hardware shops.

### Indications for Endoscopic Foreign Body Removal

Foreign bodies can be managed by conservative, endoscopic, or surgical means. Factors that influence this decision include the type of foreign object, its anatomic location, the clinical appearance of the animal, and the attentiveness with which the pet is observed by the

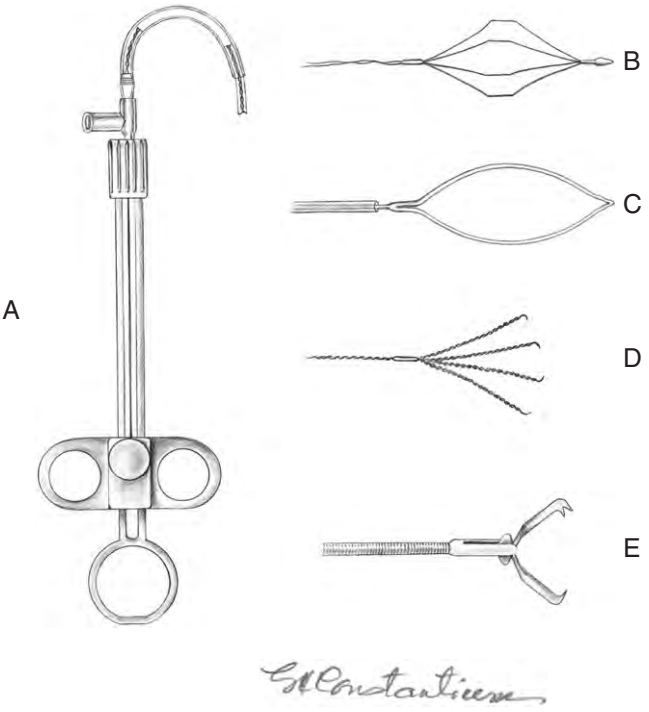



**Fig. 8-43**
Grasping equipment. A, The handle end of grasping instruments. B, A basket retrieval device. The ensheathed basket is passed through the operating channel of the endoscope. When near the object to be retrieved, the basket is extended from the sheath. The basket springs apart and can be maneuvered over the object. Withdrawing the basket into the sheath compresses the basket and entraps the foreign body. C, Snares function in a similar manner to basket retrieval instruments. D, Four-pronged graspers also function in a similar manner to basket retrieval instruments. E, Jawed graspers are used to grasp small objects. They are most useful when the object is not smooth-surfaced.

owner. Radiographic evaluation of the patient before endoscopy is recommended. Radiography assists localization of the foreign body and the detection of perforation. When sharp objects such as needles and fishhooks are observed by radiography, it is important to ascertain whether the foreign body remains in the lumen of the gastrointestinal tract before endoscopy. Not uncommonly, sharp objects penetrate and migrate out of the esophageal or gastrointestinal wall where they become inaccessible to the endoscope (Fig. 8-44).

Early removal of all esophageal foreign bodies (Fig. 8-45) is critical, because they cause pain and dysphagia,

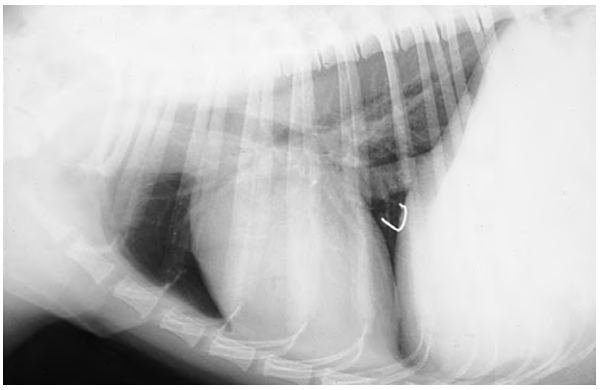


**Fig. 8-44**
Lateral radiograph of the chest of a dog with a periesophageal fishhook. This dog underwent an unnecessary endoscopy to retrieve a fishhook. The fishhook had passed through the esophageal wall into the periesophageal tissues.

and may result in esophageal stricture. Endoscopic removal is particularly desirable in view of the increased morbidity of thoracotomy and the possible complications of esophageal surgery. Timely endoscopic removal of all sharp objects from the stomach is recommended because of the risk of perforation of the stomach or, if the object leaves the stomach, perforation of the intestine. To avoid gastrointestinal obstruction, the early endoscopic or surgical removal of foreign bodies judged too large to pass through the gastrointestinal tract is recommended. Foreign bodies suspected of containing lead, zinc (such as pennies) (Figs. 8-46 and 8-47), or caustic materials (batteries) must be removed from the gastrointestinal tract immediately.

## Technique

Successful retrieval of foreign bodies requires considerable discretion, ingenuity, and technical prowess. Tightly wedged foreign bodies are never forcibly removed. If a foreign object cannot be removed by firm traction and under direct endoscopic vision, then surgical removal is indicated. Forceful removal bears a great risk of laceration of the viscus or adjacent vessels or organs (Fig. 8-48). Furthermore, tightly wedged foreign bodies usually have caused significant pressure necrosis that requires surgical inspection to determine their mural extent. Hairballs can be difficult to remove endoscopically (Fig. 8-49).

Trial and error often determines the best instrument for a particular retrieval; however, certain generalizations apply. Basket retrieval instruments are only useful in a lumen of sufficient diameter to allow their expansion (Fig. 8-50). Pronged graspers are of little value in the retrieval of foreign bodies with smooth surfaces. If the

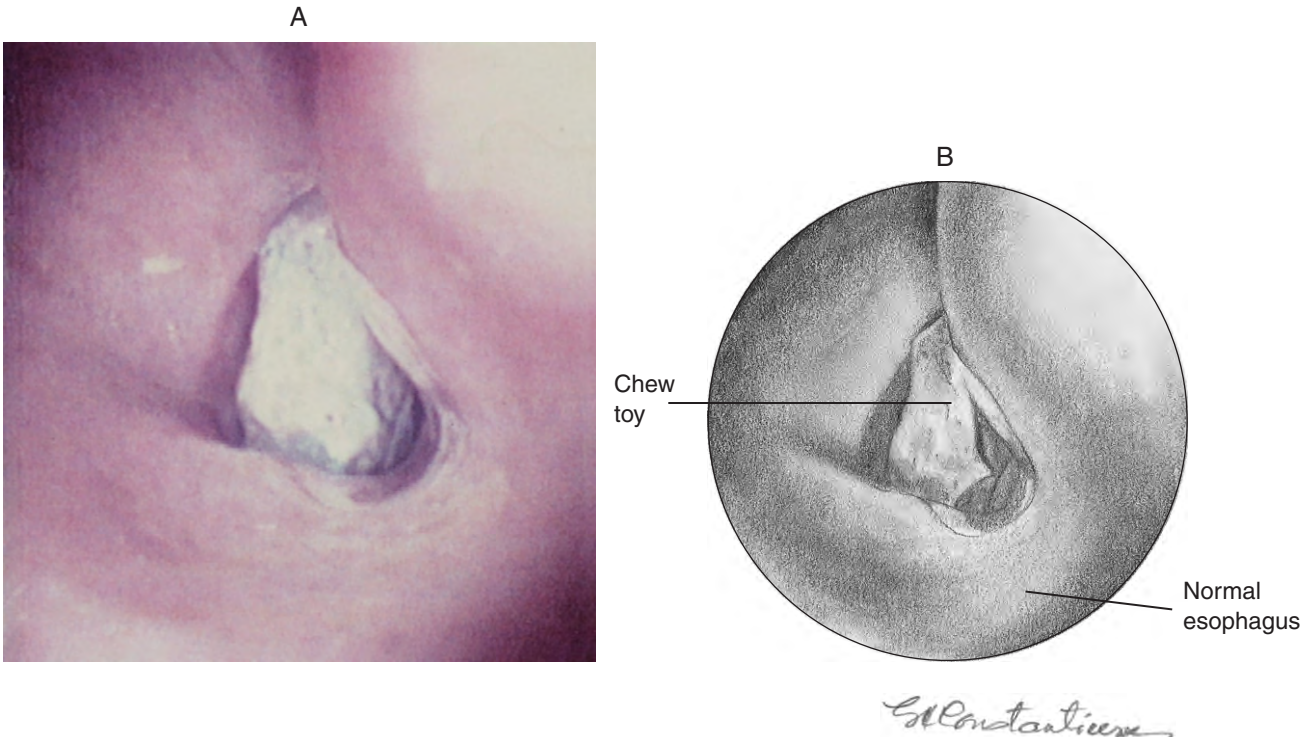



**Fig. 8-45**
Esophageal foreign body. This 5-year-old Dachshund was presented with regurgitation. Esophagoscopy revealed a chew toy wedged in the esophagus. *(Courtesy Dr. Sherri Wilson.)*

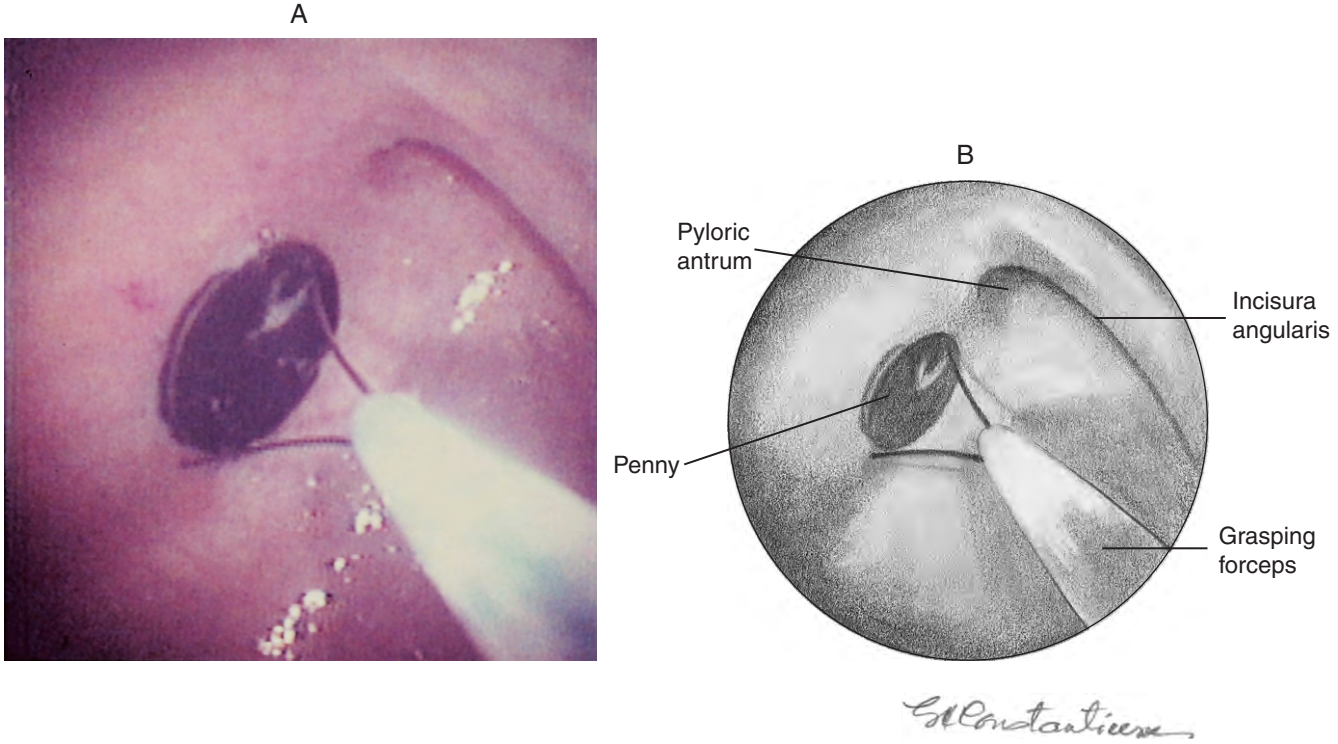



**Fig. 8-46**
Retrieval of a penny from the stomach. Three-pronged grasping forceps are extended to grasp a penny that lies at the junction of the gastric body and pyloric antrum. *(Courtesy Dr. Tullia Tonachini.)*

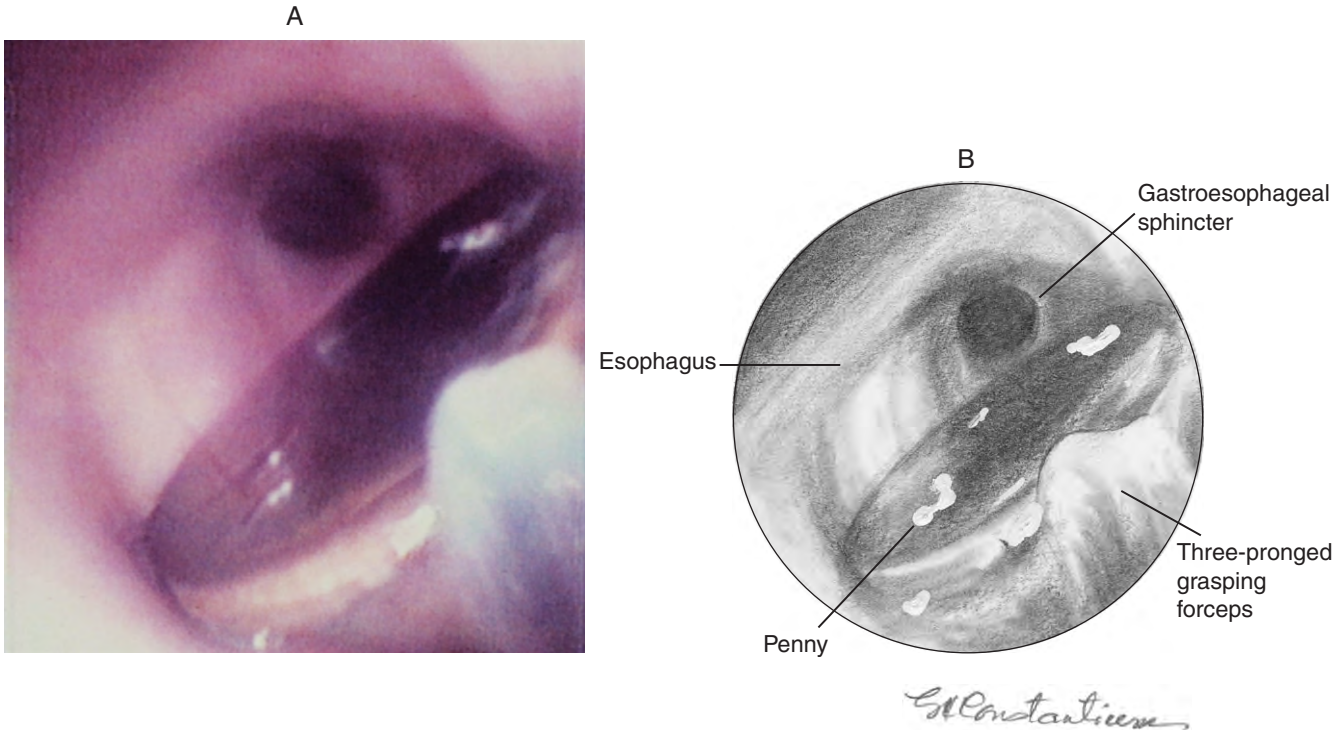



**Fig. 8-47**
Retrieval of a penny from the stomach. The penny can be seen in the grasp of the three-pronged retrieval forceps. The endoscope, graspers, and penny are in the esophagus at this point of the retrieval.

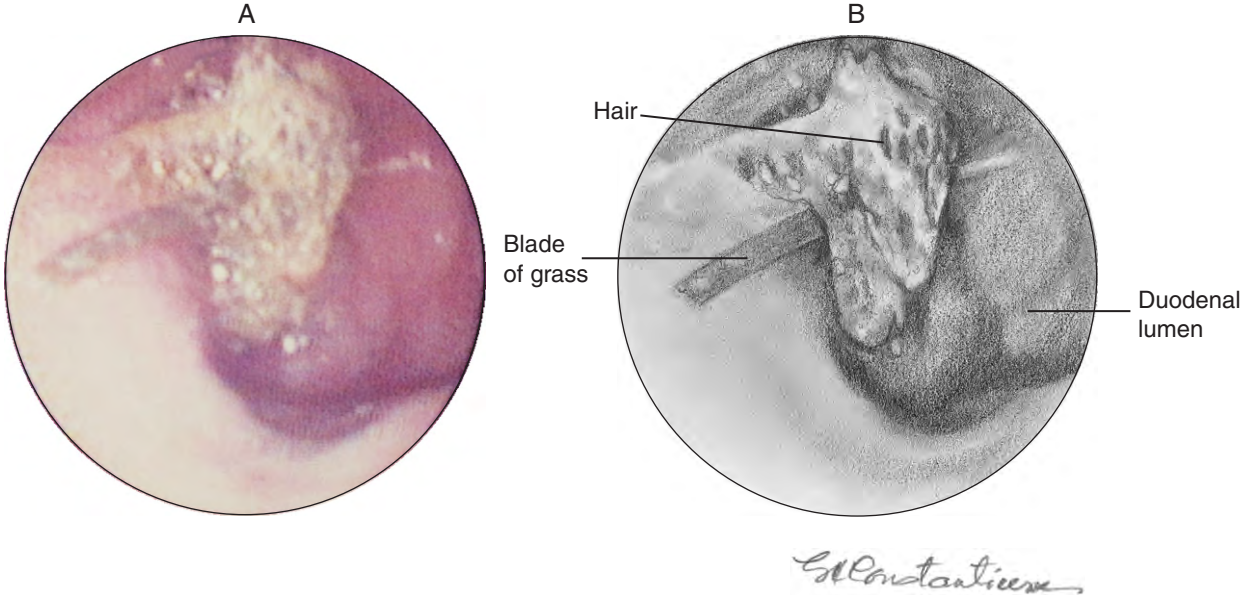



**Fig. 8-48**
A duodenal foreign body entangled with grass. Many gastrointestinal foreign bodies become coated with indigestible debris such as hair and grass. Amongst this haystack was a needle that was unwilling to budge. Wisely, the endoscopist decided upon surgical removal of the foreign body. Surgical exploration revealed that the needle lay across the duodenum and had penetrated the gall bladder. *(Courtesy Dr. Claudia Kirk.)*

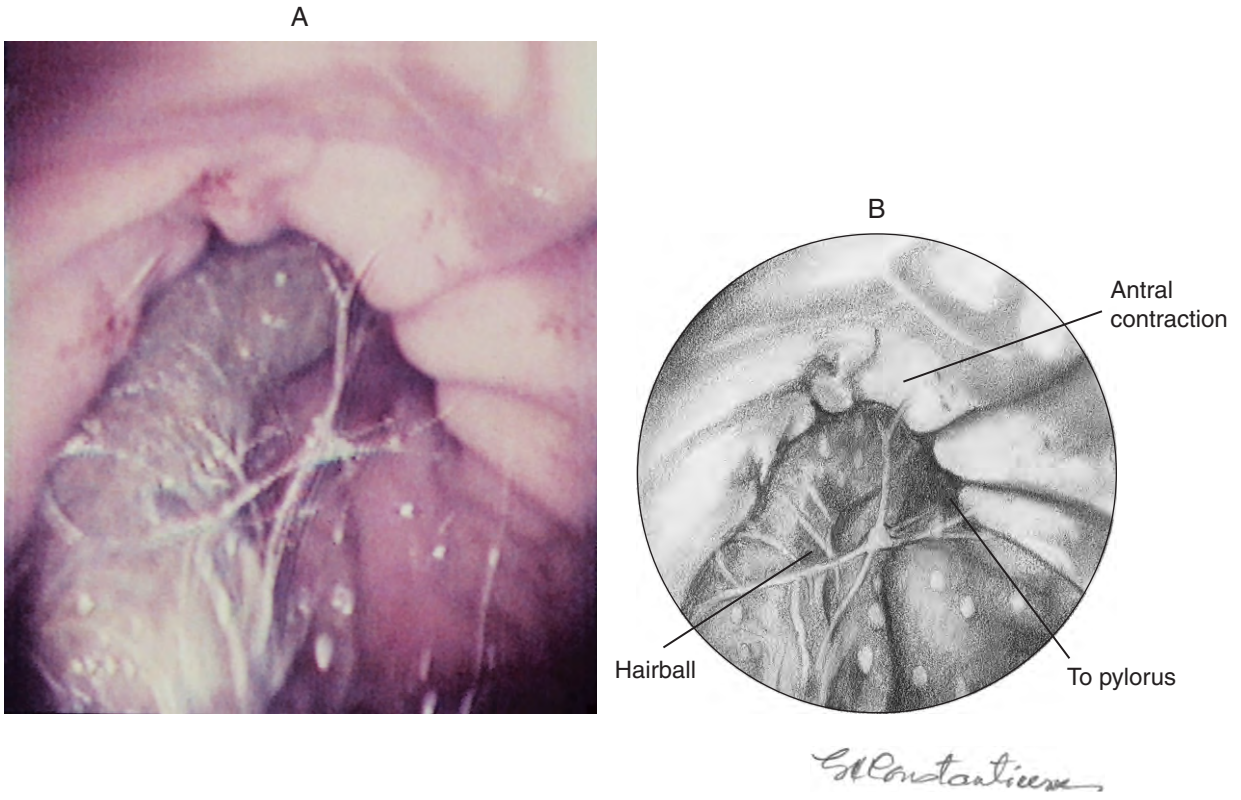



**Fig. 8–49**
Gastric hairball. A gastric hairball lies in the pyloric antrum.

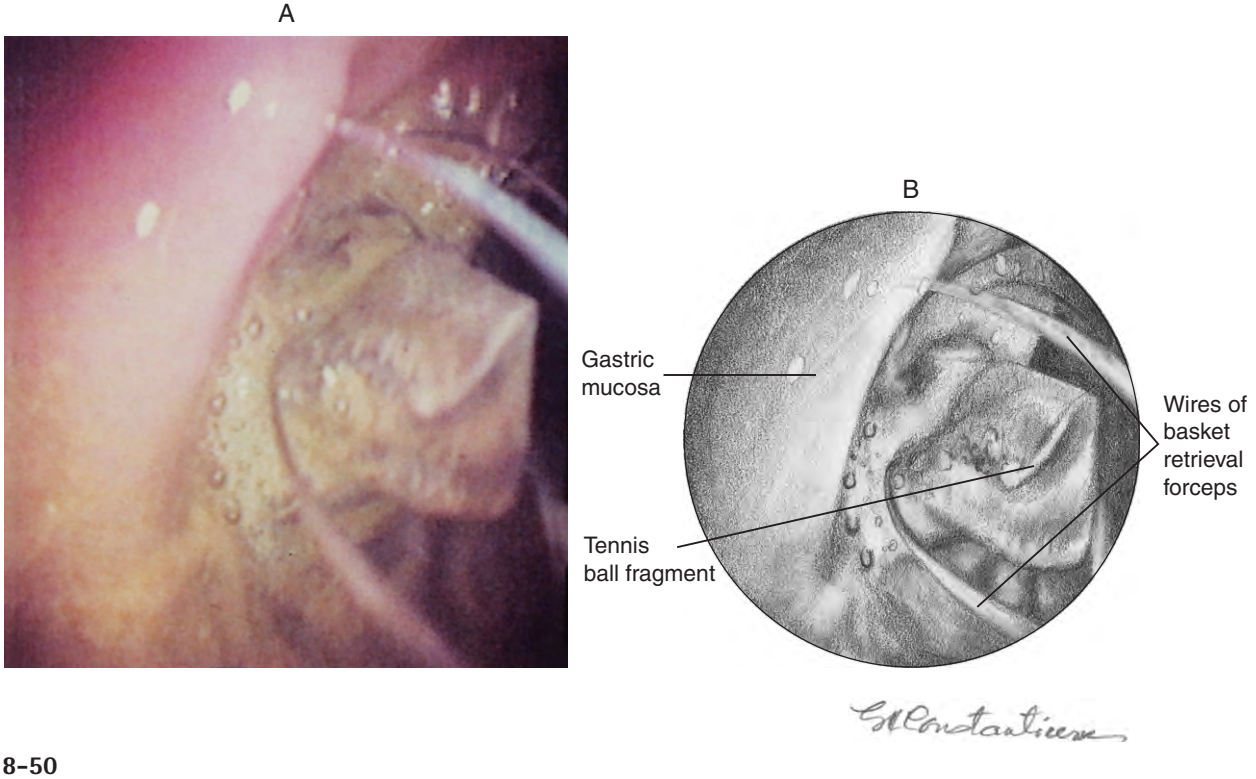



**Fig. 8–50**
Basket retrieval instrument engaging a foreign body. The wires of a basket retrieval instrument can be seen engaging the edge of a chewed-up piece of tennis ball. This fragment was successfully removed by endoscopy. *(Courtesy Dr. Claudia Kirk.)*

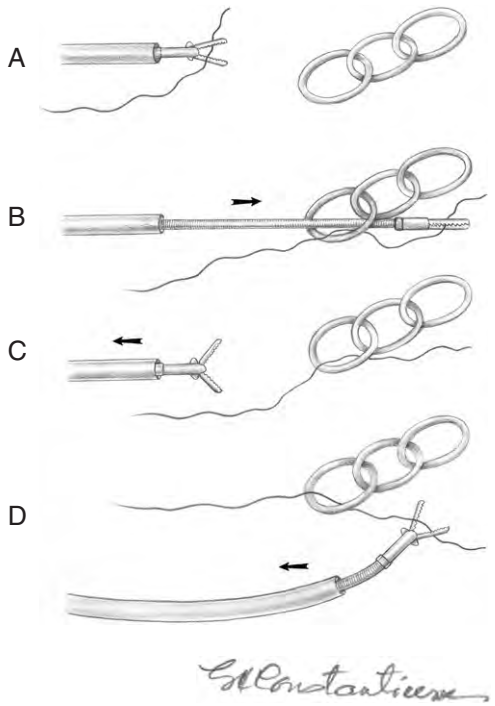



**Fig. 8-51**
Diagram of the endoscopic technique for entrapment of foreign bodies with suture material. **A,** With the endoscope removed from the animal, a biopsy or grasping instrument is passed through the biopsy channel until the instrument's jaws just appear. One end of a 2-m length of sturdy suture material is grasped in the instrument's jaws and the endoscope passed to the foreign body. **B,** Using the grasping instrument, the suture material is passed through a hole in the foreign body. **C,** The suture material is let go and the grasping instrument removed from the hole in the foreign body. **D,** The suture material is then regrasped on the other side of the foreign body and drawn out of the mouth by removal of the endoscope. The result is a loop of suture material that passes into the animal's mouth, through the foreign body, and out the mouth again, enabling the object to be removed by gentle traction.

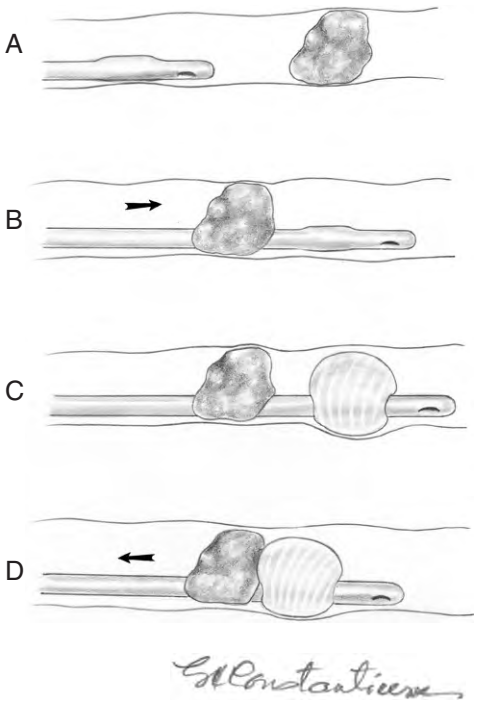



**Fig. 8-52**
Diagram depicting use of a Foley catheter for removing esophageal foreign bodies. **A and B,** The Foley catheter with deflated cuff is passed alongside the foreign body. This can be made easier by stiffening the Foley catheter with a piece of wire. **C,** The cuff of the catheter is then inflated. **D,** The inflated cuff is used to draw the foreign body out.

surface is smooth but indentable, strong jaw-tooth graspers are usually effective. Certain metals may be retrieved by magnetic extractors.

Endoscopic entrapment with suture material can be used to remove large foreign bodies, such as choke chains, from the stomach. To entrap a foreign body with suture material, the following technique is used (Fig. 8-51). With the endoscope removed from the animal, a biopsy or grasping instrument is passed through the biopsy channel until the instrument's jaws just appear. One end of a 2-m length of sturdy suture material is grasped in the instrument's jaws and the endoscope passed to the foreign body. Using the grasping instrument, the suture material is passed through a hole in the foreign body and let go. The suture material is then regrasped on the other side of the foreign body and drawn out of the mouth by removal of the endoscope. The result is a loop of suture material that passes into the animal's mouth, through the foreign body, and out the mouth again, enabling the object to be removed by gentle traction.

Additional useful retrieval techniques include (1) pulling esophageal foreign bodies into a preplaced rigid endoscope in the esophagus, thus aiding atraumatic removal of sharp objects; (2) pushing obstinate esophageal foreign bodies into the stomach where they may be digested (e.g., bones), better manipulated to an appropriate orientation for removal, or more easily removed surgically; (3) placing a Foley catheter distal to the object and then using the inflated catheter to draw the foreign body out (Fig. 8-52).

## BOUGIENAGE AND BALLOON CATHETER DILATION

Bougienage or balloon catheter dilation of esophageal strictures is sometimes required. Endoscopy assists the clinician to perform these procedures safely. The endoscope allows visual assessment and biopsy of strictures before dilation. This helps differentiate postinflammatory strictures, extraesophageal compressions, and strictures resulting from neoplasia, thus facilitating the selection of an appropriate therapy. Endoscopy simplifies the placement of bougies or balloon catheters directly into the orifice of the stricture and allows assessment of the effect of the procedure on the mucosal tissue and luminal diameter. Dilation of strictures can be performed with balloon catheters or rigid dilators. Rigid bougies are less desirable than balloon dilators because they produce less radial force and more shearing forces; however, they are effective in many situations.

### Balloon Catheter Dilation

Suitable balloon dilators for gastrointestinal work have a 15- to 20-mm inflatable diameter with a length of 6 to 8 cm. Balloon diameters smaller than 10 mm are of little value because they provide insufficient distention of esophageal strictures. Shorter lengths are inadequate for long strictures because they may not extend past the margins of the lesion and therefore are difficult to keep in position during inflation. Although designed to pass through the biopsy channel of the endoscope, some of the longer balloon catheter dilators are not sufficiently flexible at their tip to pass through flexible gastroscopes and must be passed alongside the endoscope. Once the balloon has been centered in the stricture, it is gradually inflated with a syringe (Fig. 8-53).

The progress of the dilation can be monitored by fluoroscopy using a contrast media–filled balloon or with endoscopy. Manometers can be used to measure pressures applied, but are not essential. Successful passage of a 10-mm diameter gastroscope through the previously strictured area is indicative of a successful procedure in small dogs and cats. Larger dogs require a slightly greater esophageal diameter to remain relatively symptom-free.

### Bougienage

Rigid bougies are tapered probes of variable diameter. They are used by systematically increasing the diameter of the bougie passed through the stricture. The stricture is dilated as widely as possible without the use of excessive force. The diameter of the largest bougie that is accommodated helps judge the success of the procedure.

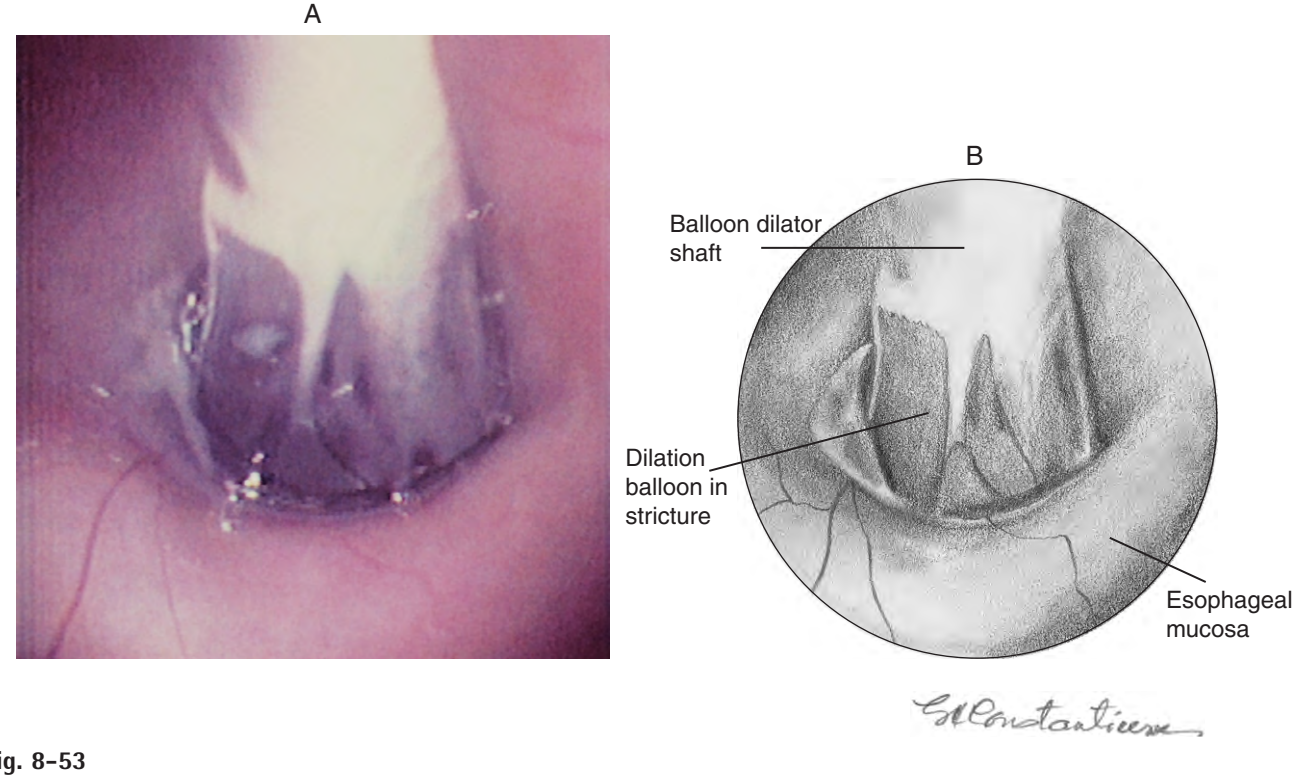



**Fig. 8–53**
Dilation of a balloon catheter in the lumen of the stricture. A partially inflated balloon dilation catheter is in position in the lumen of the stricture shown in Fig. 8-11.

For example, the comfortable passage of a 40-French diameter bougie through an esophageal stricture of a 20-kg dog suggests adequate bougienage.

## Complications of Stricture Dilation

Complications of bougienage and balloon catheter dilation are not uncommon, particularly in inexperienced hands. Complications include perforation of friable esophageal tissues and bleeding from ruptured periesophageal vessels entrapped by the inflammatory or neoplastic disease process that formed the stricture. Insufflation of the esophagus proximal to the stricture can lead to gastric overdistention from the passage of air through the stricture. If this occurs, gastric decompression can be achieved by trocarization of the stomach with a needle.

## Follow-up Therapy

Repeated dilation of esophageal strictures is usually required to maintain an adequate luminal diameter. In the first month of treatment, weekly dilation may be required but the frequency usually declines thereafter. Alternatively, the repeat procedure is performed as soon as regurgitation recurs. Some patients may only require one dilation. Adjunctive medical therapy can be used to help prevent restricturing. If the cause of the stricture is reflux esophagitis, metoclopramide (0.2 to 0.4 mg/kg three to four times per day) and proton pump inhibitors are useful. Postoperative corticosteroids are commonly recommended to inhibit fibrosis.

## Endoscopic Placement of Gastrostomy Tubes

Endoscopic placement of a gastrostomy tube (PEG tube) is indicated for long-term (weeks to months) nutritional support of anorectic or dysphagic animals. PEG tubes are better tolerated than pharyngostomy or nasogastric tubes and can be easily managed at home. They are of comparatively large diameter and thus allow the economic use of blended pet foods and the direct administration of medicines. Complications are rare, but include pressure necrosis of the gastric wall or failure of gastroabdominal adhesion, both of which can result in peritonitis. An increased risk of peritonitis due to failure of gastroabdominal adhesion following endoscopic placement of gastrostomy tubes has been noted in large, debilitated dogs undergoing chemotherapy. Gastrostomy tubes in such patients may be better placed surgically. Gastrostomy tubes are not recommended in vomiting animals.

## Technique

Endoscopic placement of gastrostomy tubes requires brief anesthesia. The animal is placed in right lateral recumbency so that the stomach tube may be placed through the greater curvature of the stomach and the left body wall. The site of emergence for the catheter is just ventral to the 13th rib. The area is clipped and prepared aseptically.

The most commonly used technique for the endoscopic placement of gastrostomy tubes in veterinary patients (Fig. 8-54) uses a specially prepared Pezzer mushroom-tipped catheter. A suitably sized catheter for dogs is 24 French and for cats is 20 French. Gastrostomy kits containing already prepared catheters can be purchased from human surgical supply houses but are expensive. Tubes can be prepared as follows: A 2- to 3-inch piece is cut off of the female end of the mushroom-tipped catheter, and the cut end of the catheter is trimmed to facilitate introduction into the female end of a disposable plastic micropipette (flared polypropylene IV catheter or polypropylene tom cat catheter). The 2- to 3-inch section of rubber that was previously cut from the mushroom catheter is cut in half to make two equal pieces, and a small slit is cut in each piece. These serve as flanges to prevent movement of the stomach away from the body wall. The catheter is passed through the slit in one of the flanges until the mushroom tip and the rubber flange are touching.

The left paracostal area centered just ventral to the distal end of the thirteenth rib is surgically prepared. The endoscope is introduced into the stomach, which is carefully inflated until the abdomen is distended but not drum tight. The body wall is transilluminated with the endoscope to ensure the spleen is not between the stomach and body wall. A 16- to 18-gauge, 1.5- to 2-inch needle is inserted through the skin just ventral to the thirteenth rib, passed through the body and gastric walls, and into the gastric lumen. Heavy suture material of sufficient length to comfortably reach from mouth to last rib is threaded through the needle into the lumen of the stomach. The suture is grasped with an endoscopic retrieval instrument, and the endoscope is withdrawn from the animal thus drawing one end of the suture through the esophagus and out of the mouth. Be careful not to draw all of the suture into the stomach. At the mouth the suture material is passed through the lumen of the tapered plastic pipette (small end first) and firmly tied to the cut and trimmed (female) end of the mushroom catheter. The catheter is snugly wedged into the female end of the pipette. The end of the suture material outside the abdominal wall is grasped and firm traction is applied to draw the entire catheter assemblage (pipette first) through the mouth, lumen of the esophagus and stomach, and out through the stomach and body walls. Further gentle traction on the catheter results in the distal (flanged) end of the catheter drawing the stomach wall against the body wall. It is anchored in this position by the second flange placed over the catheter at the skin surface. The endoscope is then reinserted into the stomach and the appearance of the mucosa about the gastrostomy

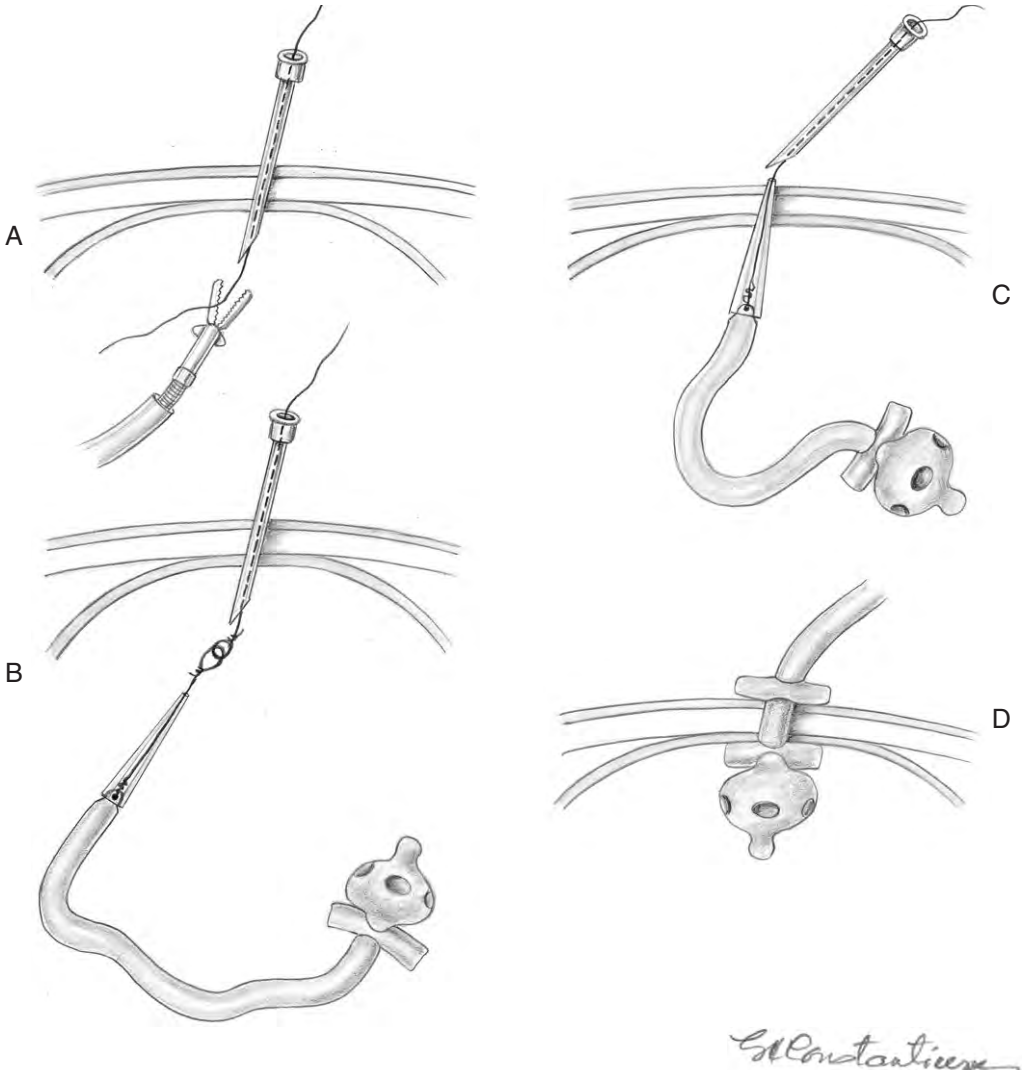



**Fig. 8-54**
Diagram depicting endoscopic placement of a gastrostomy tube (PEG tube). **A,** A large-bore needle is inserted through the body wall into the gastric lumen. Sturdy suture material is passed through the needle into the lumen of the stomach where it is grasped with a retrieval instrument. **B,** The suture material and endoscope are withdrawn from the stomach. At the mouth, the suture material is tied to a piece of thread that has been previously bound to a Pezzer mushroom-tipped catheter capped with a pipette tip. The suture material is then grasped at its point of exit from the abdominal wall and firm traction is applied to draw the entire catheter assemblage (pipette first) through the lumen of the mouth, esophagus, and stomach. **C,** The catheter assemblage is then drawn through the stomach and body wall until the distal (flanged) end of the catheter fixes the stomach wall against the body wall. **D,** The stomach is anchored in this position by the second flange placed over the catheter at the skin surface.

tube assessed. If blanching of the mucosa is observed, less tension is applied to the tube, otherwise necrosis of the gastric wall may ensue as a result of ischemia. The catheter is bandaged in place to prevent vandalism by the patient. After 6 to 7 days, the catheter may be safely removed when tube feeding is no longer required. To remove the catheter, firm external traction is applied and the catheter is cut as close to the distal tip as possible. In large dogs, the internal flange and mushroom tip usually pass uneventfully but can be removed endoscopically if desired. In small dogs and in cats, endoscopic removal of the tip is indicated. The catheter can also be removed by applying traction until the mushroom tip is pulled through the stoma.

## CONCLUSION

Upper gastrointestinal endoscopy is a frequently performed endoscopic procedure that is particularly suited for the diagnosis of upper gastrointestinal diseases with a luminal or mucosal location. Contraindications are few and complications are rare. The most suitable endoscopes for upper gastrointestinal work in small animal patients are those designed specifically for veterinary application and pediatric gastroscopes. Procedures that can be performed with upper gastrointestinal endoscopy include mucosal biopsy, brush cytology, aspiration of duodenal fluid for culture and cytology, foreign body retrieval, bougienage of strictures, and endoscopic placement of gastrostomy tubes. Issues that face veterinary endoscopists include the interrelationship between contrast radiology and endoscopy, the advisability of routine combination of upper and lower gastrointestinal endoscopy, the reasons for discordance between clinical signs, endoscopic appearance, and biopsy findings, and the role of posttreatment biopsies.

## SUGGESTED READING

Gualtieri M: Esophagoscopy, *Vet Clin North Am Small Anim Pract* 31(4):605-630, 2001.

Mansell J, Willard MD: Biopsy of the gastrointestinal tract, *Vet Clin North Am Small Anim Pract* 33(5):1099-1116, 2003.

Tams TR: *Handbook of small animal gastroenterology*, ed 2, St Louis, 2003, Saunders.

Zoran DL: Gastroduodenoscopy in the dog and cat, *Vet Clin North Am Small Anim Pract* 31(4):631-656, 2001.

# 9 Endoscopic Evaluation of the Colon

*Keith P. Richter*

Endoscopic examination of the colon is commonly performed in veterinary medicine to evaluate dogs and cats with large intestinal disease. Adequate patient preparation, thorough knowledge of equipment and technique, and the ability to harvest adequate biopsy specimens result in an accurate diagnosis in most cases. This chapter reviews these aspects of performing colonoscopy.

## INDICATIONS

Indications for proctoscopy and colonoscopy include any suspected disease of large intestinal origin that produces an abnormal gross or microscopic mucosal appearance of the colon or rectum. In general, this is the test of choice for evaluating signs referable to the large intestine. The most common indication is large bowel pattern diarrhea. This pattern typically results in an increased frequency of defecation with a decreased volume of feces per attempt. Often there is progressively decreasing volume during each defecation episode. Urgency and unproductive attempts are common. Blood and mucus in the feces are variably seen. Additional indications for colonoscopy include tenesmus (with normal or abnormal fecal consistency), hematochezia (with or without normal-formed feces), dyschezia (pain during defecation), palpable or visible rectal masses, suspected large bowel obstruction, and increased fecal mucus. Vomiting, weight loss, and poor appetite are signs usually attributed to small intestinal disease, although they can be seen with either obstructive large intestinal disease (stricture, mass, intussusception) or severe infiltrative mucosal disease (inflammatory or neoplastic). In these cases, both upper gastrointestinal endoscopy and colonoscopy are performed together to evaluate as much of the bowel as possible.

Before considering colonoscopy, the clinician should obtain a thorough history, perform a physical examination (including digital rectal examination), perform multiple parasitic examinations, and consider appropriate diet trials. Usually therapeutic trials, including dietary, antiparasitic, and salicylate-containing antiinflammatory drug therapy (e.g., sulfasalazine or mesalamine derivatives), are used for acute large intestinal signs. If these fail or signs are chronic, severe, or progressive, then colonoscopy should be considered.

Radiographs (including barium enema) may document anatomic obstruction but not mucosal disease. A mucosal biopsy is usually necessary to complete the examination; therefore radiography is usually not performed. Ultrasound is also a low-yield procedure in most cases. Occasionally a mass is identified during ultrasound examination that is thought to be of large intestinal origin. If ultrasound-guided aspirates or biopsies are nondiagnostic, colonoscopy may be helpful to further evaluate these lesions.

Rigid endoscopy is often adequate to evaluate the descending colon. Because most inflammatory diseases of the large intestine in the dog and cat are diffuse, their presence is commonly detected in the descending colon, making rigid proctoscopy a valuable procedure. Advantages of using a rigid proctoscope include ease of use, the need for less training or experience, and the ability to more easily clean the colon when feces are present (due to the large lumen of the rigid scope compared with a small biopsy channel of a flexible scope). In addition, rigid biopsy instruments procure much larger and therefore far superior specimens compared with flexible biopsy instruments. When complete large bowel examination is desired, a flexible fiberoptic or electronic video endoscope can be used to evaluate the entire colon and possibly the ileum. These provide superior mucosal visualization and the ability to perform a more complete examination. I use both scopes in virtually all procedures. The rigid scope is used to evacuate residual fecal material, examine, and obtain biopsy specimens with a rigid instrument from the descending colon. The flexible scope is used for visual evaluation and as a means to obtain biopsy specimens from the remaining portions of the colon.

## EQUIPMENT

Endoscopic examination of the colon can be accomplished with either a rigid or flexible scope. If a limited examination of the anorectal area is needed, a human rigid anoscope can be used. These are generally 8 to 10 cm in length. They are cone shaped and tapered to an end diameter of 8 to 20 mm (Fig. 9-1). Their use generally requires minimal preparation, and the procedure can be performed with the patient awake or under sedation. Similarly, a large otoscope cone can be used for a similar limited examination. A human rigid proctoscope (Fig. 9-2) can be used for visualization of the descending colon and rectum, whereas a flexible endoscope allows visualization of the entire colon and possibly the ileum.

The rigid proctoscope (sleeve) contains a large central lumen for visualizing and obtaining biopsy specimens. This instrument is made of metal or plastic. The latter is meant to be disposable, but it can be cleaned and reused. Light is transmitted via a fiberoptic cable from a remote light source and exits at either the proximal or distal aspect of the scope. I prefer a scope wherein the light exits at the proximal aspect because it is easier to keep clear of fecal material during the procedure. The proctoscope also includes an obturator (stylus), which allows atraumatic entry into the rectum, and an attached air insufflation bulb, which distends the colon for optimal visualization. A glass lens system with magnifying prism covers the proximal aspect of the proctoscope and provides magnification for superior visualization (Fig. 9-3). This device has a small channel for introduction of instruments without having to remove the magnifying eyepiece (Fig. 9-4). Alternatively, a removable glass eyepiece (see Fig. 9-3) can be used to cover and seal the proximal aspect to prevent air leakage and allow insufflation. The eyepiece is temporarily removed when instruments or cleaning swabs are inserted through the lumen. Proctoscopes are available in several sizes. I use a 30-cm long, 21-mm diameter scope for dogs larger than 5 kg, and a 20-cm long, 12-mm diameter scope for smaller dogs and cats.

For flexible colonoscopy, an endoscope used for upper gastrointestinal endoscopy is suitable. Ideally this should be 1 m in length, have four-way deflection of the tip, have an air/water insufflation channel, and have at least a 2-mm diameter biopsy/suction channel (2.8 mm preferred). The larger the diameter of the biopsy channel, the larger



**Fig. 9–1**
Metal tapered anoscopes. These range in tip diameter from 8 to 25 mm.



**Fig. 9–2**
Metal rigid proctoscopes. The larger scope is 30 cm long and 21 mm in diameter. The smaller scope is 20 cm long and 12 mm in diameter. Top to bottom: 12-mm obturator, 20-mm sleeve, 12-mm sleeve, 20-mm obturator, insufflation bulb.



**Fig. 9–3**
Magnifying lens with attached insufflation bulb, used to cover the proximal aspect of the proctoscope. Alternatively, a glass eyepiece (lower right) can be used to cover the proctoscope, allowing an airtight seal to permit insufflation.

the biopsy instrument that can be used. The diameter of the scope is not as critical as in upper gastrointestinal endoscopy. An insertion tube diameter from 7.8 to 11 mm is suitable. In smaller patients, entry into the ileum is more difficult with scopes of larger diameter. A general rule is that the diameter of the pyloric opening is similar to the diameter of the ileocolic sphincter. See Chapter 1 for details on selecting an endoscope.

Rigid biopsy instruments are used with the rigid proctoscopes and should have 4- to 6-mm diameter cups, ideally with an angled tip (Fig. 9-5). These rigid instruments procure far superior specimens compared to flexible instruments that are used with flexible endoscopes, although the flexible biopsy forceps can be used if rigid biopsy forceps are not available. I prefer forceps in which the margins of the cups appose each other (rather than fit inside each other), because these are much safer and carry less risk of perforation. With the angle at the tip, it is easier to direct the cups into the mucosa. I use a Jackson cup forceps with a 4-mm cup and a 45-degree angle (see Fig. 9-5). Figure 9-6 shows other biopsy instruments that can be used for colonoscopy.

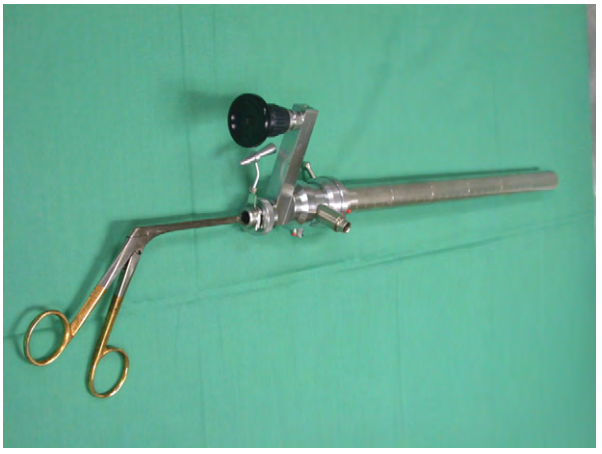


**Fig. 9-4**
Biopsy channel of the magnifying lens, permitting introduction of instruments while maintaining an airtight seal to permit insufflation.

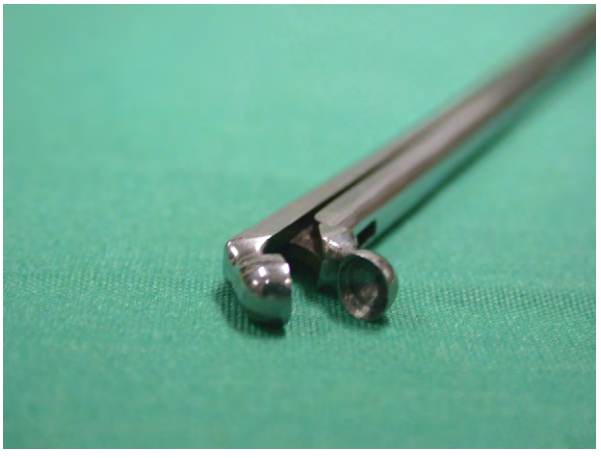


**Fig. 9-5**
Jackson cup forceps with a 4-mm cup and a 45-degree angle used to obtain colon biopsies through a rigid scope.

## PATIENT PREPARATION

Patient preparation is important in performing a reliable examination, because residual fecal material can prevent complete visualization of the mucosal surface. Patients should be fasted for 24 to 48 hours before the procedure. Samples for culture and parasite examination should be obtained before preparation. One method of preparation involves administration of multiple warm water enemas. The enema volume is important and should be at least 22 ml/kg. (Many dogs can easily take double this volume.) This can be accomplished with an "enema bucket," in which a metal container has a small spout at the bottom attached to a soft tube inserted into the colon, thus allowing gravity to force the water into the patient. For cats and small dogs, a dose syringe attached to a soft tube inserted into the patient is used to force the water into the patient. The tube should be lubricated and advanced as far as it will easily pass, and should not be forced. If a large amount of water or fecal material is expelled, the enema is immediately repeated. Phosphate or soapy enemas

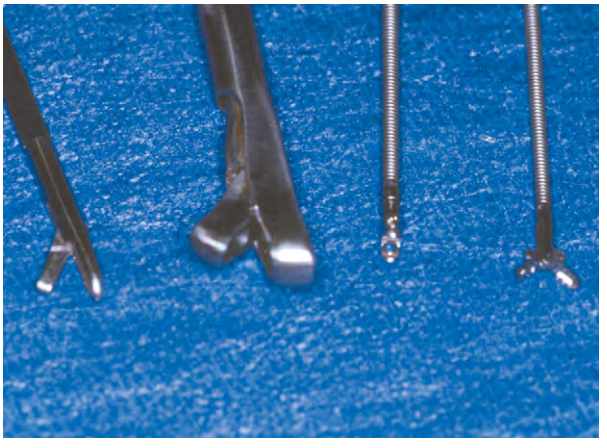


**Fig. 9-6**
Assortment of other biopsy forceps. From left to right: (1) Small rigid forceps used through a rigid scope, (2) larger rigid forceps used through a rigid scope, and (3) two 1.8-mm flexible forceps, generally used through the channel of a flexible scope. Note that, for the larger rigid forceps, the jaws fit inside each other, and, although use of the larger rigid forceps increases the ease of obtaining samples, it also increases the risk of bowel perforation.

are not used because of their potential to cause colonic irritation. Phosphate enemas (Fleet) should not be given to cats because they can severely alter calcium and other electrolyte concentrations, and be fatal. The last enema should result in the return of clear fluid without fecal material and should be administered at least 1 to 2 hours before the procedure to facilitate evacuation and minimize artifactual hyperemia of the mucosa.

A preferable method of preparation involves the use of an oral gastrointestinal lavage solution, which contains polyethylene glycol as the main nonabsorbed solute (GoLYTELY). Use of this solution results in a severe osmotic diarrhea with virtually no net absorption or secretion of electrolytes, bicarbonate, or water. This method of preparation is contraindicated with confirmed or suspected intestinal strictures. This method has been shown to result in better colonic preparation than use of multiple enemas in dogs. I currently administer 25 ml/kg via orogastric tube three to five times, 1 hour apart, 12 to 18 hours before colonoscopy. In addition, an enema is given shortly after the last GoLYTELY administration and 1 to 2 hours before the endoscopy procedure.

## TECHNIQUE

General anesthesia is required. The patient is placed in right lateral recumbency for rigid colonoscopy. This allows residual fluid to pool in the ascending colon and facilitate examination of the descending colon. The patient is placed in left lateral recumbency for flexible colonoscopy. This allows residual fluid to pool in the descending colon where it is more easily removed, also facilitating examination of the ascending colon and ileum. Before colonoscopy, a digital rectal examination should be performed to check for a mass, stricture, or diverticulum in the distal rectum. When advancing any scope through the colon, two general rules to follow are "do not advance unless you can see the lumen" and "when in doubt, back up." For rigid colonoscopy, the instrument is lubricated and then passed into the rectum with the obturator in place. As soon as the scope "pops" through the anus and into the rectum, the obturator is immediately removed and the glass cap or prism magnifier placed to allow visualization. As the colon is entered, air is insufflated to allow visualization of the entire circumference. With air insufflation, the scope is gradually advanced while the practitioner views the entire circumference of the descending colon. The large lumen of the proctoscope facilitates removal of residual fecal material. This can be accomplished with large cotton-tipped applicators (Tipped Proctoscopic Applicators, Puritan, Guilford, Me) (Fig. 9-7) or with gauze sponges held by rigid grasping forceps. If a large amount of feces is present due to inadequate preparation, enemas can be administered during the procedure. This can be accomplished by



**Fig. 9-7**
Large cotton-tipped applicators (Tipped Proctoscopic Applicators, Puritan, Guilford, Me) used to clean residual fecal material in the colon through a rigid scope.

infusing a large volume of warm water through the lumen of the scope, or by removing the scope and using an enema tube as described in the section on patient preparation. Once the rigid scope is advanced as far as possible, it is gently removed under direct visualization. Again, the scope is manipulated so the entire circumference is visualized, using the air insufflation bulb to maintain adequate distention. The scope is then removed from the colon, and the flexible scope can be inserted to evaluate the remainder of the colon and ileum. Once that is completed, the rigid scope is reinserted all the way, and biopsy specimens are obtained with a rigid instrument as the scope is gradually withdrawn from the colon.

For flexible colonoscopy, the scope is advanced using insufflation to facilitate passage. The lumen should always be visible and the scope should advance easily while visualizing the entire circumference of the colon wall. Occasionally, insufflation cannot be maintained due to leakage out of the anus around the scope. To correct this, an assistant applies gentle pressure by squeezing the anus around the scope with a gloved hand. If an anorectal lesion is suspected, the scope can be retroflexed after entry into the rectum. This can be accomplished by deflecting the tip of the scope 180 degrees in the "up" direction (most flexible scopes have at least 180-degree angulation in one of the four directions) while advancing the scope. Rotation of the insertion tube of the scope after retroflexion allows more complete antegrade visualization of the anorectal area. If the patient is less than 10 to 15 kg, the rectal diameter may be too small to perform this maneuver because the bending radius of the endoscope tip may be too large. After examining the rectum, the scope is further advanced into the colon. While advancing the scope, if resistance is met, the scope should be withdrawn and the tip gently manipulated and air insufflated to straighten

any flexures or redundant folds in the colon. Occasionally, rotation of the insertion tube of the scope helps get around corners. Although not recommended, the scope must occasionally be "blindly" advanced around corners (see Chapter 8, Fig. 8-4). This is accomplished by deflecting the tip while simultaneously advancing the scope around a corner. At the splenic and hepatic flexure, "blindly" advancing is common. A common problem is that the scope is advanced, while the tip does not move or occasionally paradoxically moves backward, away from the direction of insertion. This is due to the redundancy or deformability of the colon. In this instance, the scope is gently advanced and withdrawn small distances repeatedly to facilitate passage. The redundant regions of the colon are straightened as a result, and the examination can continue. In addition, proper air insufflation also acts to straighten the colon. If there is resistance to passage, mechanical abnormalities such as strictures, masses, ileocolic intussusception, and cecal inversion should be sought.

With practice, the cecum can be reached in most animals, and the ileum can be entered in some. It is much easier to identify the ileocecal colic junction in a properly prepared patient. If the ileocolic junction is open, entry into the ileum is relatively easy with practice and experience. This can be accomplished by directing the scope into the opening of the ileum and advancing with gentle pressure. Often twisting the scope clockwise or counterclockwise aids in entry. When entering the ileum, gentle fine deflections of the tip of the scope are most helpful to allow entry into the lumen. With practice, the proper direction of tip deflection allows passage of the scope into the ileum. Placing the tip of the scope against the opening, insufflating, and applying gentle pressure can sometimes allow entry. In many instances, the opening to the ileum is closed or the angle to enter the ileum is extreme and impedes entry. In these cases, a flexible biopsy instrument is advanced into the ileum for a distance of approximately 2 to 3 cm. The instrument is used as a guidewire to advance the scope into the ileum with gentle pressure. As the scope is advanced and pops into the ileum, the forceps are simultaneously withdrawn into the channel to prevent trauma to the mucosa of the ileum.

Generally, the colon is visually examined on the way in toward the ileum (in a retrograde direction) and again during withdrawal of the scope (in an antegrade direction). The latter often gives superior visualization because the colon is distended and straighter as the scope is removed. Biopsy specimens should only be obtained during withdrawal of the scope after visually inspecting the area to be biopsied (see later). Otherwise, excessive bleeding from a biopsy site obscures visualization as the scope is removed, preventing thorough examination during withdrawal of the scope. In addition, there is an increased risk of perforation if the scope is advanced following biopsy procurement. This is primarily true when using rigid forceps.

I use both a rigid and flexible scope in virtually all procedures. The rigid scope is used to evacuate residual fecal material, and examine the rectum and descending colon. The flexible scope is then used to visually evaluate and obtain biopsy specimens of the ileum, ascending colon, transverse colon, and proximal descending colon. Finally, the rigid scope is reinserted again to obtain biopsy specimens of the descending colon and rectum with a rigid forceps.

## NORMAL FINDINGS

The normal colon wall when distended with air is smooth, glistening, pink, and easily distended (Figs. 9-8 and 9-9). Submucosal vessels are easily visualized in most of the colon, especially the transverse and descending colon (Figs. 9-10 and 9-11). The colon wall is examined for texture, color, friability, diameter, distensability, parasites, erosions, ulceration, masses, and strictures. Lymphoid follicles, seen as small, depressed, gray plaques, are normally seen (Figs. 9-12 to 9-14). However, they may become excessive or prominent with inflammatory diseases. When the ileocolic junction is reached, it has a variable appearance (Figs. 9-15 to 9-20). In most cases, the opening to the ileum appears as a circular raised mound of tissue with a central opening or depression. In some cases a minimal amount of tissue is raised, giving the opening a border that is flush with the colon wall (this is more common in cats), whereas in other cases there is a marked amount of raised tissue around the rim. Immediately adjacent to the ileum is the opening to the cecum. This appears as a hole with no raised rim of tissue. When viewed through the endoscope, the opening to the cecum is usually just below the opening to the ileum, either to the left or right. The cecal mucosa has longitudinal folds, similar to the appearance of rugal folds in the stomach. The lumen may appear curved, tortuous, or serpentine when entered. The ileum has an appearance similar to the duodenum (Fig. 9-21). The normal ileum is pink, smooth, and uniform, and has a velvet-like texture. The villi are friable, and it is easy to create a mucosal defect by gently scraping the scope or biopsy forceps against the mucosa.

## COLON BIOPSY

Following complete examination of the colon and ileum, biopsy specimens are obtained from multiple levels as the scope is withdrawn. Many diseases, such as idiopathic inflammatory bowel disease and lymphoma, have normal gross appearance (especially in cats). Therefore biopsy specimens must always be obtained. The large intestine can be biopsied under direct visualization through a rigid proctoscope or flexible endoscope. When specimens are obtained through a flexible endoscope, the size of the biopsy instrument is limited by the diameter of the biopsy channel (usually 2 to 2.8 mm). However, mucosal

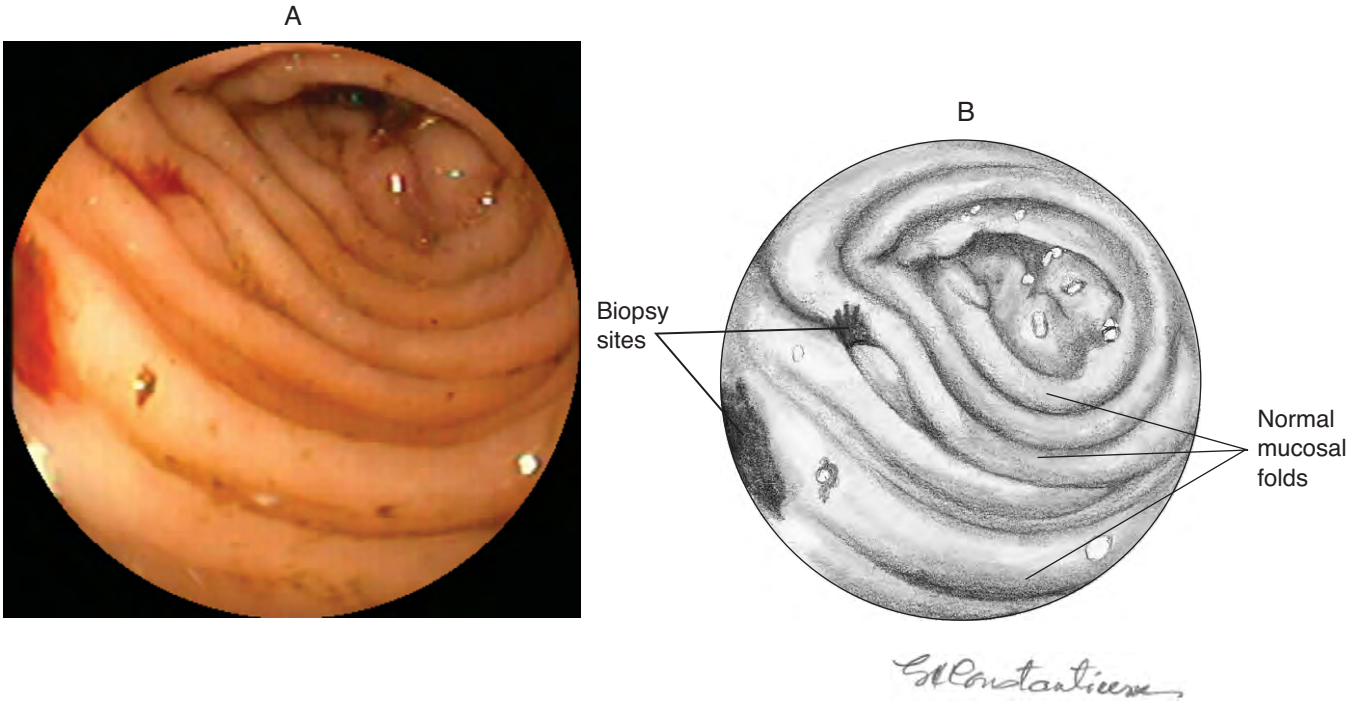



**Fig. 9-8**
Normal, smooth, pink colonic mucosa with normal mucosal folds. Red areas are bleeding from recent biopsy sites.

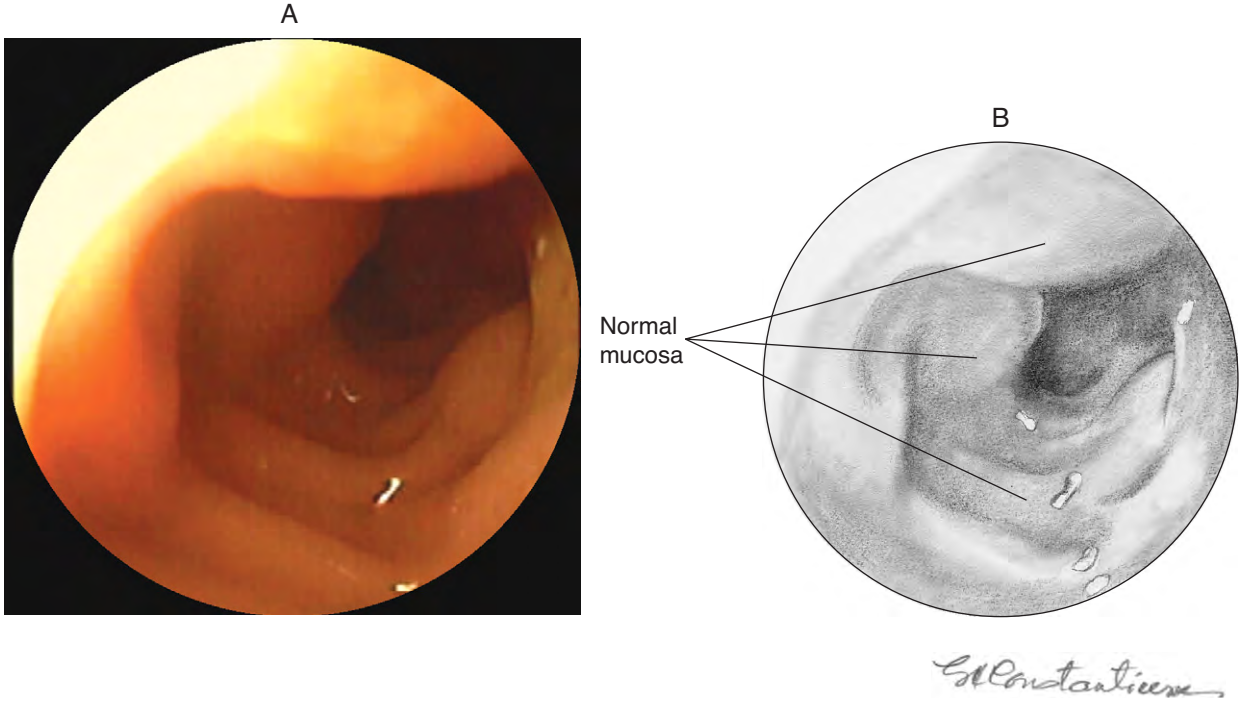



**Fig. 9-9**
Normal, smooth, pink colonic mucosa.

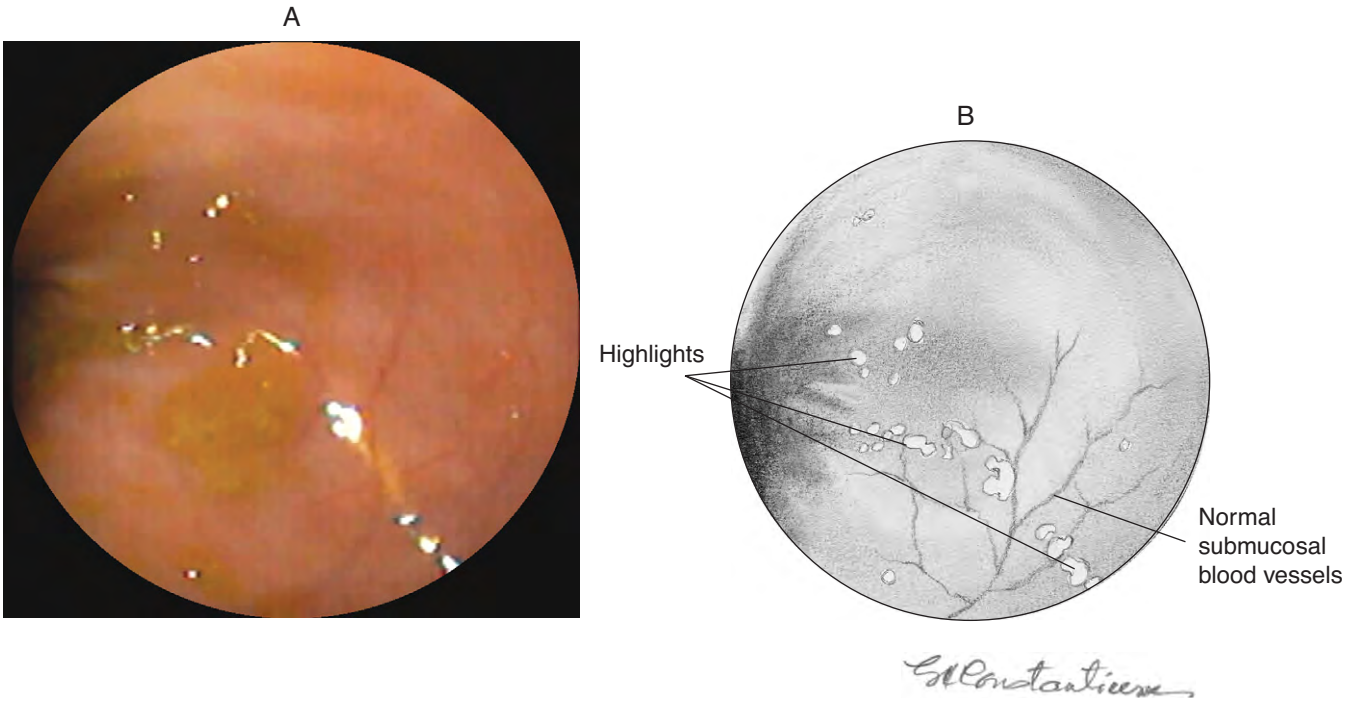



**Fig. 9-10**
Normal descending colon. Note the easily visible submucosal vessels.

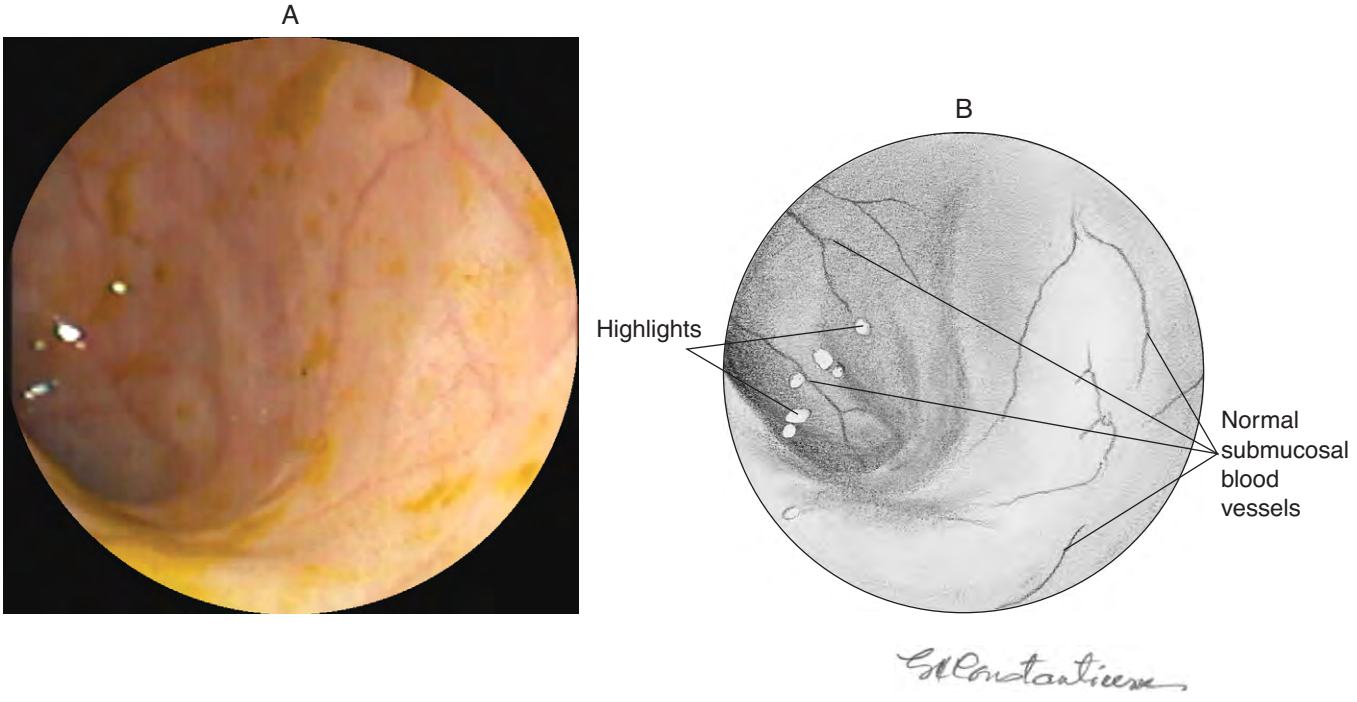



**Fig. 9-11**
Normal descending colon. Note the easily visible submucosal vessels.

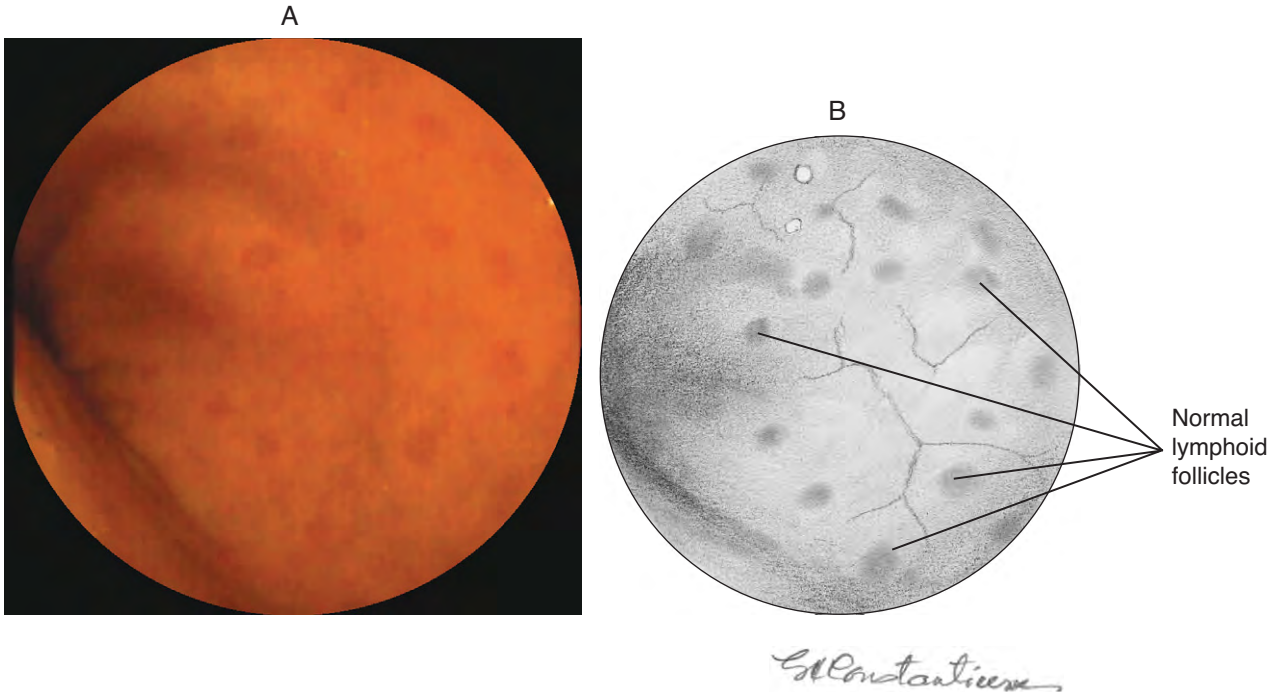



**Fig. 9-12**
Lymphoid follicles visible as discolored, depressed punctate areas in the descending colon.

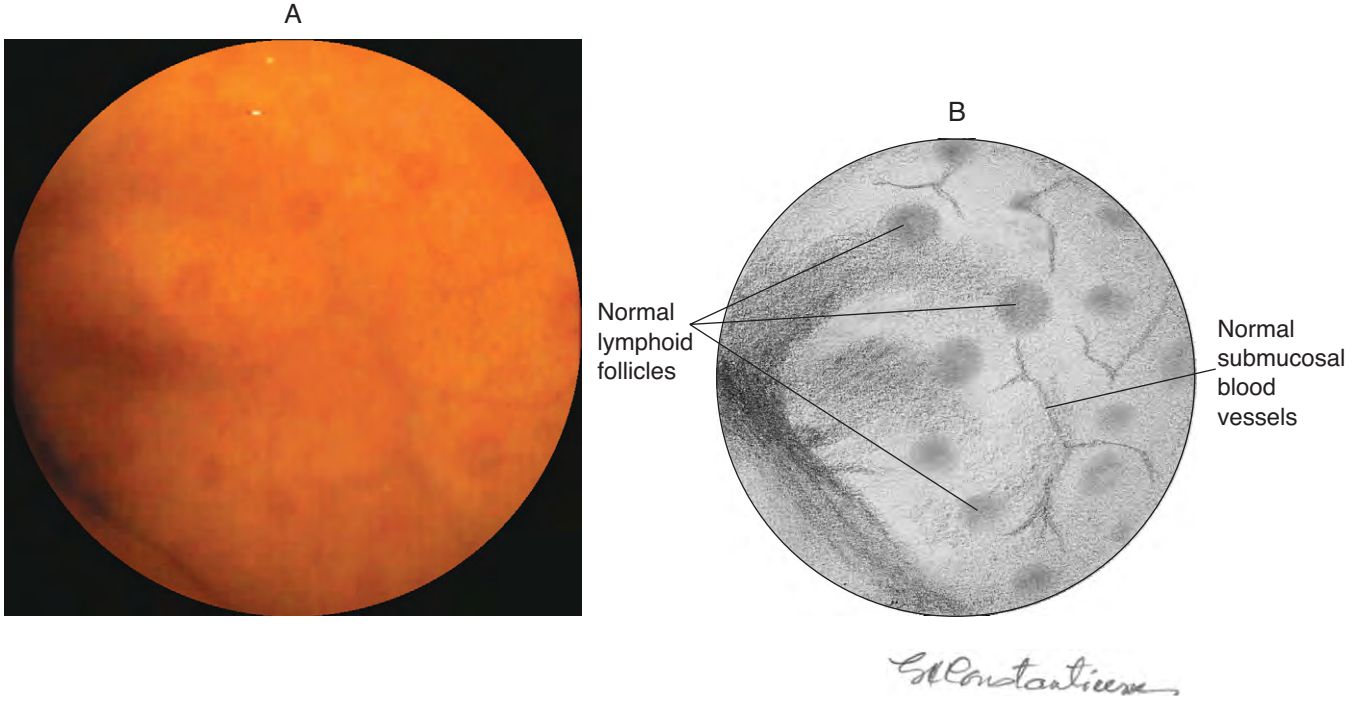



**Fig. 9-13**
Close-up view of lymphoid follicles seen in Fig. 9-12 as discolored, depressed punctate areas in the descending colon.

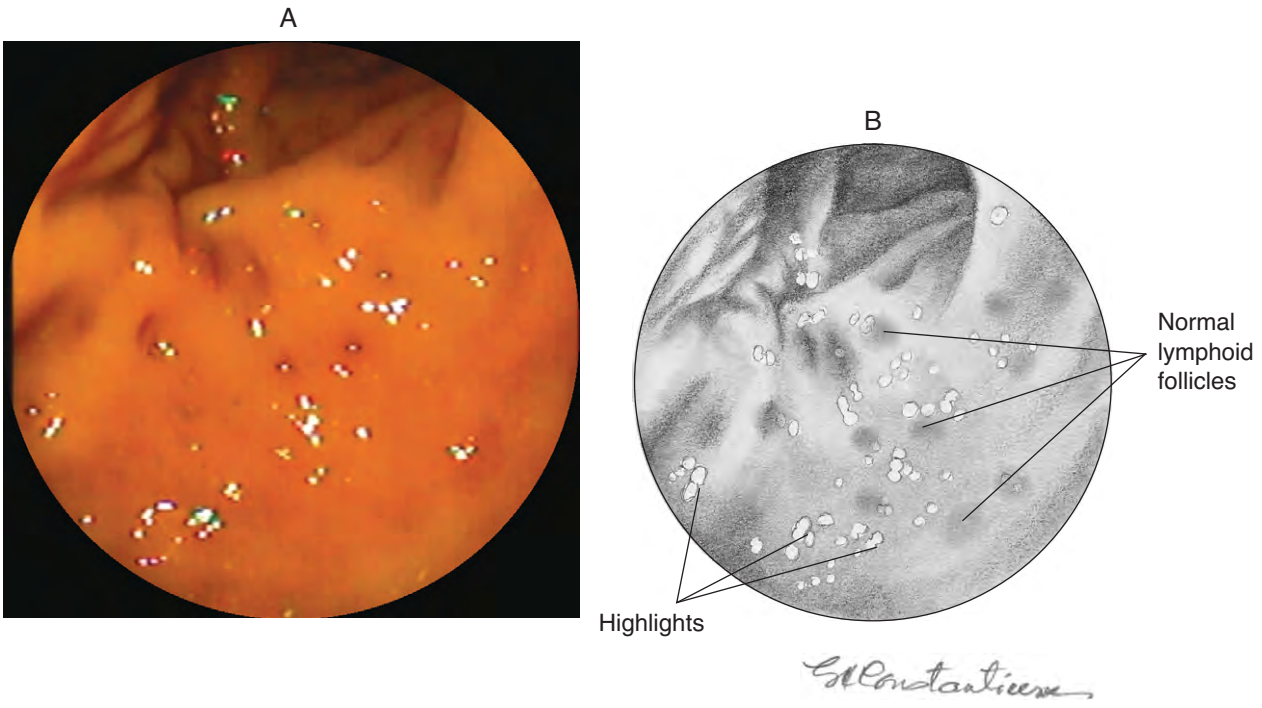



**Fig. 9-14**
Lymphoid follicles visible in the descending colon. Note depressed, discolored punctate areas.

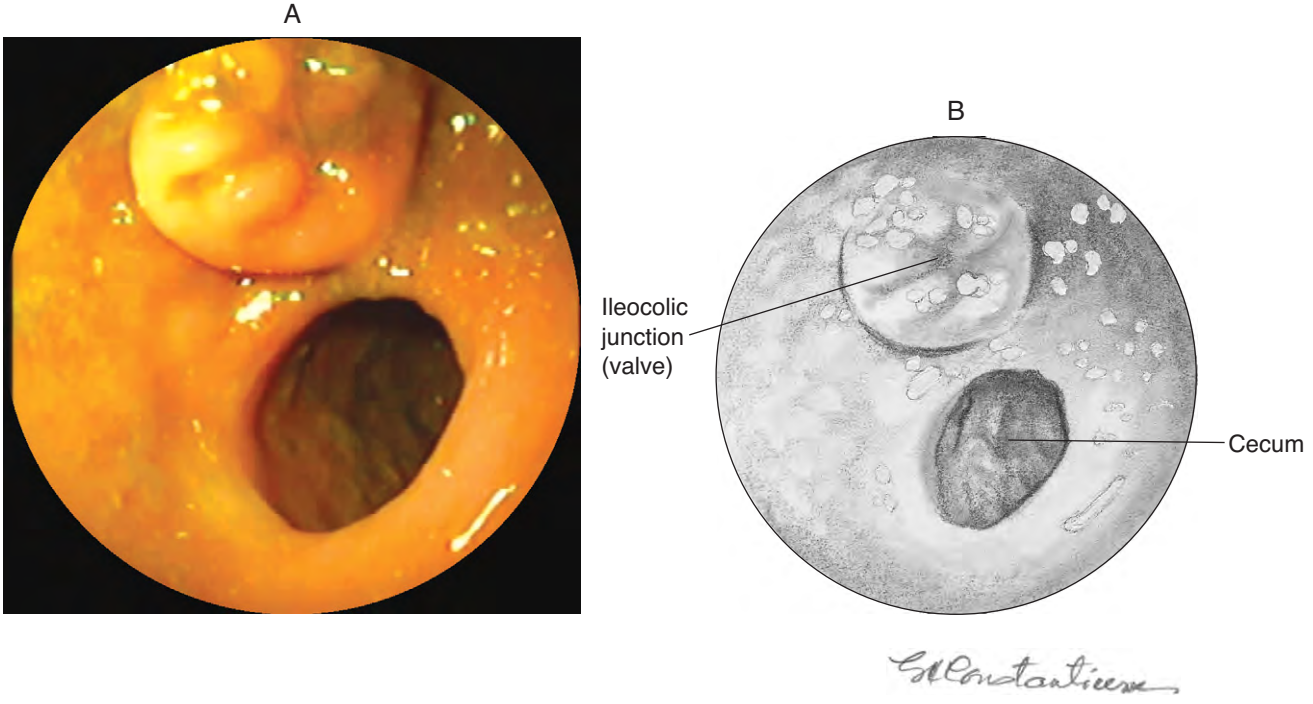



**Fig. 9-15**
The ileocolic junction has a variable appearance. The raised mound of tissue with the central opening at the top of the figure is the ileocolic orifice. The open hole at the bottom of the figure with no raised tissue is the opening into the cecum.

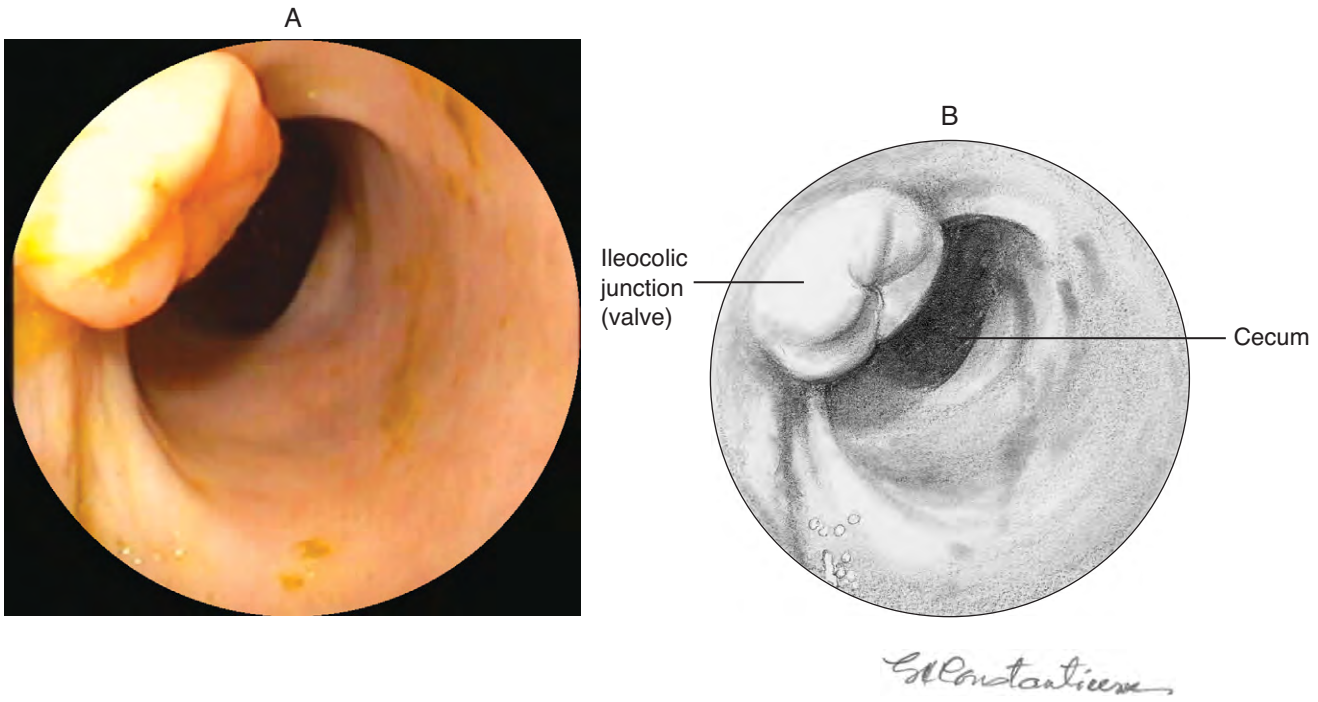



**Fig. 9-16**
The ileocolic junction has a variable appearance. In the upper left corner of the figure, the raised mound of tissue on the side of the colon with the central opening is the ileum. The open continuation of the colon with no raised tissue or demarcation from the colon is the cecum.

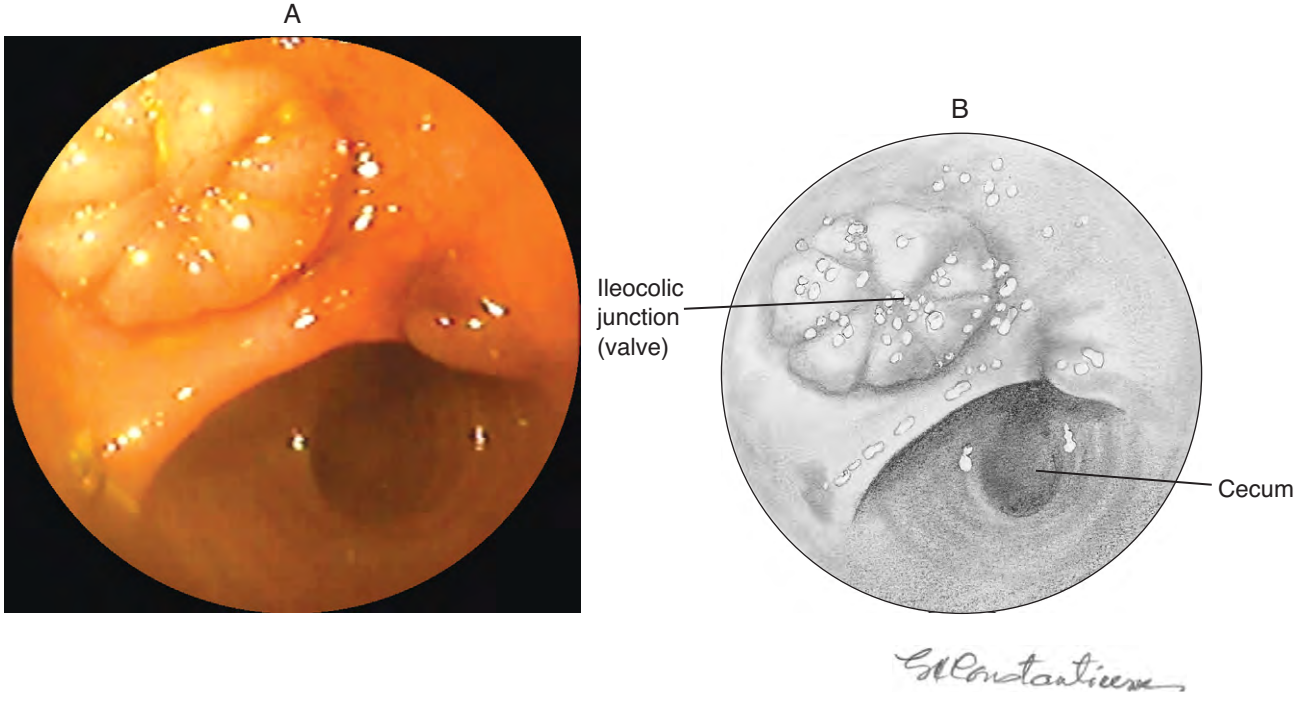



**Fig. 9-17**
The ileocolic junction has a variable appearance. The raised mound of tissue in the upper left of the figure facing directly at the colon lumen with the central opening is the ileocolic junction. The open hole with no raised tissue in the lower right is the opening to the cecum.

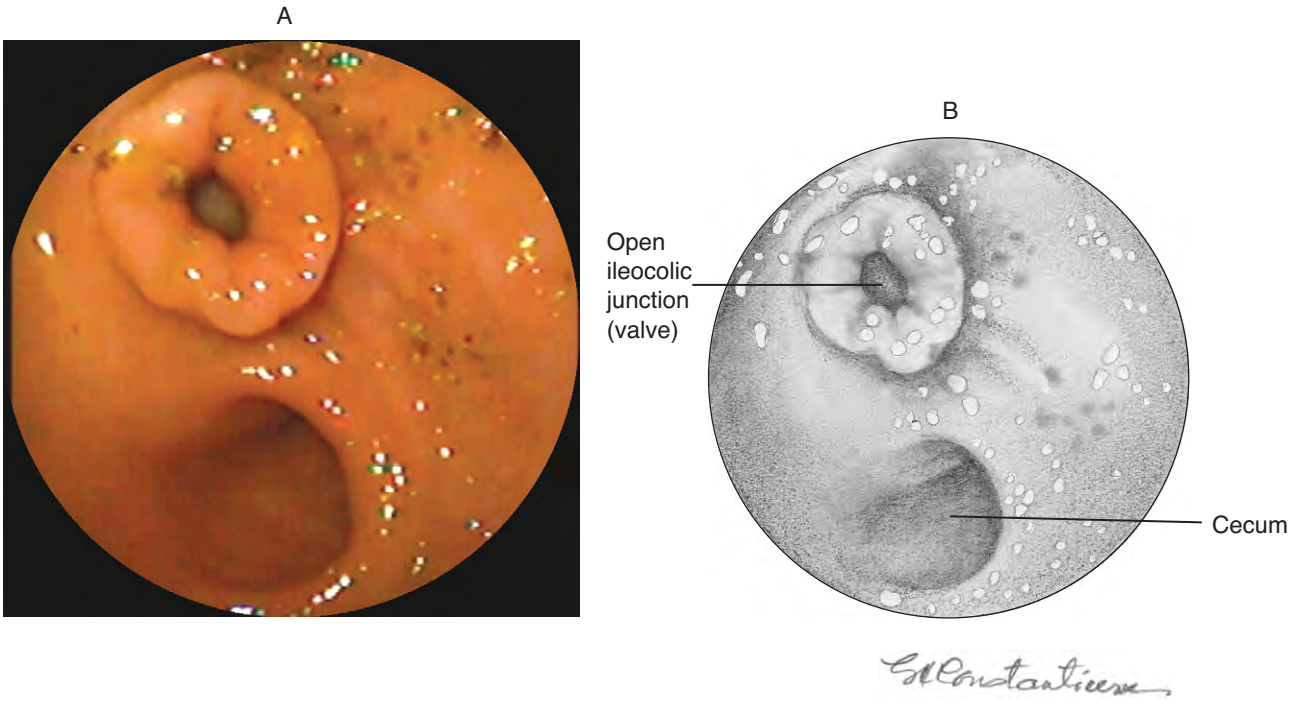



**Fig. 9-18**
The ileocolic junction has a variable appearance. The raised mound of tissue in the upper left of the figure with the central opening is the ileum. The ileocolic sphincter is relaxed. The open hole with no raised tissue at the bottom of the figure is the opening to the cecum.

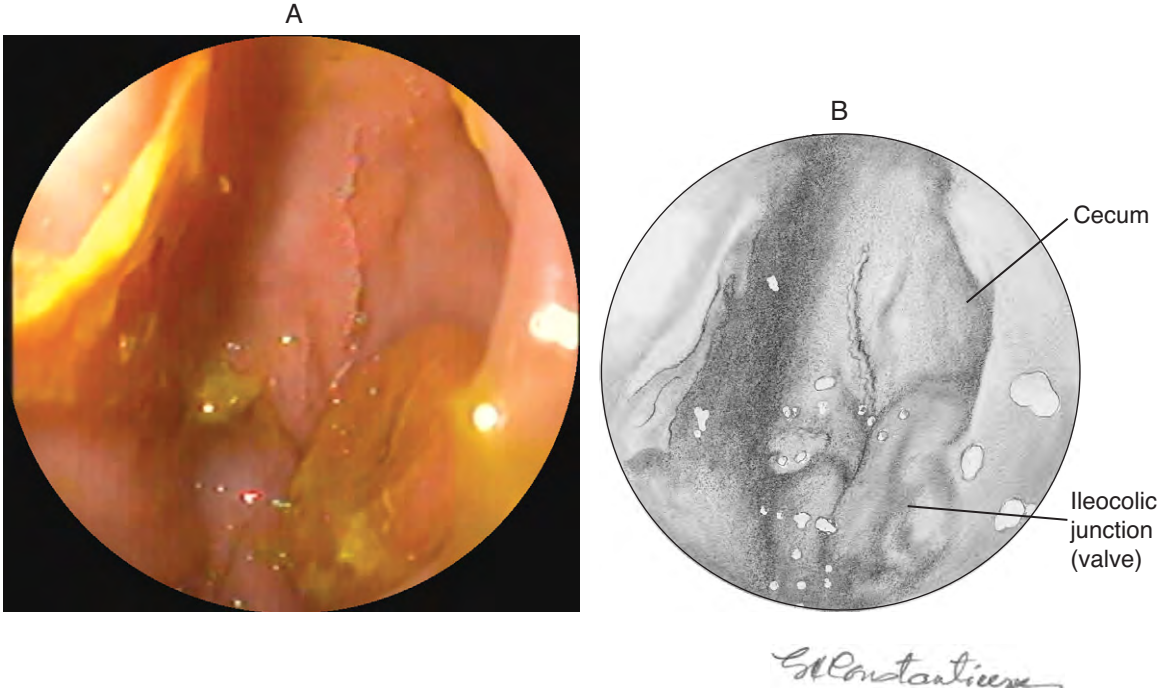



**Fig. 9-19**
Close-up of ileocolic junction. In this view, the ileum is on the lower right and the cecum is on the upper right.

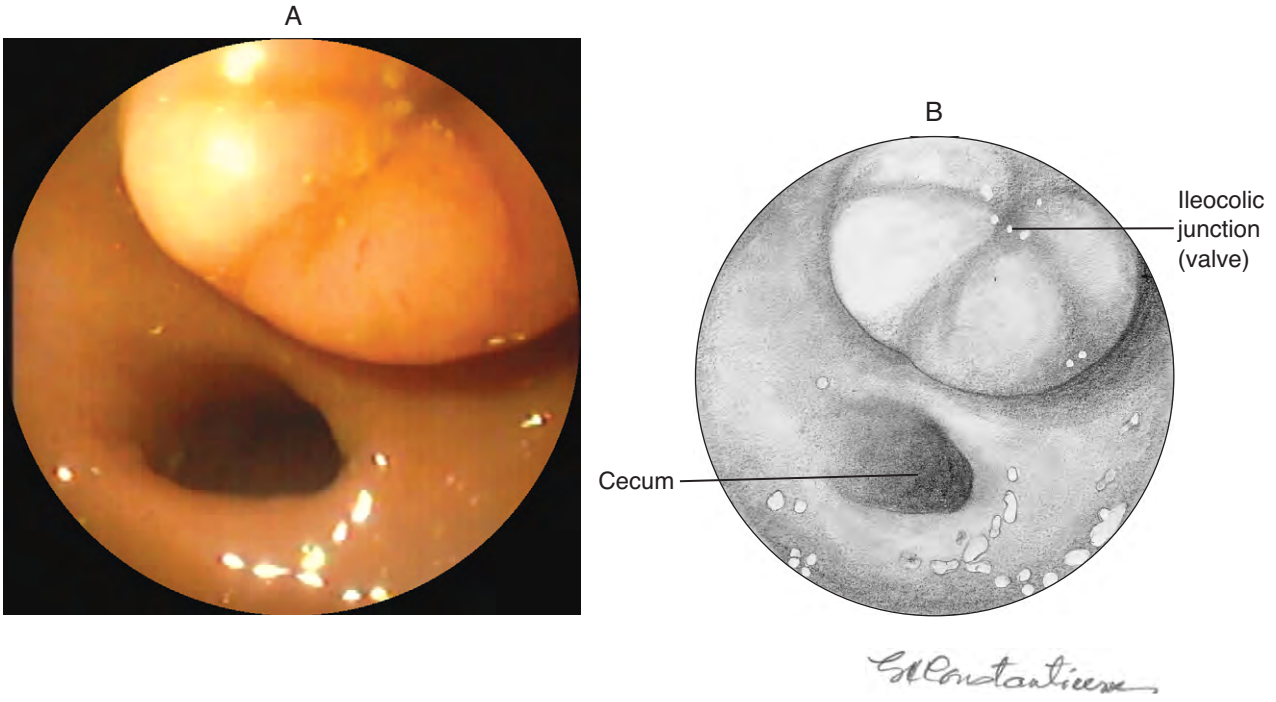



**Fig. 9-20**
Close-up of ileocolic junction. In this view, the ileum is on the upper right and the cecum is on the lower left.

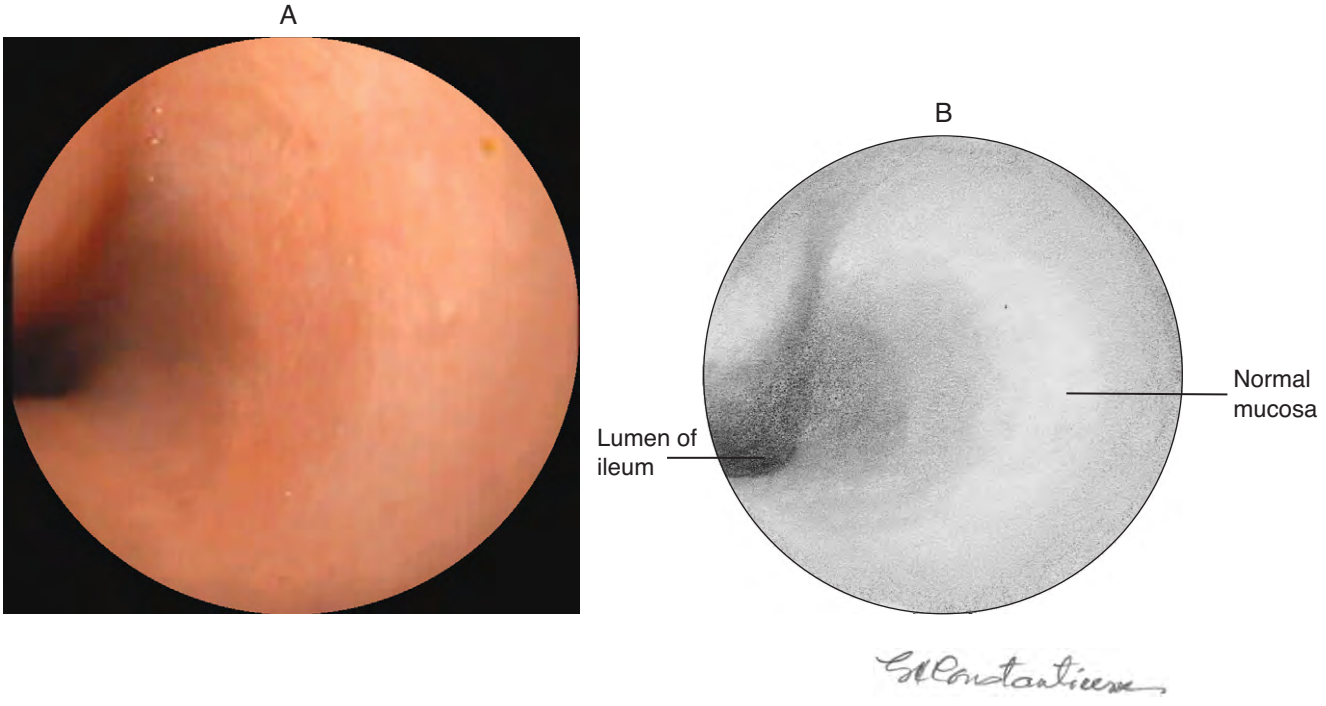



**Fig. 9-21**
Normal ileum. Note the pink, smooth, uniform, velvet-like texture.

specimens obtained with these instruments, usually including muscularis mucosa, are often diagnostic. The likelihood of perforating the colon with such an instrument is remote, unless there is a severely diseased wall. These instruments can also be used through a rigid proctoscope, or alternatively a large rigid forceps can be used. Although the latter can harvest larger biopsy samples, there is greater risk of causing a perforation. When obtaining biopsy specimens with a flexible forceps, the colon should not be maximally insufflated in order to obtain larger samples (see Figs. 9-5 and 9-6).

With experience, larger rigid forceps can be used safely, and relatively large biopsy specimens can be obtained. This is a major advantage of performing rigid colonoscopy. I use Jackson cup forceps with 4-mm cups at a 45-degree angle at the tip (see Fig. 9-5). The biopsy technique is more critical when using rigid instruments. The colon should never be tightly insufflated, or a full thickness grasp (and subsequent perforation) is possible. If necessary, the air should be let out when using the biopsy channel of the magnifying prism (see Fig. 9-4). Air is automatically released when a glass cap is used and subsequently removed. The mucosa is gently grasped with the cups of the rigid forceps. As the forceps are pulled back and slowly withdrawn, they are slowly closed more tightly. This allows some separation of the mucosa from deeper layers and minimizes the risk of perforation. Once there is sufficient tension on the mucosa, they are closed very tightly and pulled, thus cutting the mucosal sample. Ideally the sample should contain the entire mucosa and a small amount of the submucosa. Biopsy samples are obtained from multiple levels as the scope is withdrawn, thus giving a representative sampling of the descending colon and rectum. Once specimens are obtained, the rigid or flexible scopes should not be advanced or reinserted due to the risk of perforation.

Multiple biopsies are necessary because many are lost to processing or they are difficult to assess because of orientation artifacts and because disease processes can be heterogeneous within the colon. I commonly obtain 7 to 10 samples each from random sites in the ileum, cecum, ascending/transverse colon, and descending colon. If focal lesions are seen (e.g., ulcers, masses, or strictures), additional multiple samples should be obtained from these areas. Because many neoplastic ulcers have superficial areas of inflammation, repeated sampling of the same area might be necessary to obtain deeper tissue. Often 10 to 15 samples are necessary to obtain diagnostic tissue. Care must be taken to avoid perforation if this method is used. For exophytic (raised and proliferative) masses (most commonly seen in the rectum), large pieces are easily obtained because these are usually very friable masses.

Samples are gently placed on saline-moistened lens paper, wrapped in the paper, and submerged in formalin. Alternatively, the tissue can be placed on the sponge that fits into histopathology cassettes (Fig. 9-22). The sponge (with samples) is placed in the cassette and immersed in formalin. Abnormal appearing areas (e.g., ulcers, masses, and strictures) should be placed in separate formalin containers from the normal appearing mucosa. A pathologist experienced in interpreting small endoscopic biopsies should examine the tissue.

## COMPLICATIONS OF COLONOSCOPY

The main complication of colonoscopy is perforation of the colon. This can occur upon introduction of the instrument, when the colon is insufflated with air, or when specimens are obtained. Immediately following perforation and subsequent insufflation, there is marked distention of the abdomen with air. This can be detected by noting a tympanitic feeling of the abdominal wall or by noting a pneumoperitoneum radiographically. If a perforation is known to have occurred, immediate surgical intervention is indicated. If a perforation goes undetected, as can happen following biopsy, the animal shows signs of peritonitis, including fever, abdominal pain, and vomiting. The diagnosis can be confirmed radiographically (noting free gas in the abdomen and an abdominal effusion) (Fig. 9-23) or by evaluating a peritoneal tap or diagnostic lavage (noting purulent inflammation with phagocytized bacteria).

Additional complications include excessive bleeding and postprocedure diarrhea. These are usually self-limiting and rarely require intervention. Infection following the procedure is also rare. This can potentially be iatrogenic if the scope is not properly cleaned and disinfected after each use.

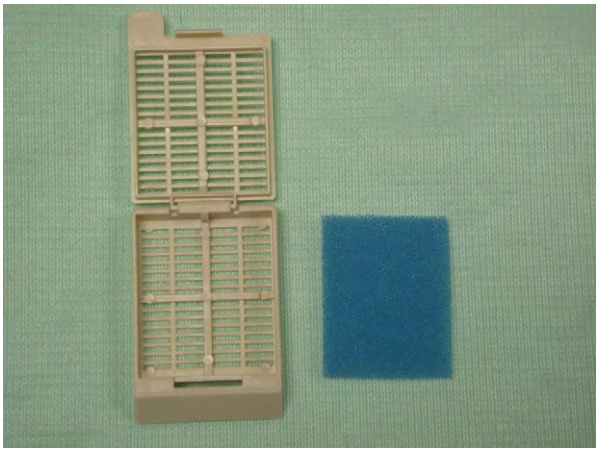


**Fig. 9-22**
Histopathology cassette. The biopsy specimens are placed onto the blue sponge, then placed in the cassette for immersion into formalin.

## ABNORMAL COLONOSCOPIC FINDINGS

With experience, the endoscopist should learn to distinguish the normal from abnormal appearance of the colonic mucosa. When a focal mucosal lesion is identified, directed multiple biopsy specimens should be obtained. When the abnormality is diffuse or when no gross abnormalities are visualized, multiple random specimens should be obtained of the ileum, colon, and rectum. Figs. 9-24 to 9-62 demonstrate various abnormalities seen during colonoscopy; Table 9-1 lists common abnormalities.

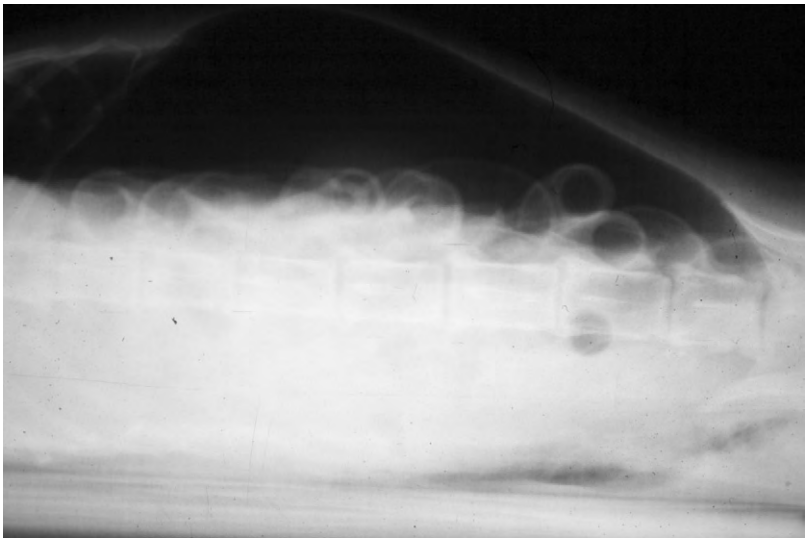


**Fig. 9-23**
Horizontal beam ventrodorsal radiograph demonstrating free abdominal gas following iatrogenic intestinal perforation. Note the accumulation of gas adjacent to the abdominal wall and rising above the abdominal viscera.

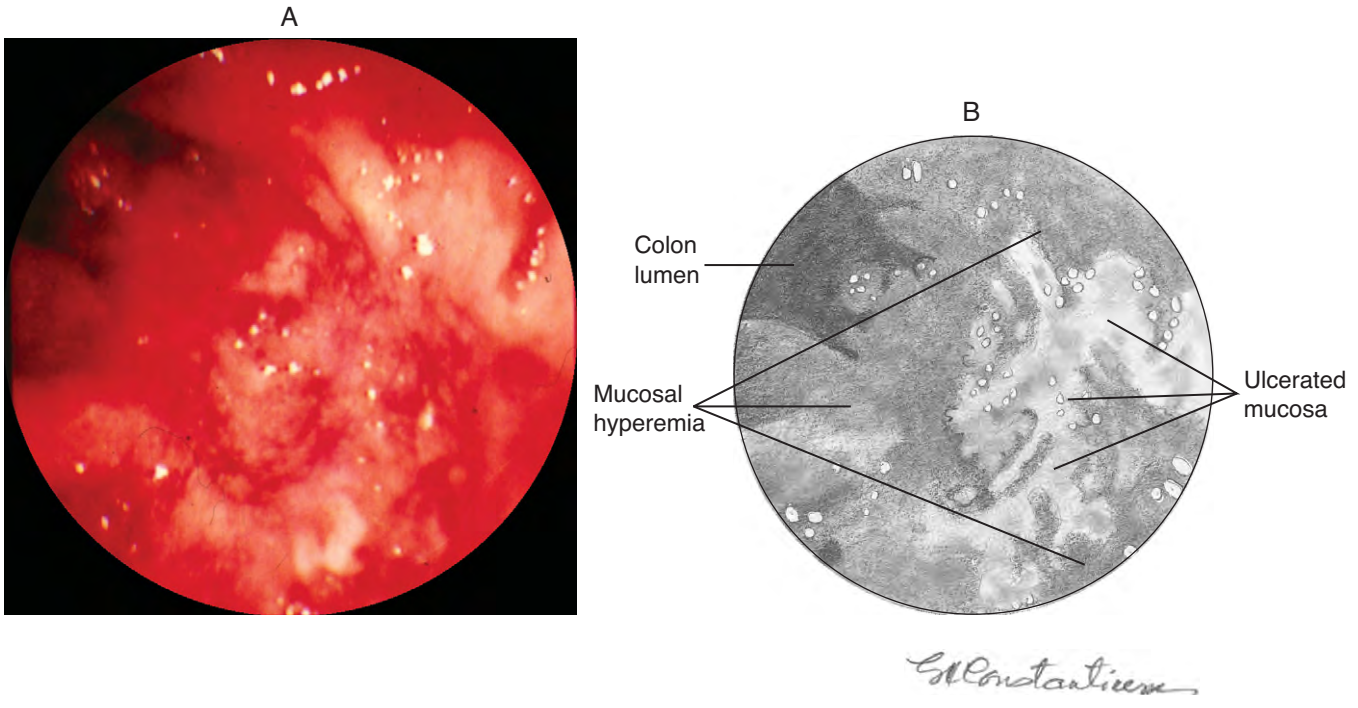



**Fig. 9-24**
Inflamed descending colon in a dog with lymphocytic, plasmacytic colitis. Note the mucosal hyperemia and superficial ulcers with fresh blood. Superficial mucosal vessels are not visible due to the mucosal infiltrate.

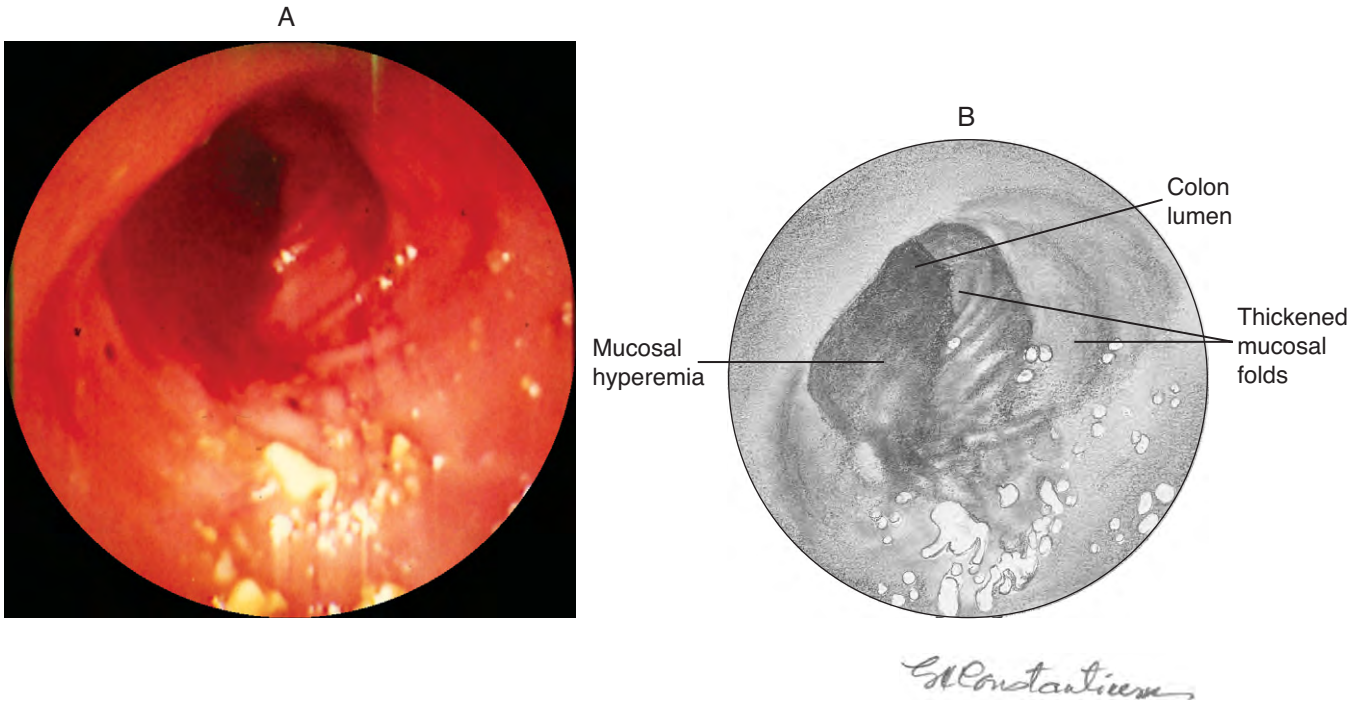



**Fig. 9-25**
Inflamed descending colon in a dog with *Campylobacter*-induced colitis. Note the mucosal hyperemia and thickened folds. Superficial mucosal vessels are not visible due to the mucosal infiltrate.

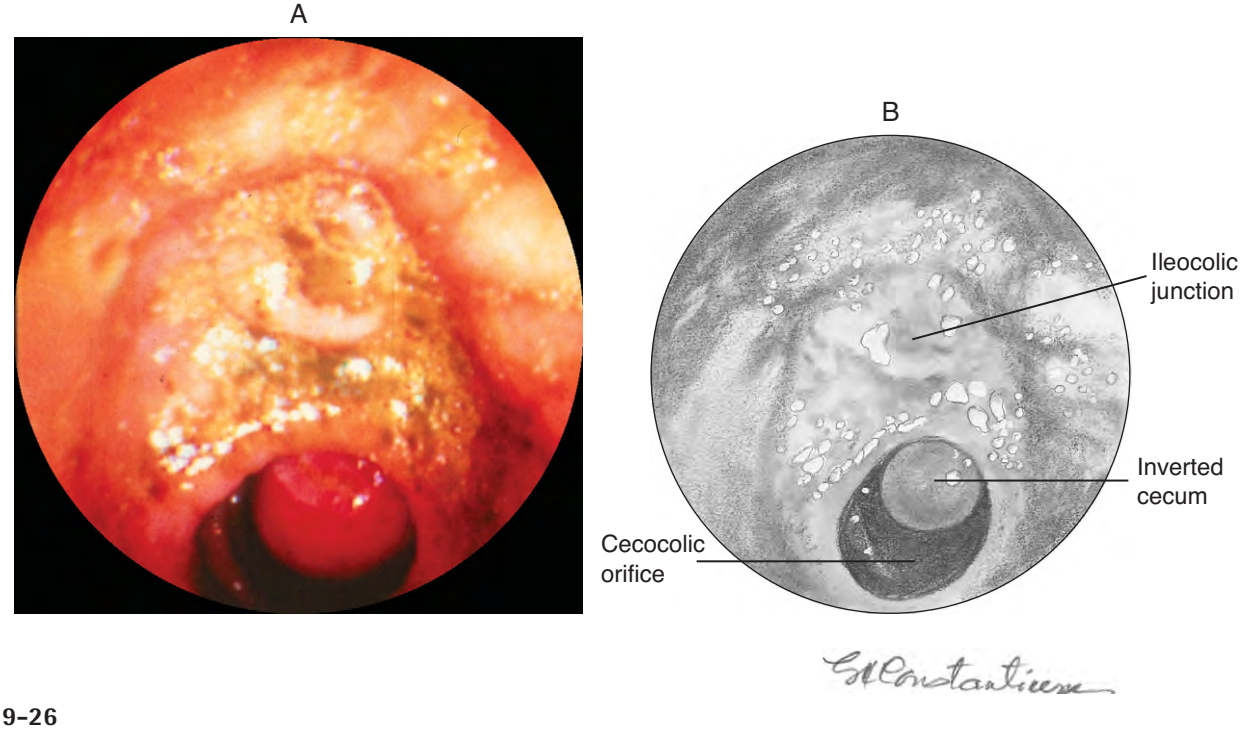



**Fig. 9-26**
Cecal inversion. Note the tip of the cecum just barely protruding from the cecocolic orifice at the bottom of the image. The opening to the ileum is in the center of the image. (A small amount of feces slightly obscures the opening.)

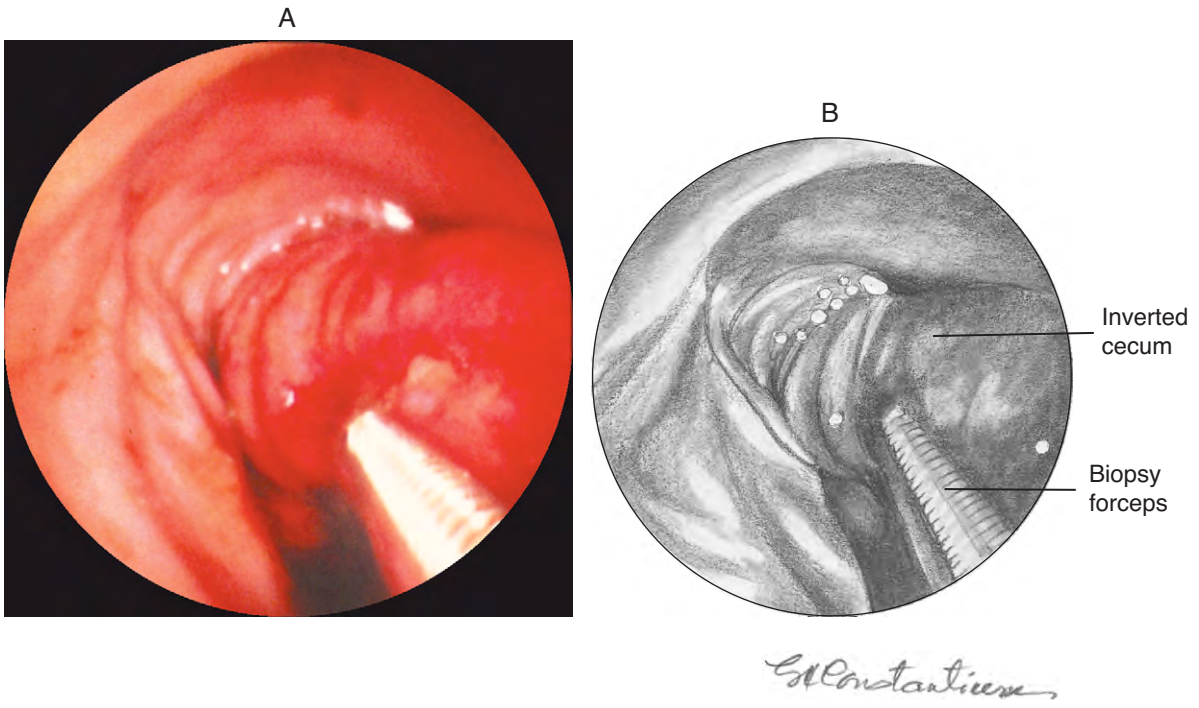



**Fig. 9-27**
Cecal inversion. A large portion of the cecum protrudes as a mass effect in the lumen of the descending colon. A biopsy forceps is visible in the center.



**Fig. 9-28**
Pneumocolon radiograph demonstrating the cecal inversion in the dog pictured in Fig. 9-27. Note the filling defect in the descending colon.

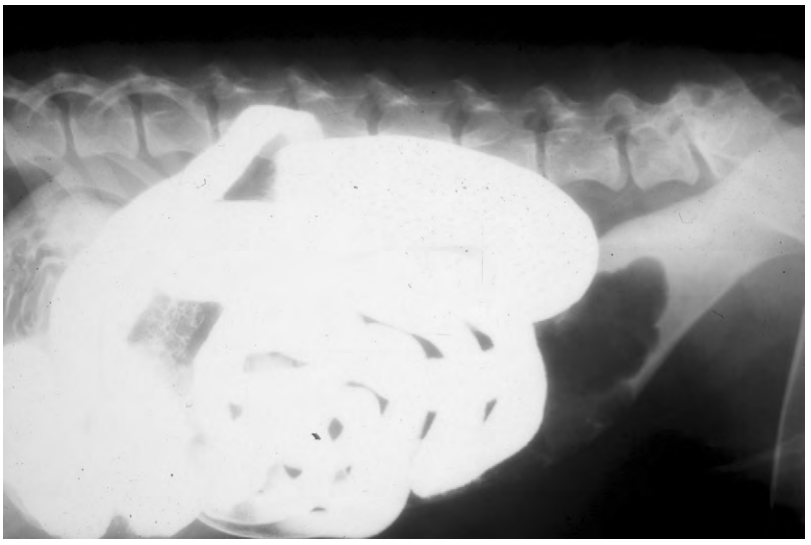


**Fig. 9-29**
Upper gastrointestinal barium series with small and large bowel follow-through demonstrating the cecal inversion in the dog pictured in Fig. 9-27. Note the filling defect in the descending colon.

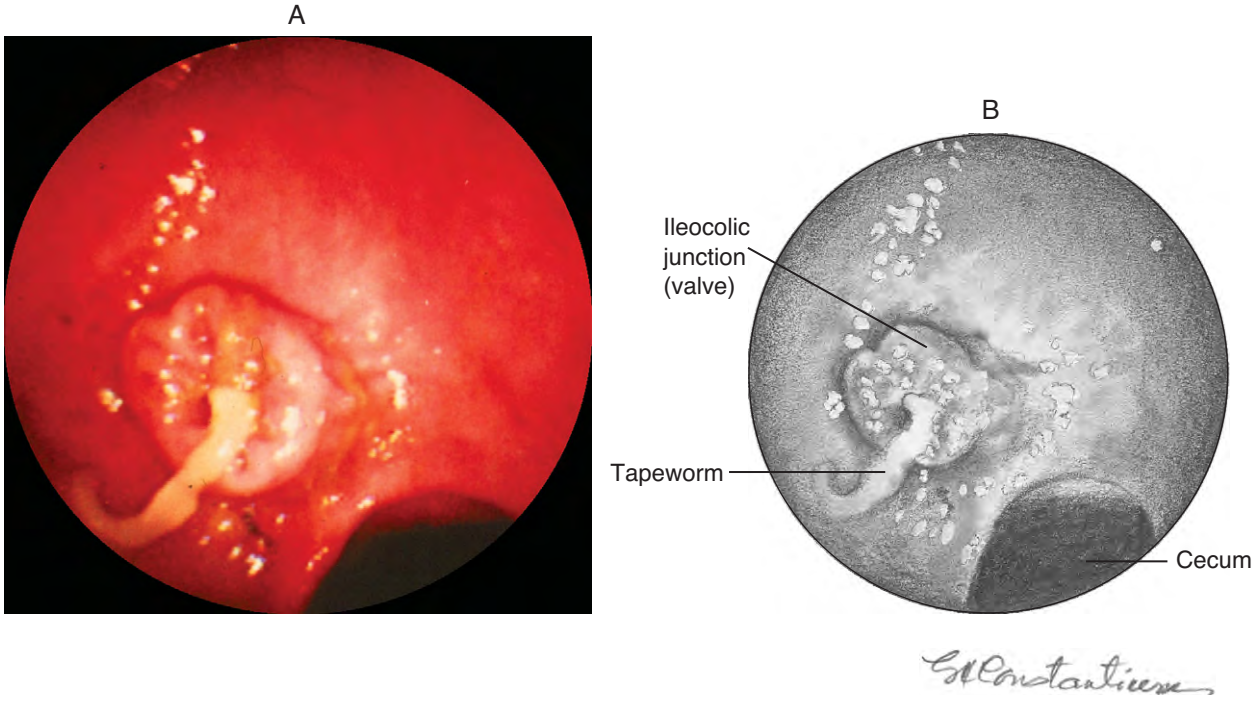



**Fig. 9-30**
Tapeworm exiting the ileum (*center*). The opening to the cecum is seen at the lower right.

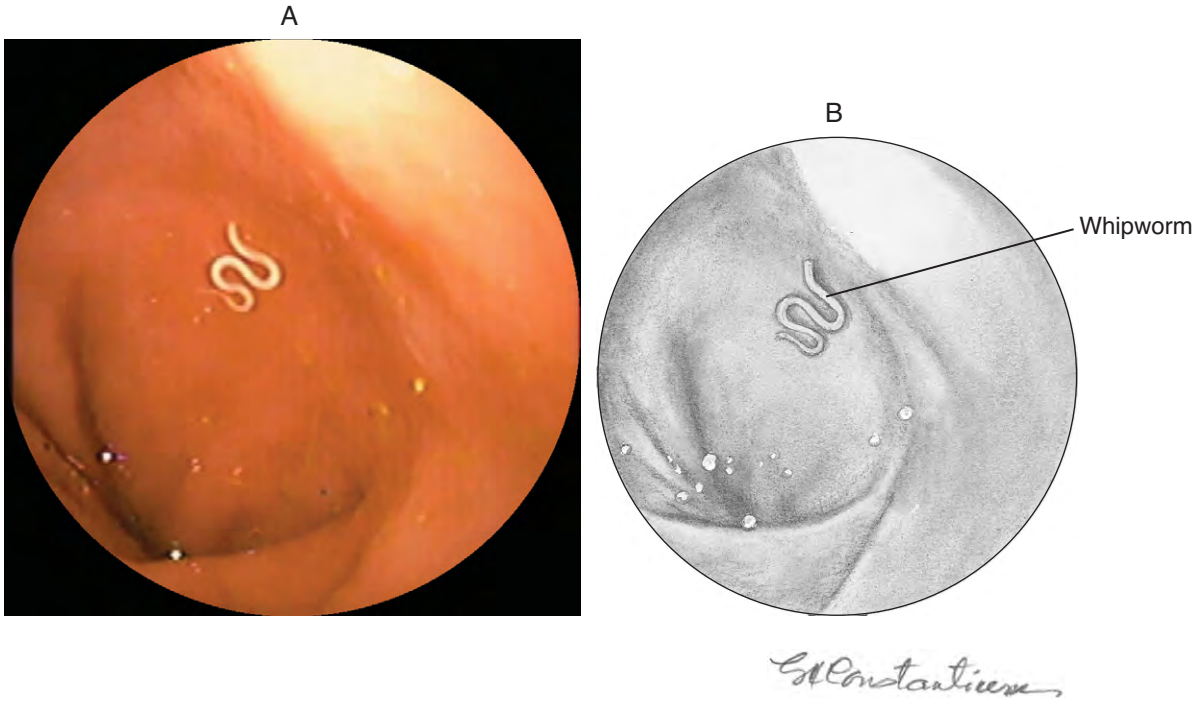



**Fig. 9-31**
Whipworm (*Trichuris vulpis*) adhered to descending colon mucosa.

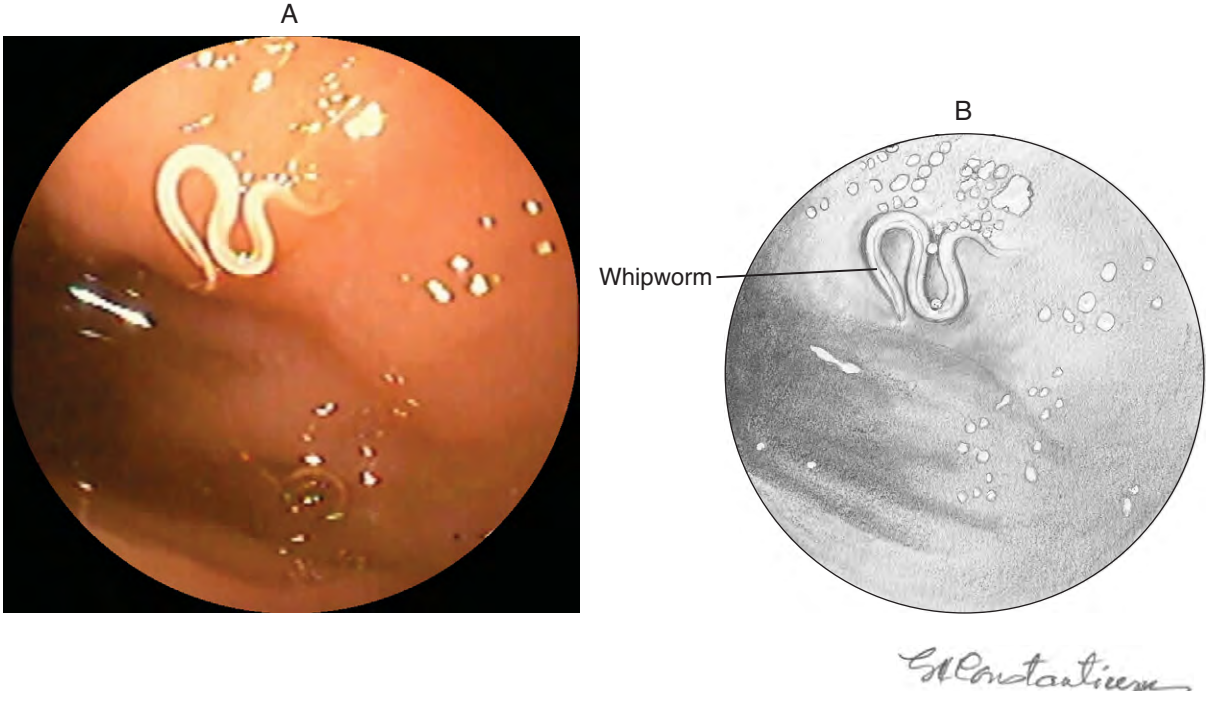



**Fig. 9-32**
Close-up of whipworm (*Trichuris vulpis*) adhered to descending colon mucosa.

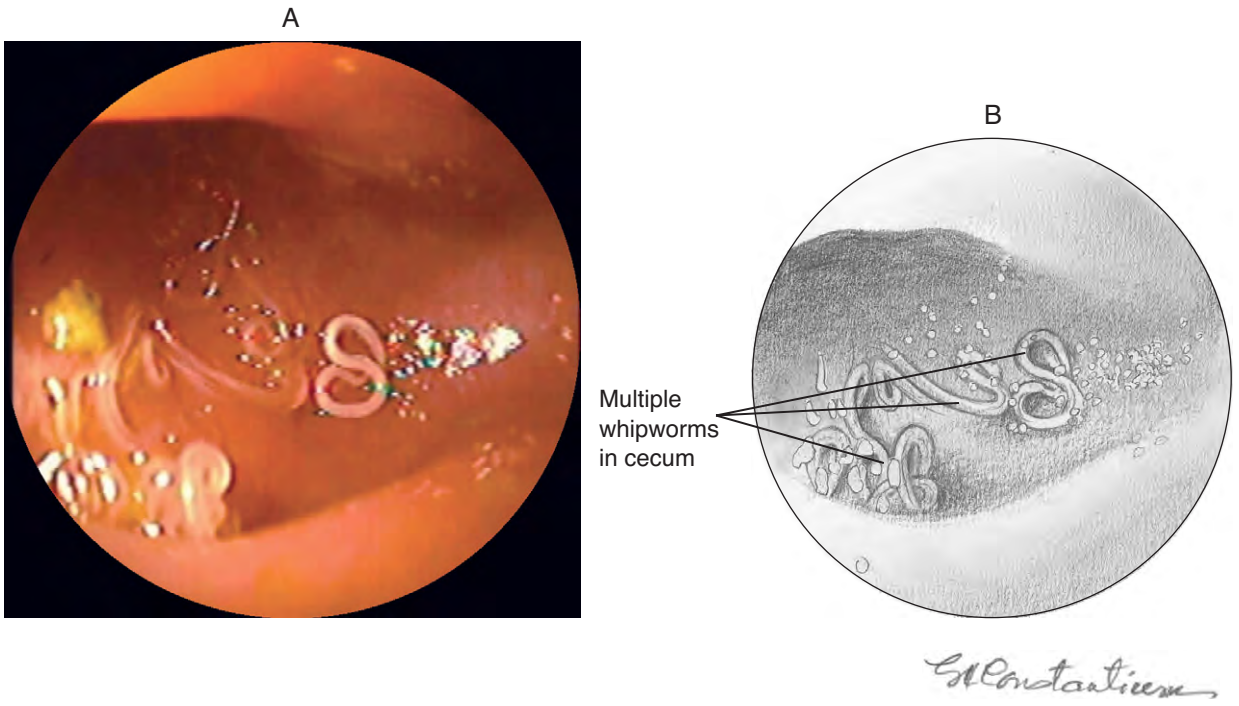



**Fig. 9-33**
Cluster of whipworms (*Trichuris vulpis*) in the cecum.

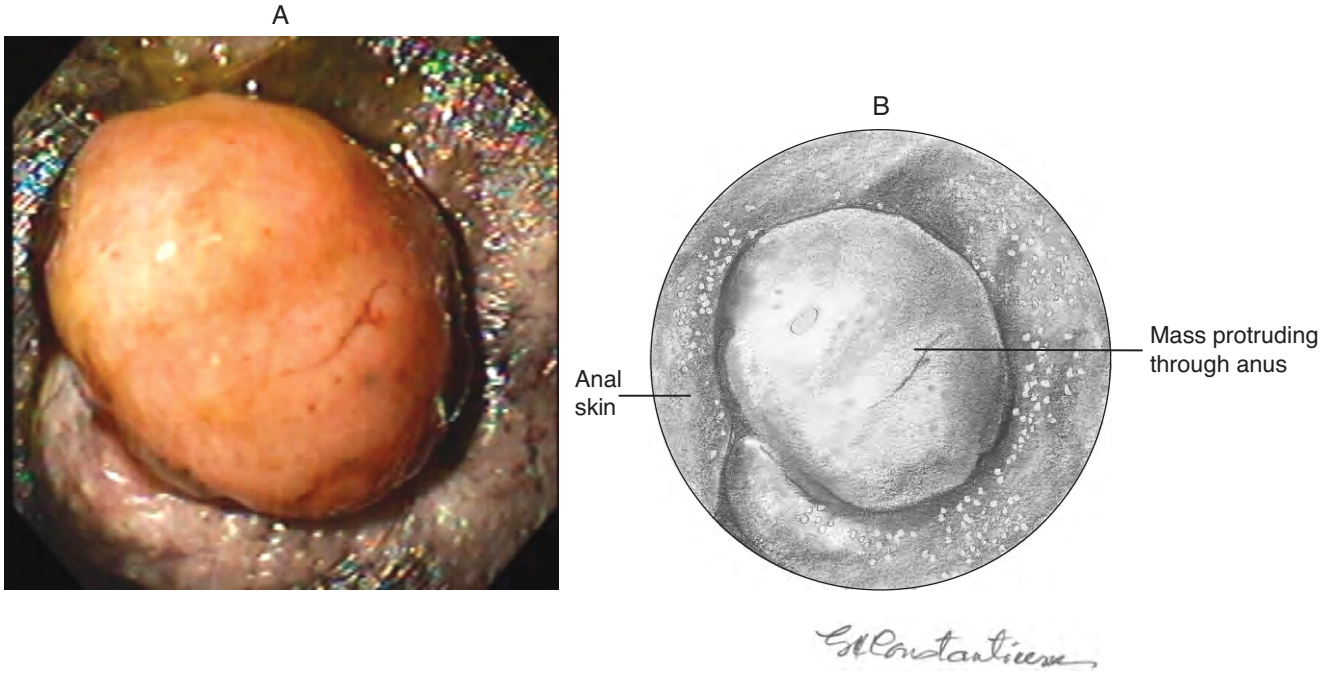



**Fig. 9-34**
Mass protruding from anus (adenomatous polyp).

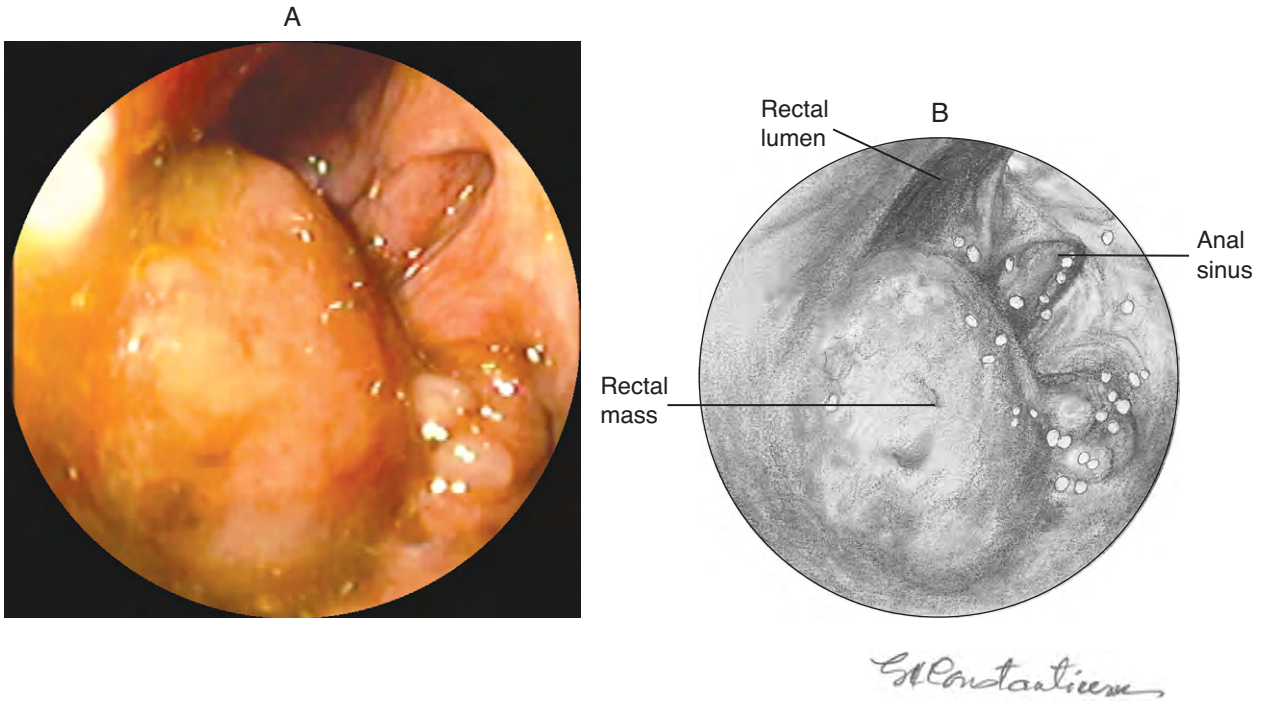



**Fig. 9-35**
Mass pictured in Fig. 9-34 after reduced into rectal lumen.

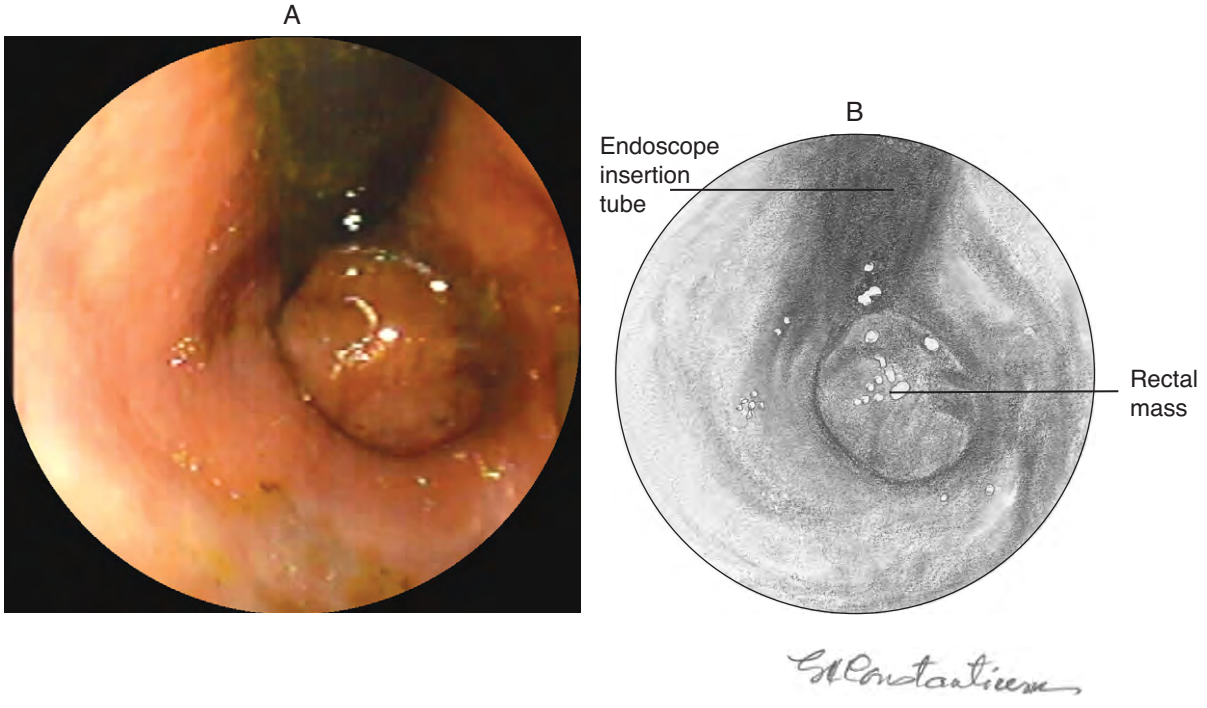



**Fig. 9-36**
Retroflexed view of the rectal mass pictured in Fig. 9-35. Note the endoscope (black tube) at the top of the image, which is visible when the scope is deflected 180 degrees.

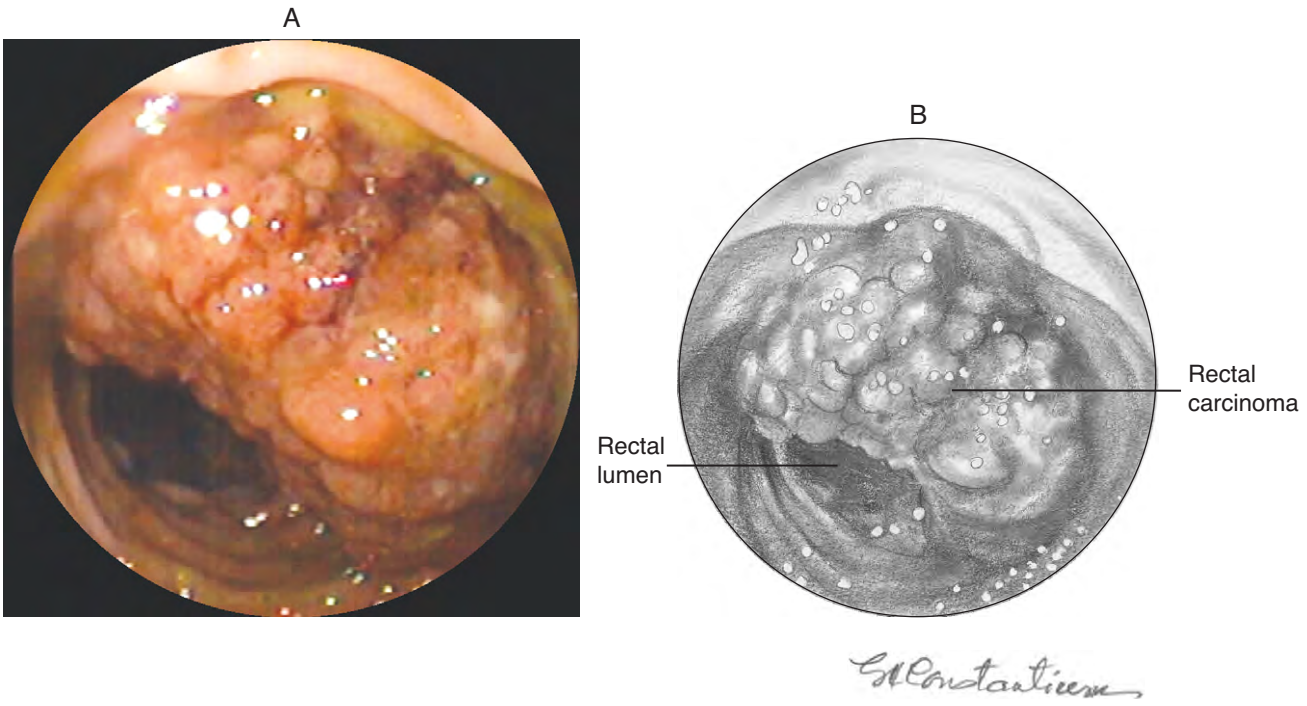



**Fig. 9-37**
Rectal mass (carcinoma in situ) visible just upon entry into the rectum. Note the irregular, raised, ulcerated tissue.

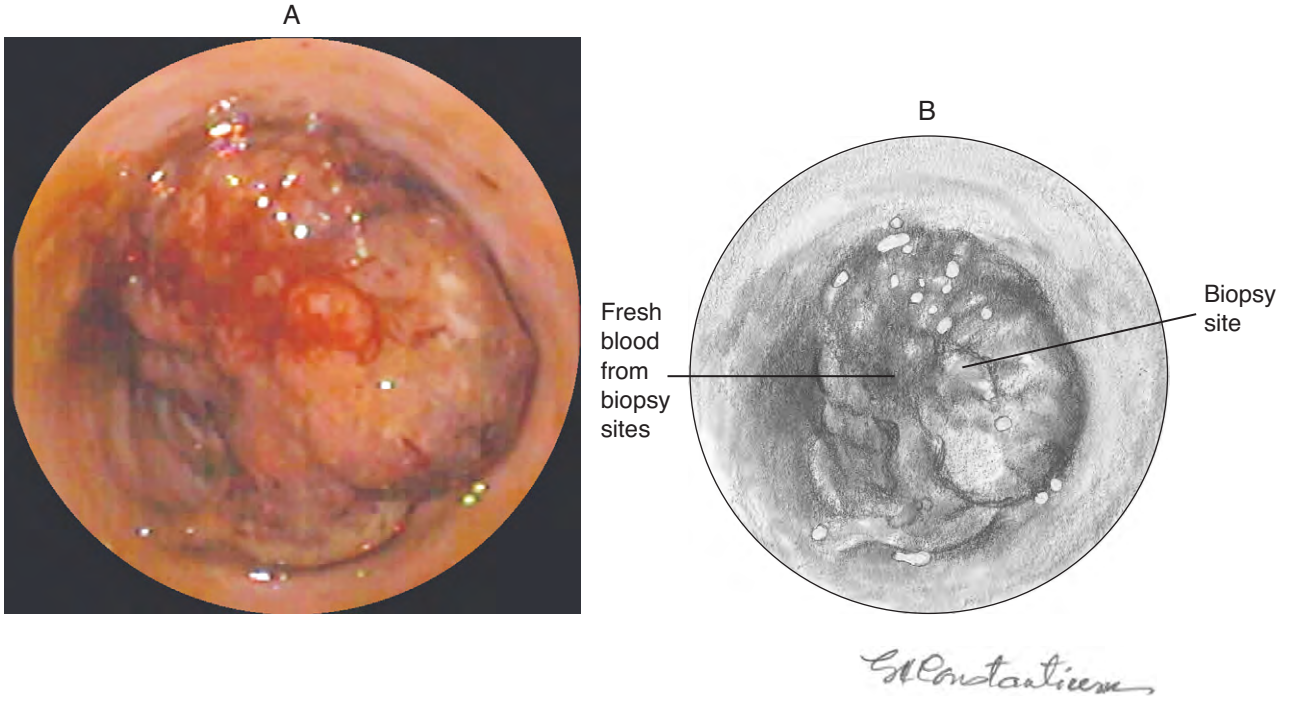



**Fig. 9-38**
Rectal mass pictured in Fig. 9-37 after biopsy specimens were obtained. Note fresh blood on the surface of the mass.

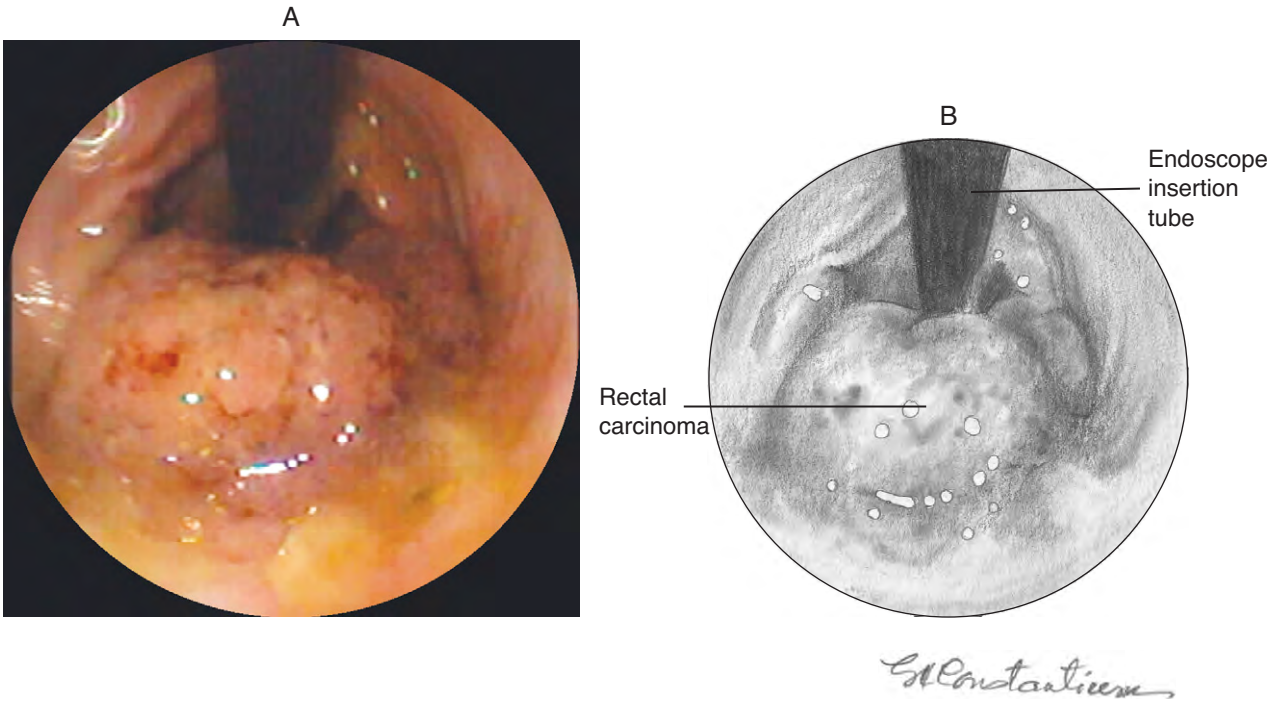



**Fig. 9-39**
Retroflexed view of the mass pictured in Figs. 9-37 and 9-38. This is visible just in front of the scope (black tube) as the scope is deflected 180 degrees.

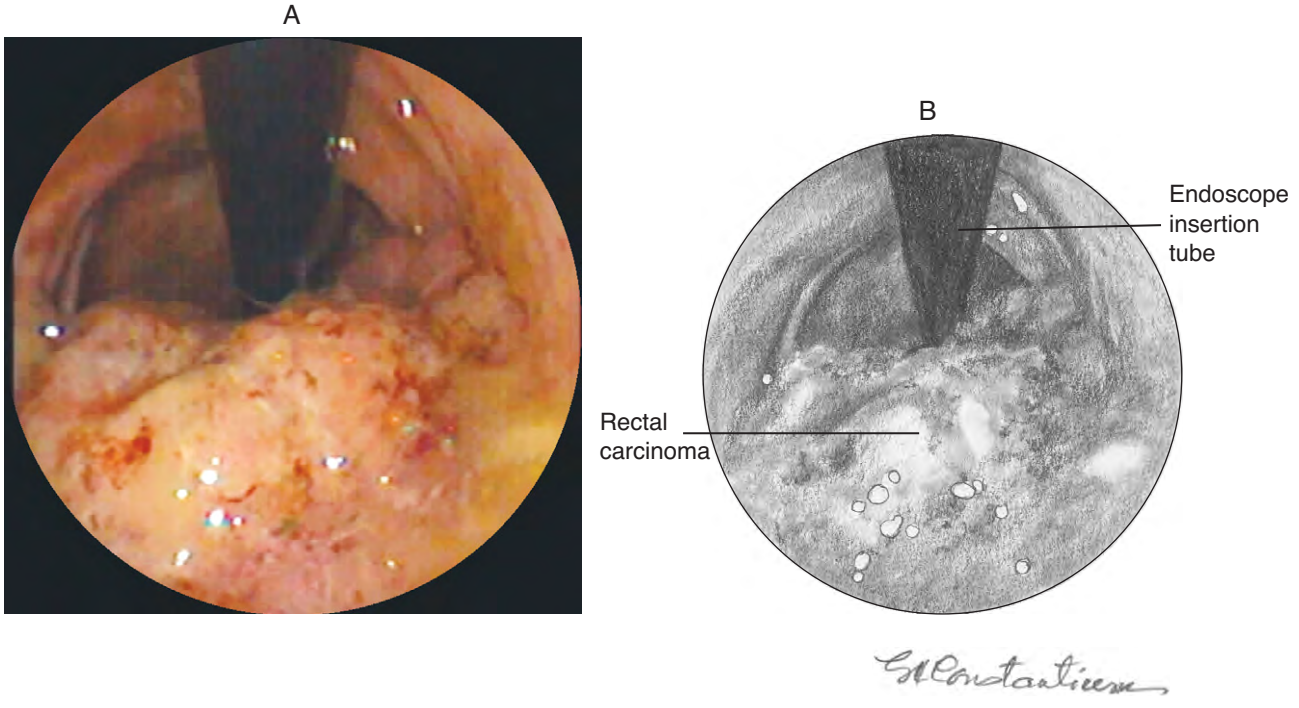



**Fig. 9-40**
Close-up retroflexed view of the mass pictured in Fig. 9-39. The close-up view is obtained by pulling the insertion tube of the scope out of the rectum, thus pulling the viewing end closer to the mass.

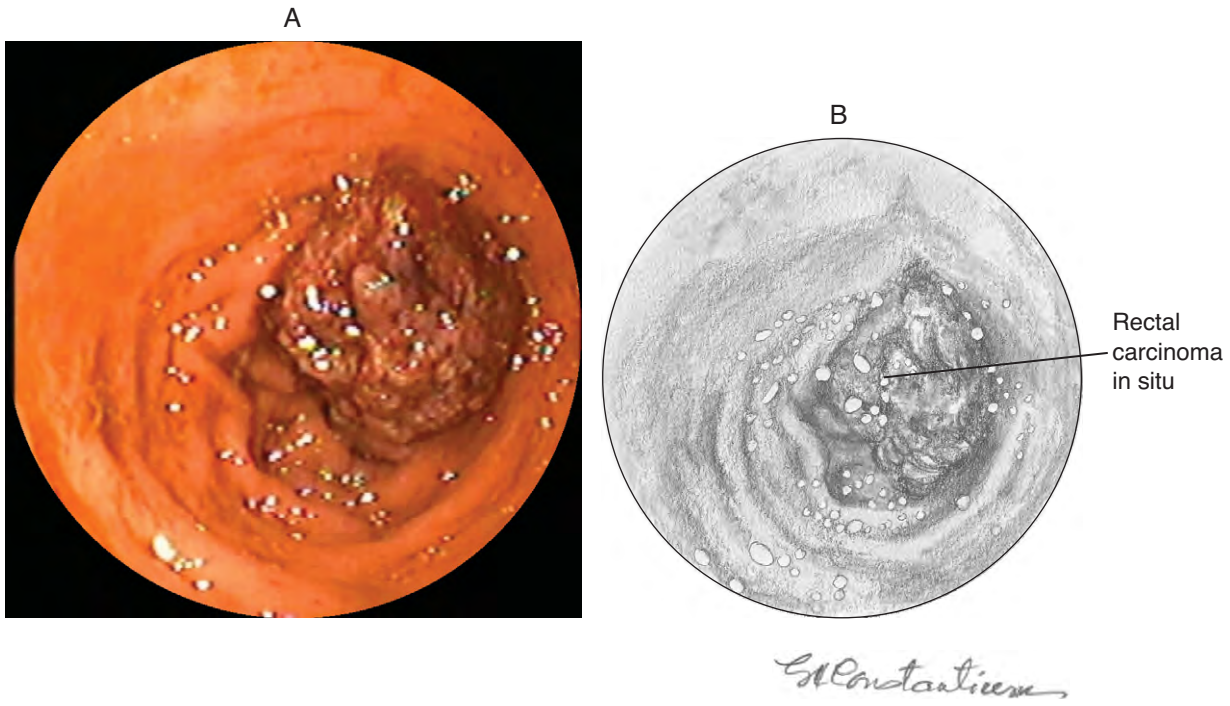



**Fig. 9-41**
Rectal mass (carcinoma in situ). Note the irregular ulcerated tissue in the center of the lumen.

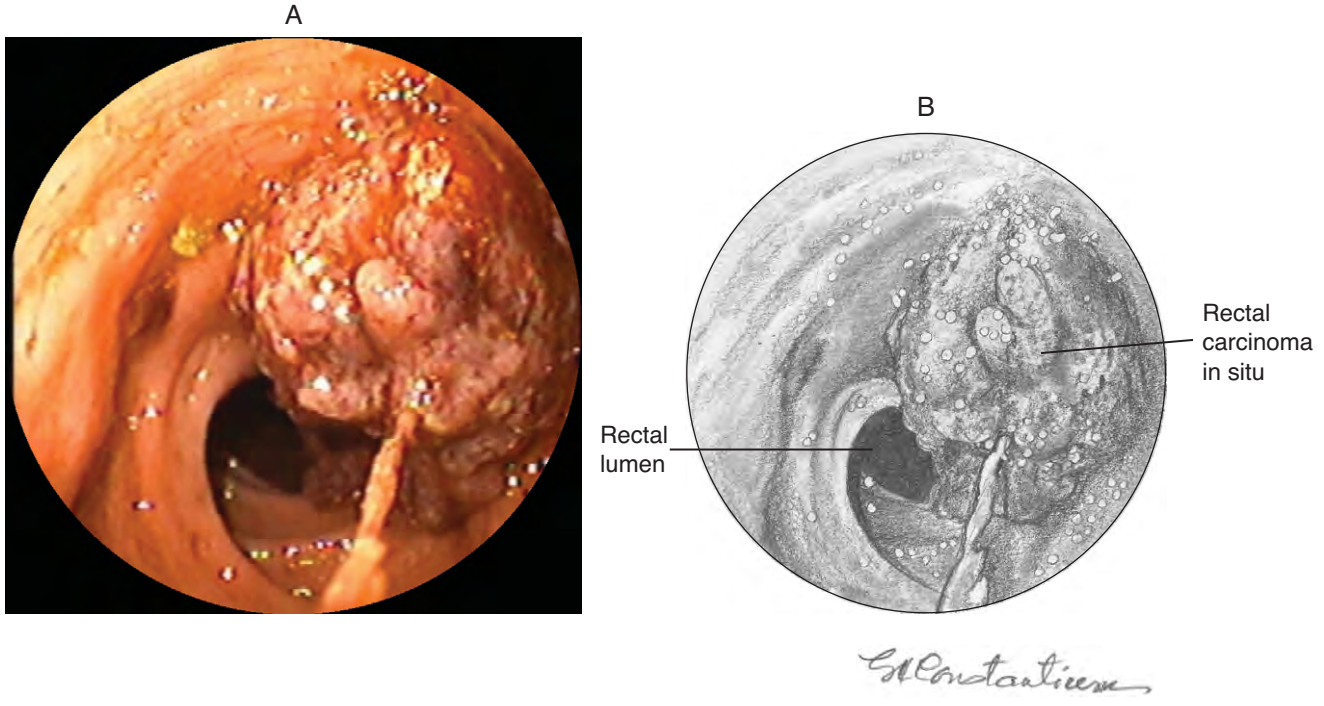



**Fig. 9-42**
Close-up view of the rectal mass pictured in Fig. 9-41.

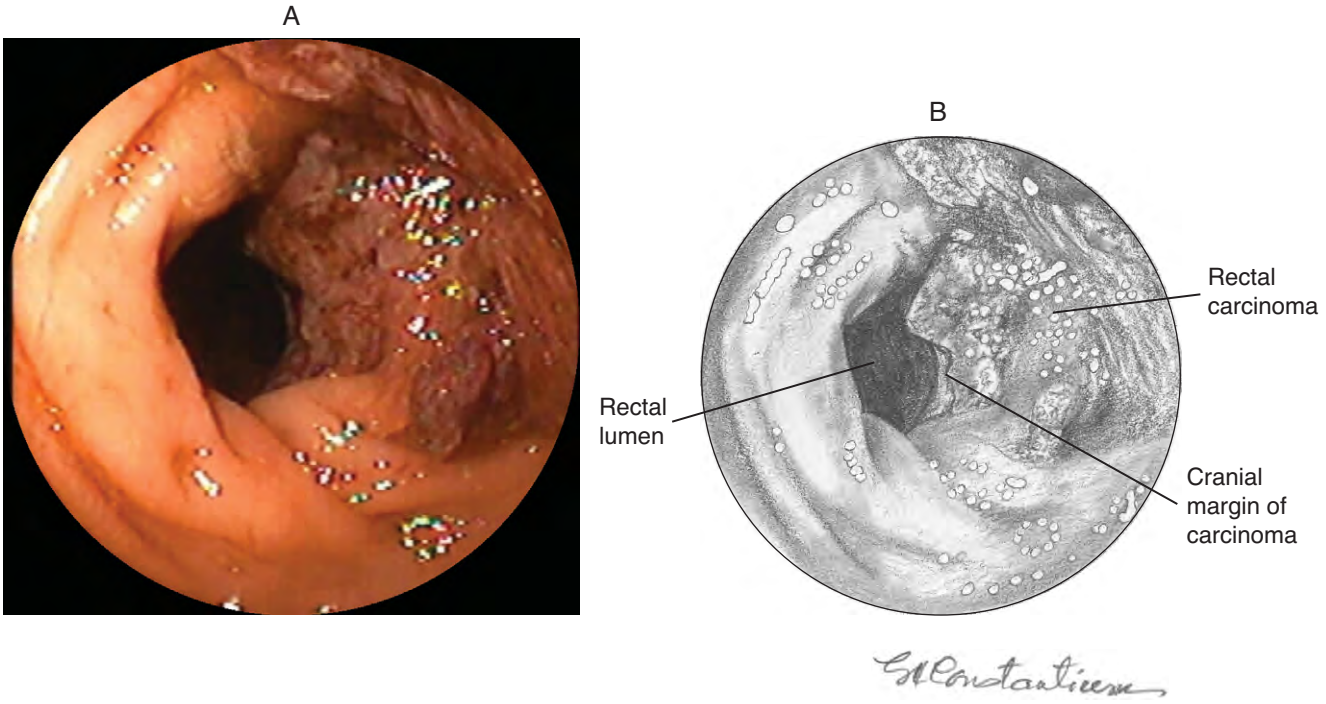



**Fig. 9-43**
Passing through the area of the rectal mass pictured in Figs. 9-41 and 9-42 showing cranial extension of the carcinoma.

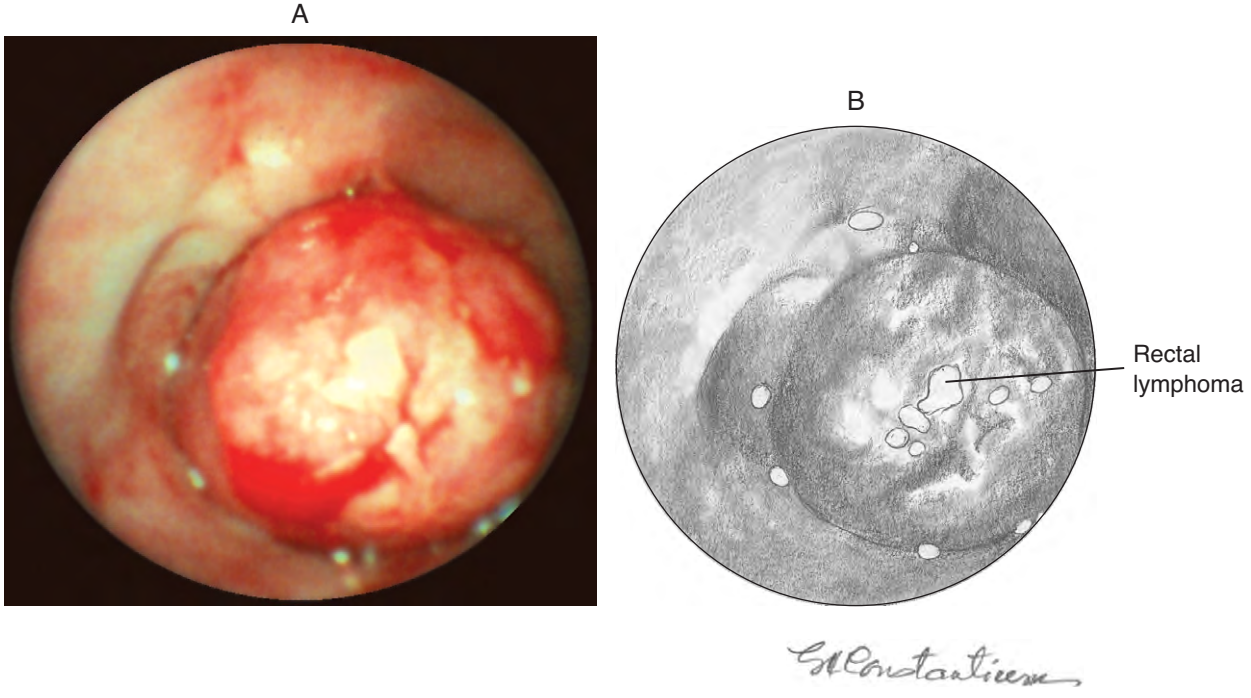



**Fig. 9-44**
Rectal mass (lymphoblastic lymphoma). Note the round, smooth, partly ulcerated surface.

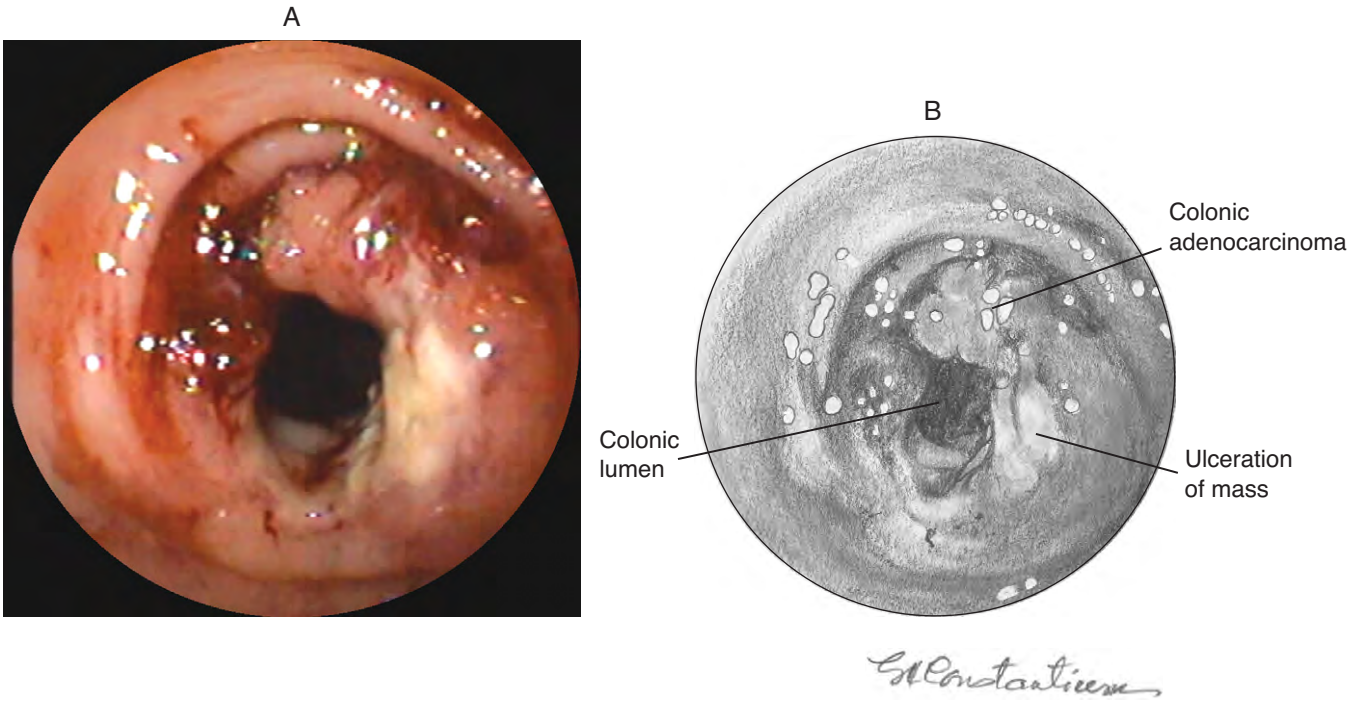



**Fig. 9-45**
Colonic adenocarcinoma in the descending colon. Note the partly raised, irregular, and partly ulcerated surface.

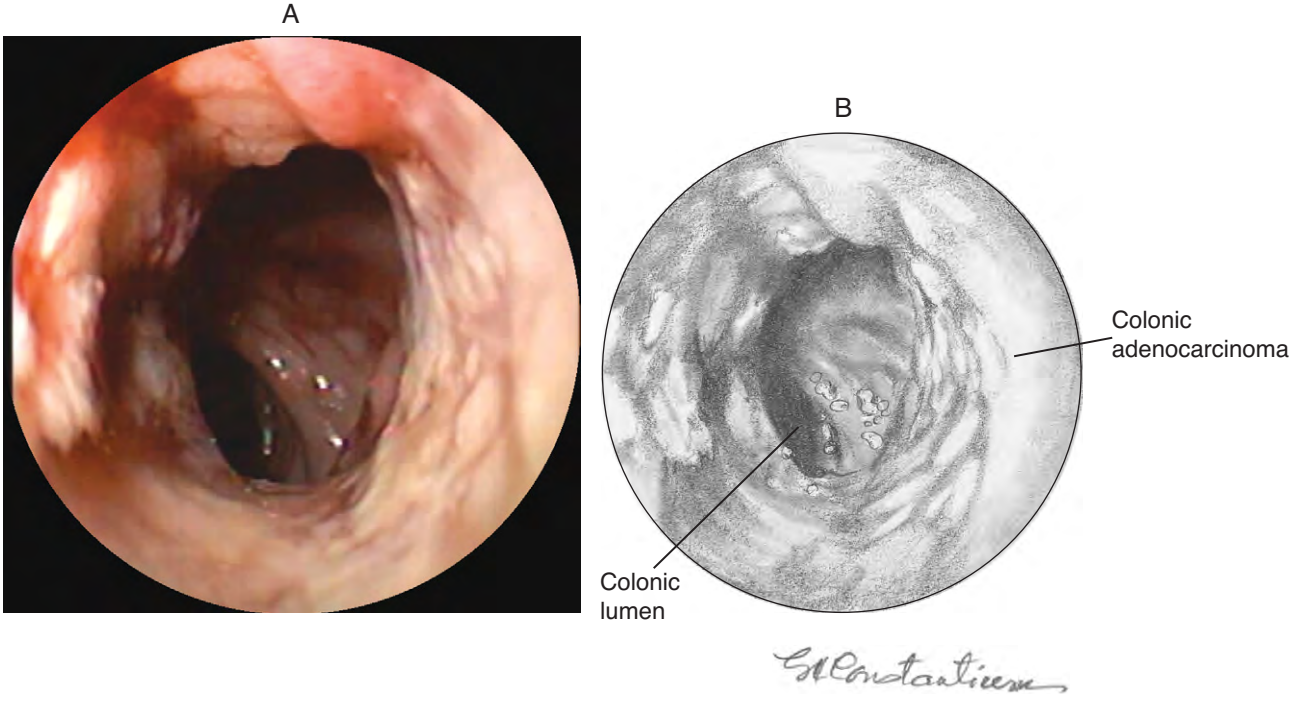



**Fig. 9-46**
Close-up of colonic adenocarcinoma seen in Fig. 9-45.

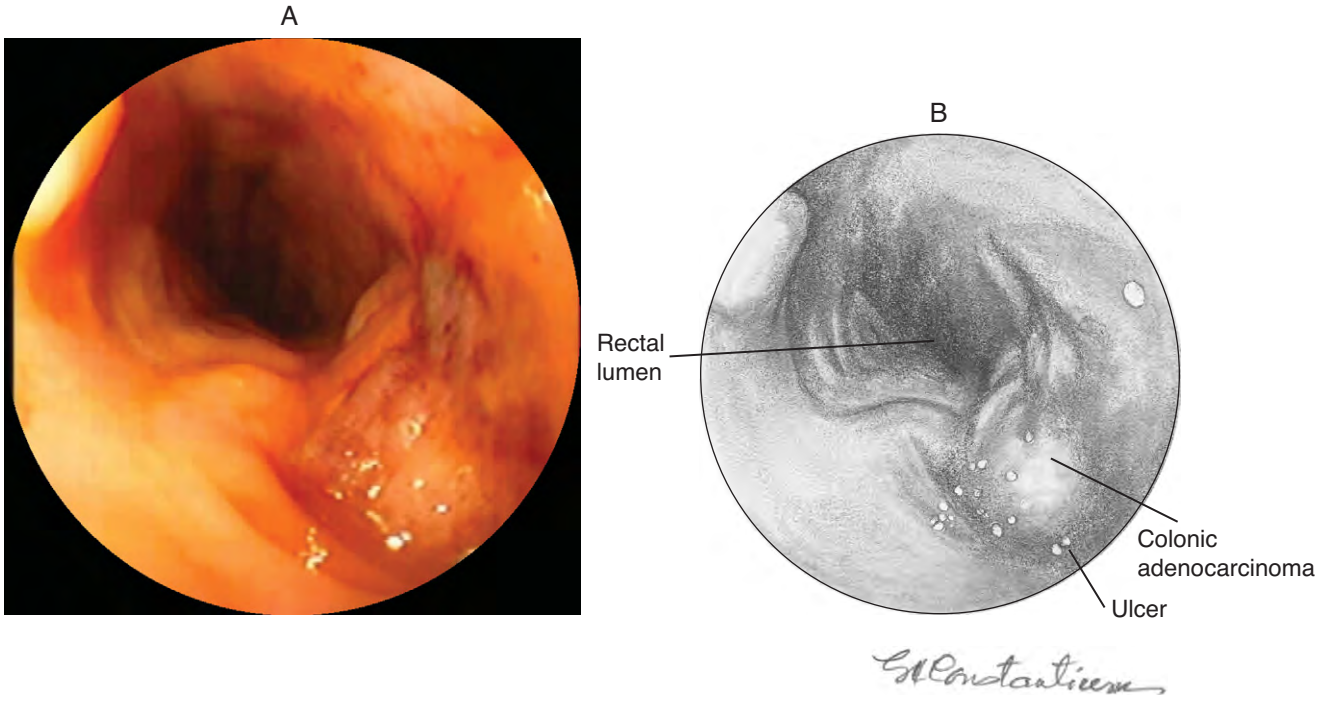



**Fig. 9-47**
Colonic adenocarcinoma in the rectum. Note the depressed irregular ulcer at the bottom right of the image.

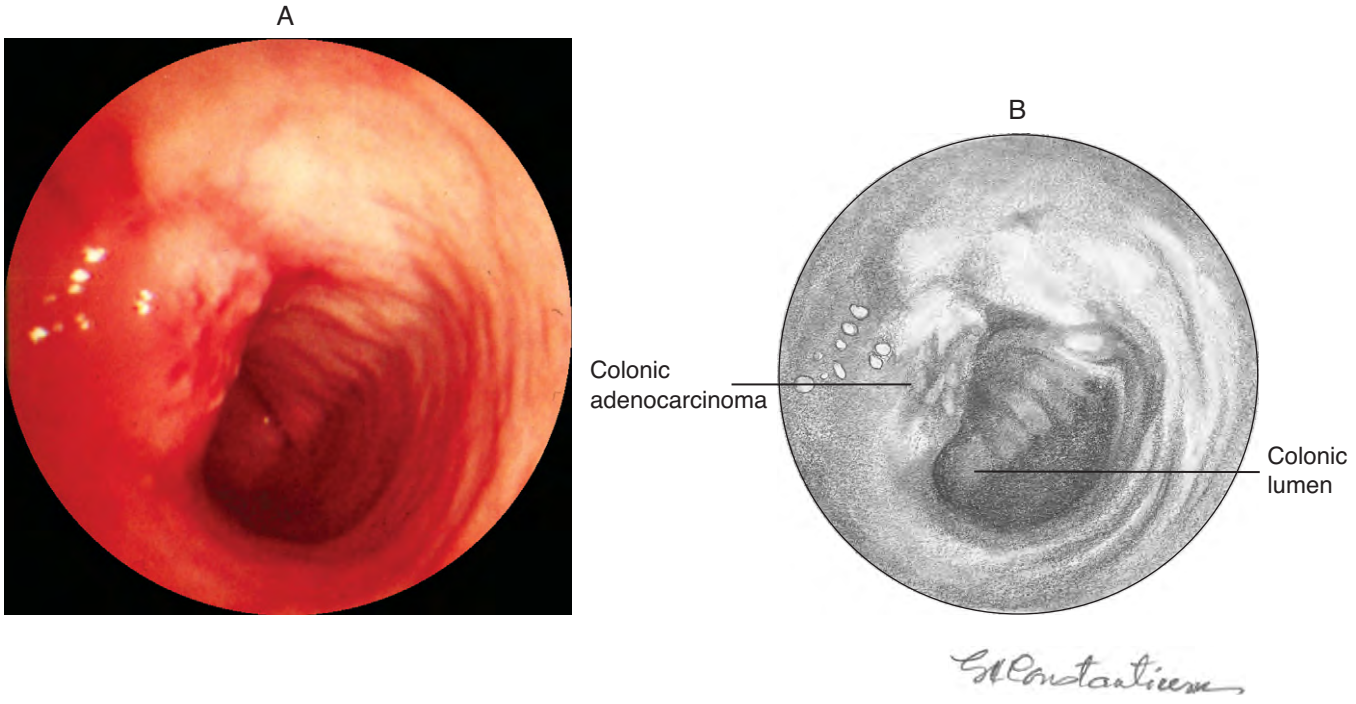



**Fig. 9-48**
Colonic adenocarcinoma in the descending colon. Note the raised, ulcerated, plaque-like lesion on the left side of the colon wall.

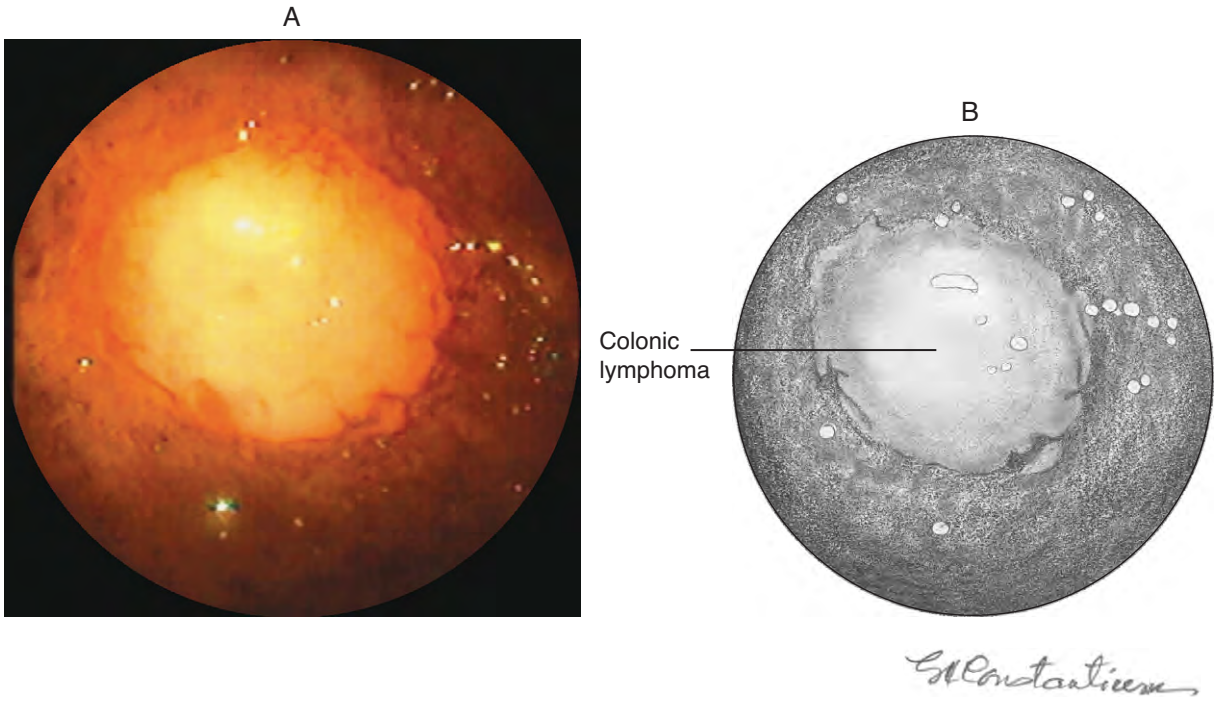



**Fig. 9-49**
Lymphoblastic lymphoma in the descending colon. Note the raised, yellow, circular lesion.

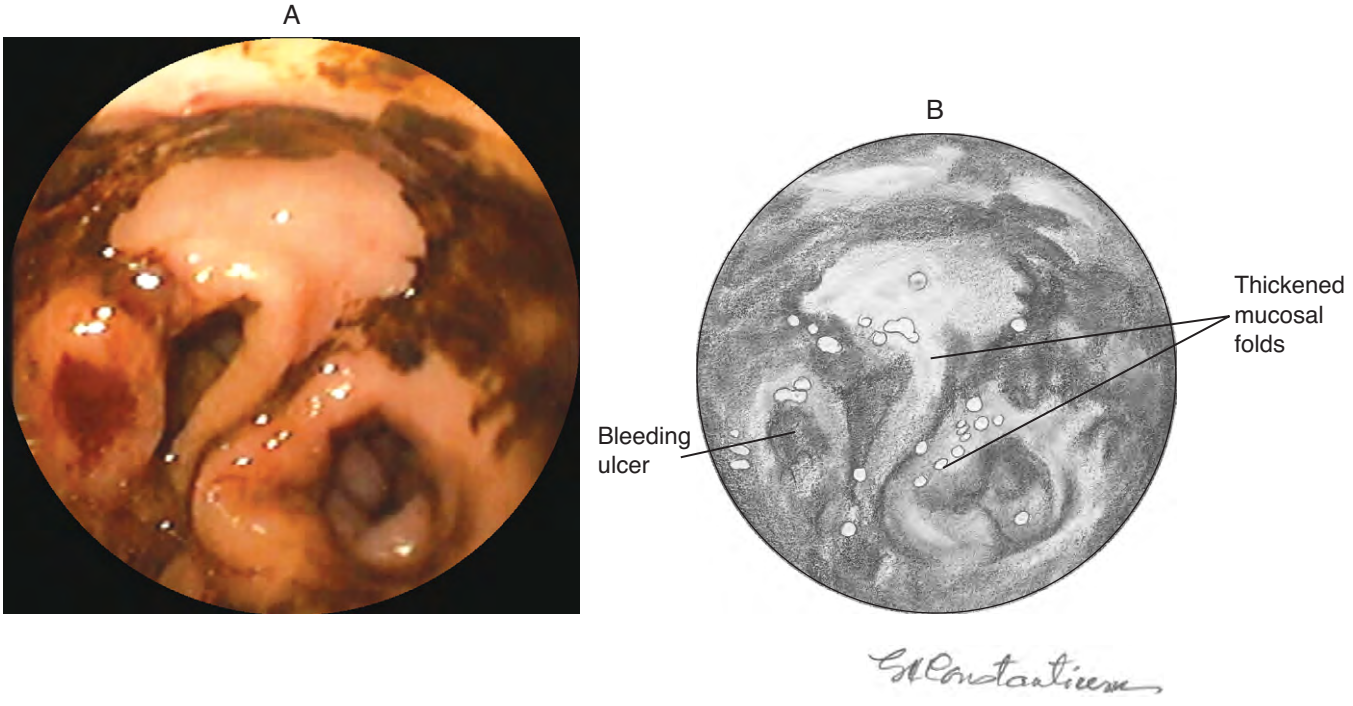



**Fig. 9-50**
Lymphoblastic lymphoma in the descending colon. Note the thickened folds with focal bleeding ulcer on the left aspect of the image.

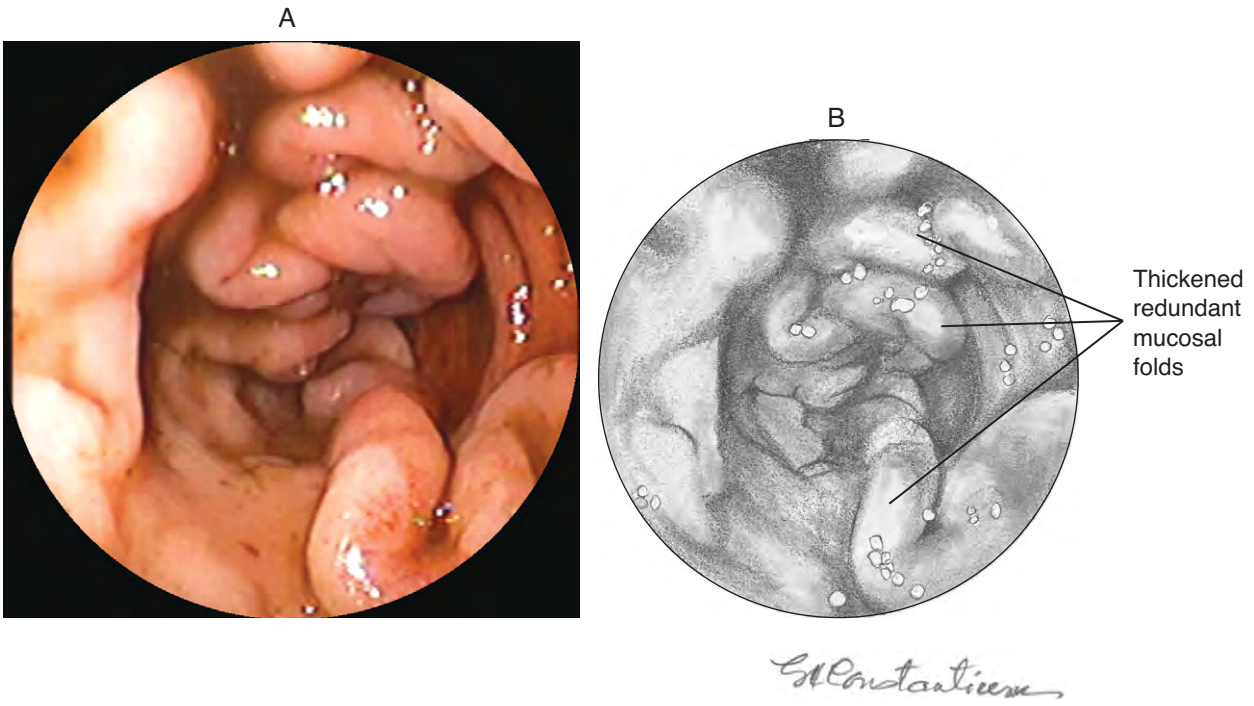



**Fig. 9-51**
Lymphoblastic lymphoma in the descending colon (same dog as in Fig. 9-50). Note the thickened and redundant mucosal folds.

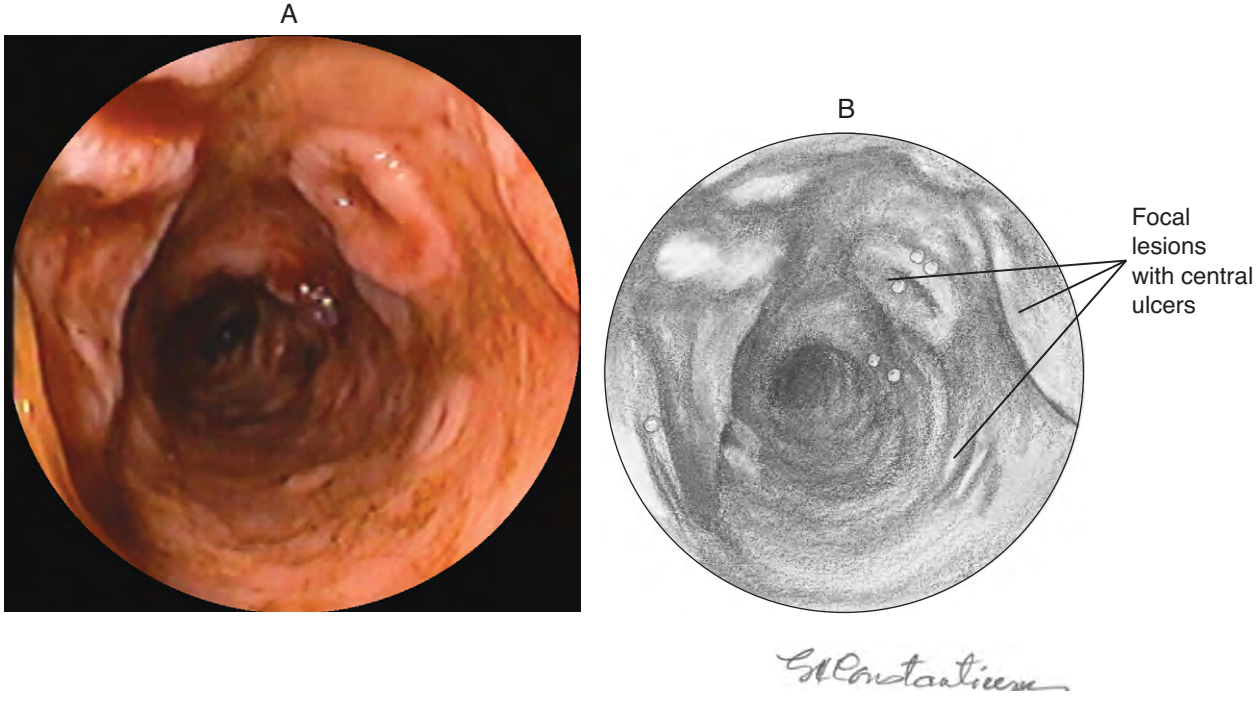



**Fig. 9-52**
Lymphoblastic lymphoma in the descending colon (same dog as in Figs. 9-50 and 9-51). Note the focal, round, raised, plaque-like lesions with central ulcers.

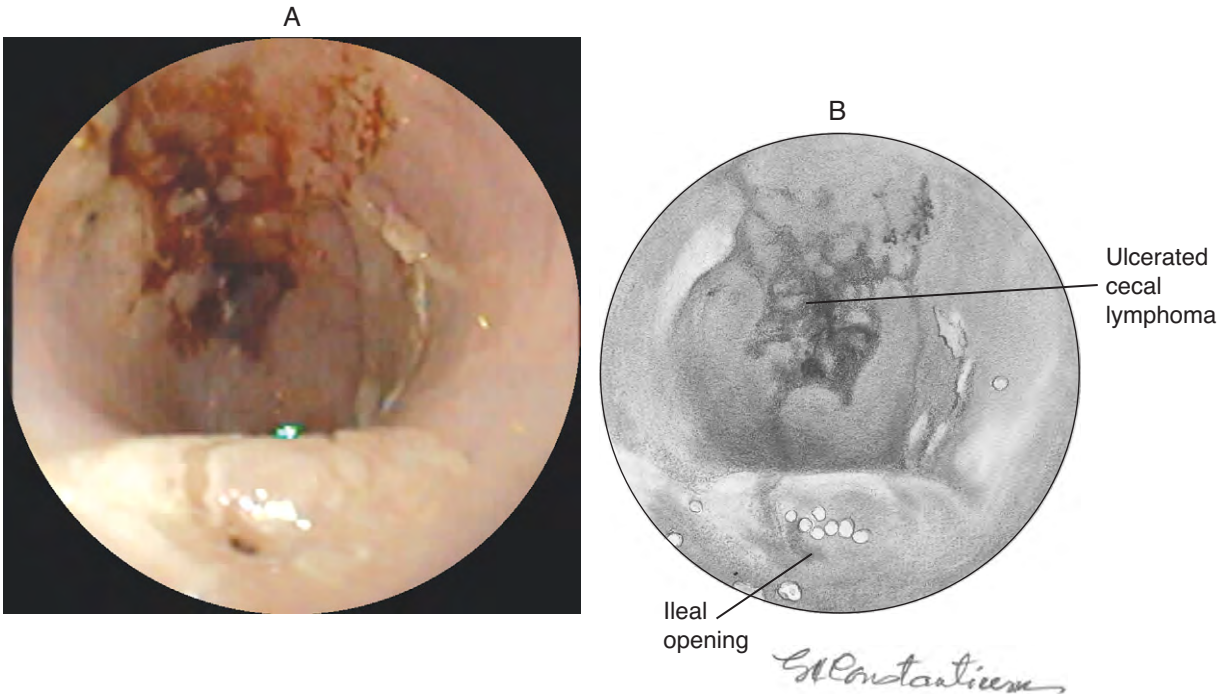



**Fig. 9-53**
Lymphocytic lymphoma in the cecum of a cat. Note the diffuse mucosal ulcers at the top of the image. The opening to the ileum is the small hole at the bottom of the image.

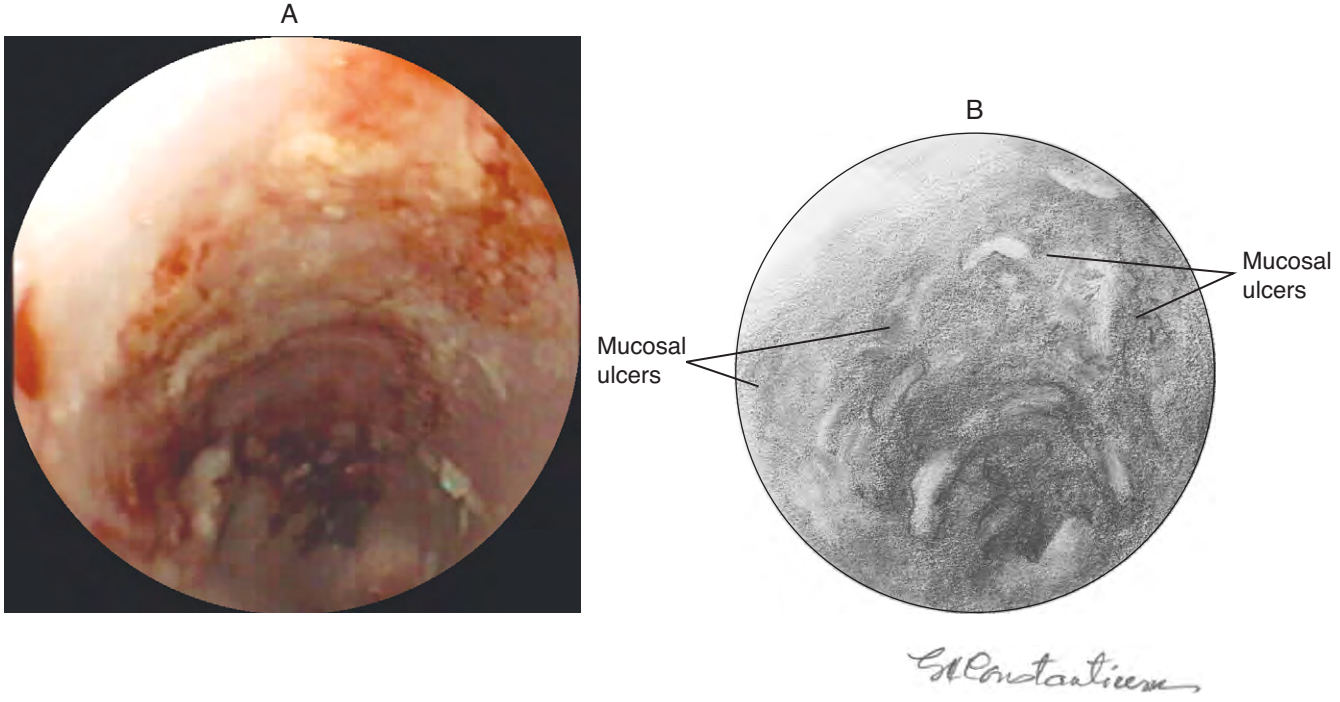



**Fig. 9-54**
Close-up of the same cat as in Fig. 9-53. Note the diffuse mucosal ulcers.

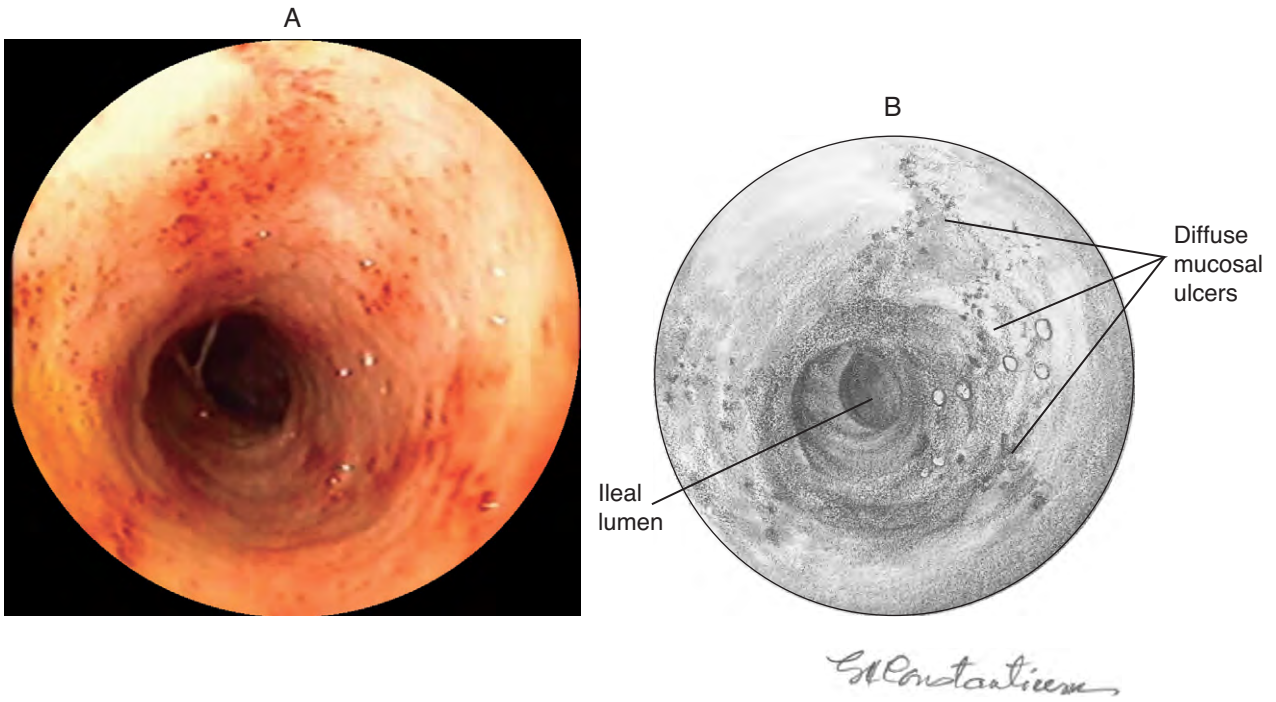



**Fig. 9-55**
Lymphocytic lymphoma in the ileum of a cat. Note the diffuse mucosal ulcers with areas of hemorrhage.

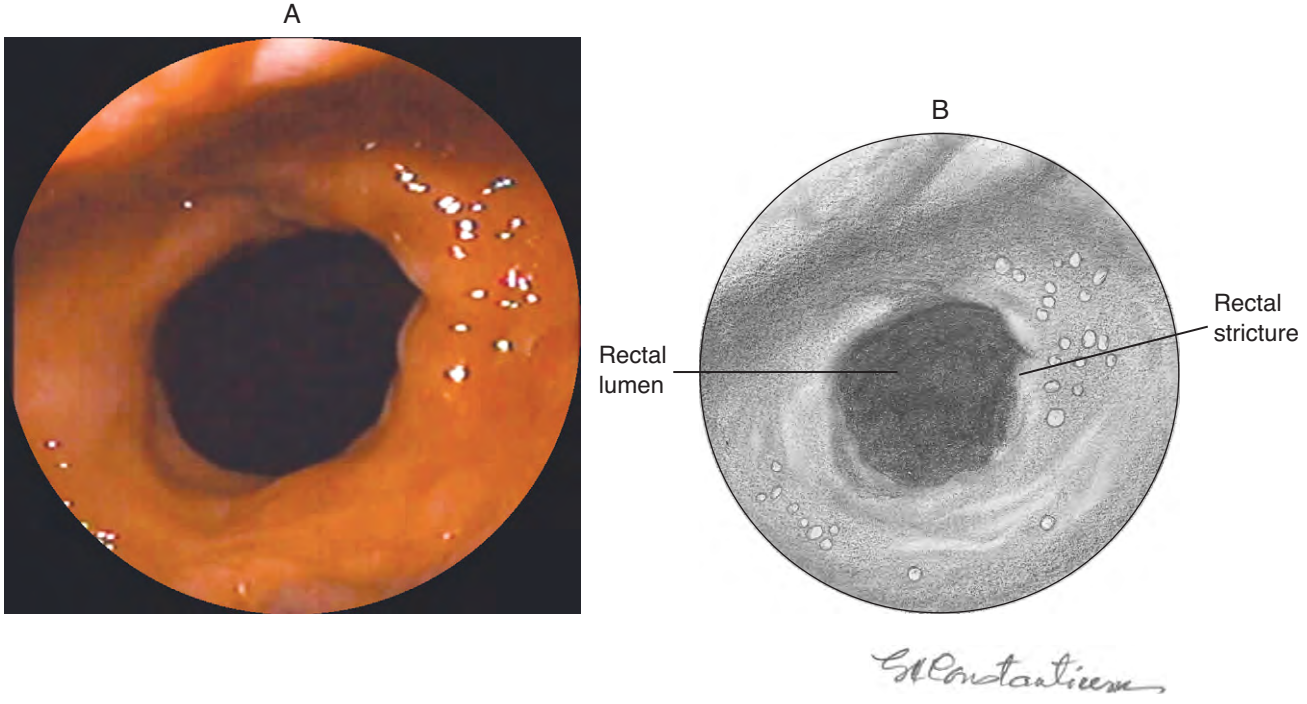



**Fig. 9-56**
Rectal stricture in a dog. Note the focal narrowing of the lumen.

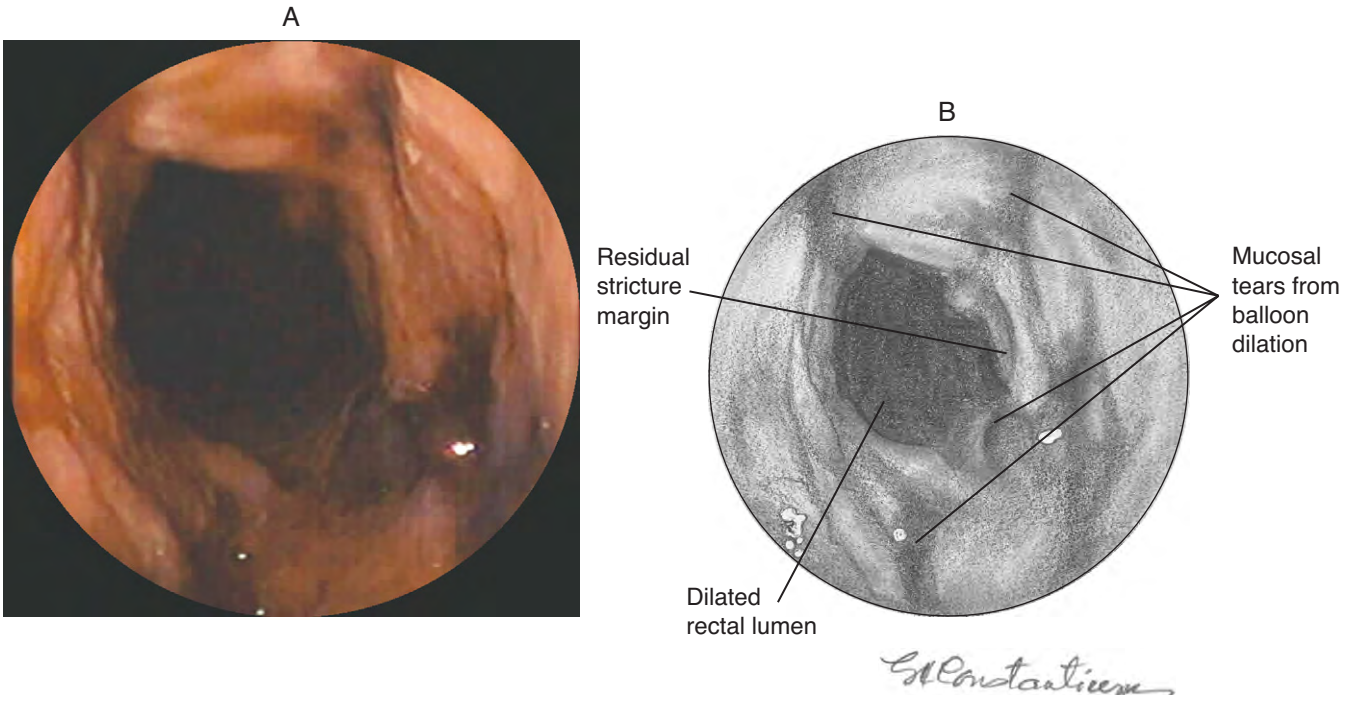



**Fig. 9-57**
Rectal stricture (same dog as in Fig. 9-56) following balloon dilation. Note the marked improvement in lumen diameter.

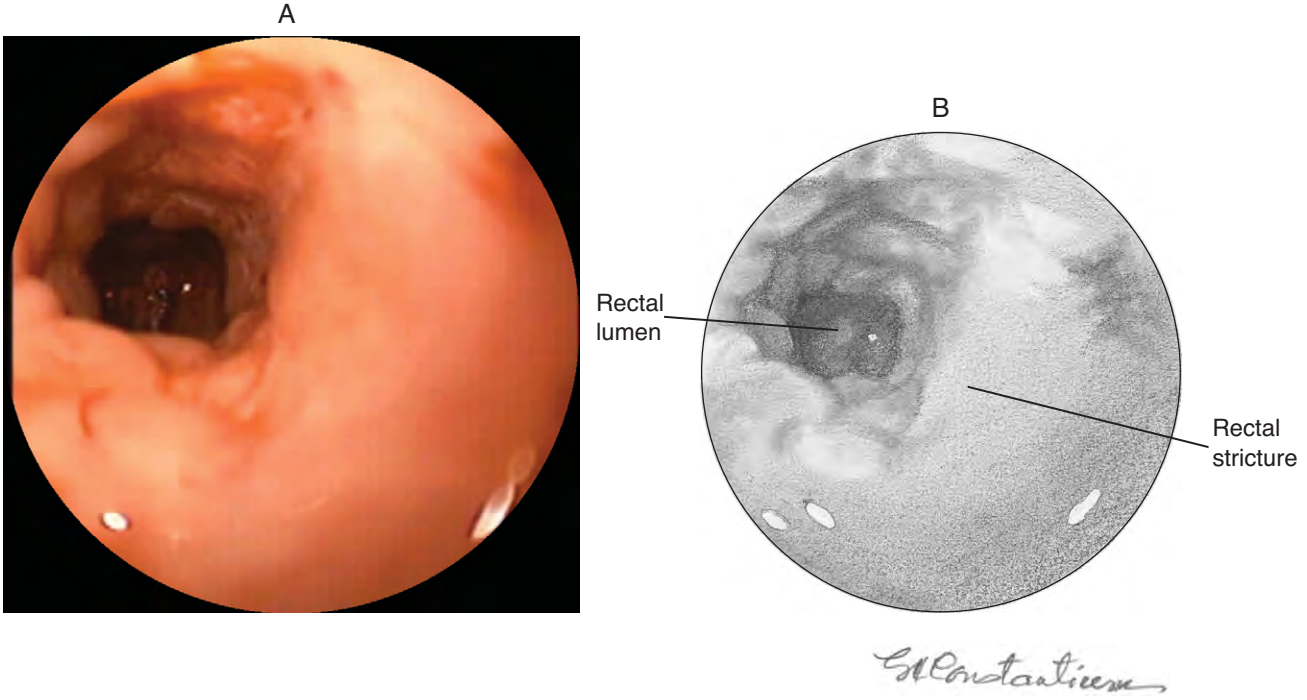



**Fig. 9-58**
Rectal stricture in a cat. Note the focal narrowing of the lumen.

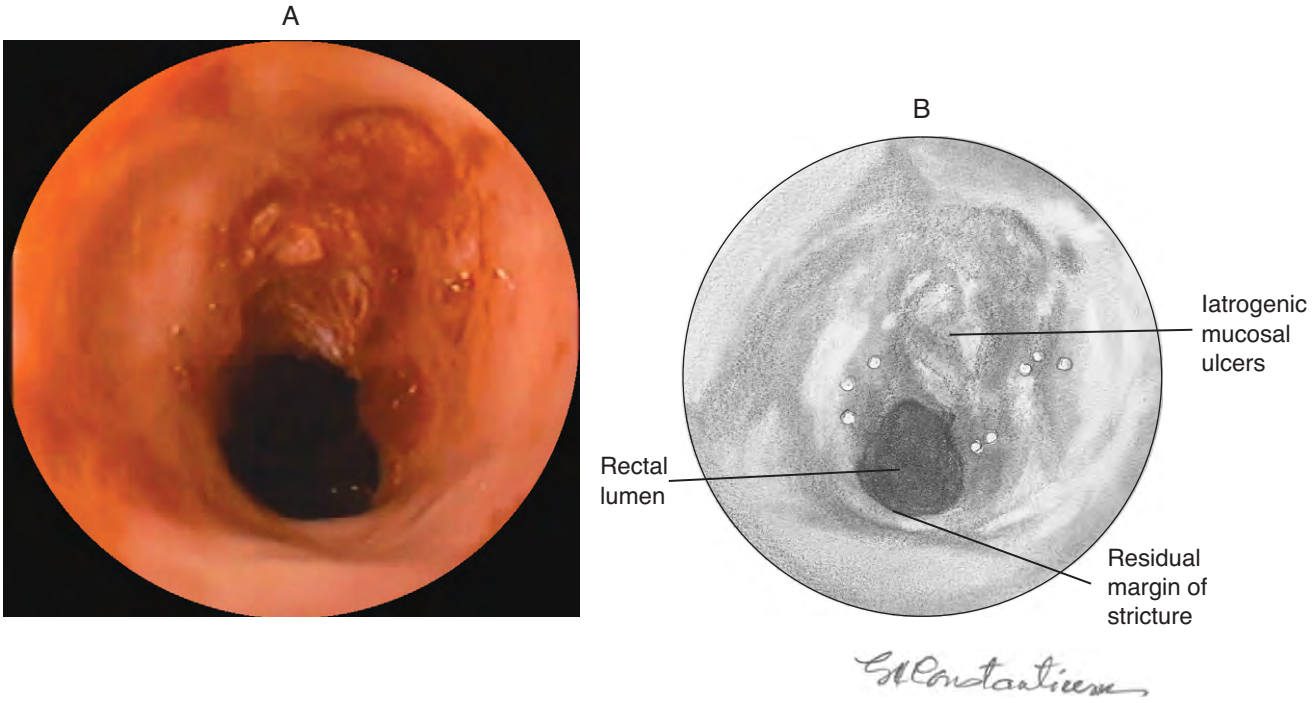



**Fig. 9-59**
Rectal stricture (same cat as in Fig. 9-58) following balloon dilation. Note the marked improvement in lumen diameter. Also note the iatrogenic mucosal ulcers.

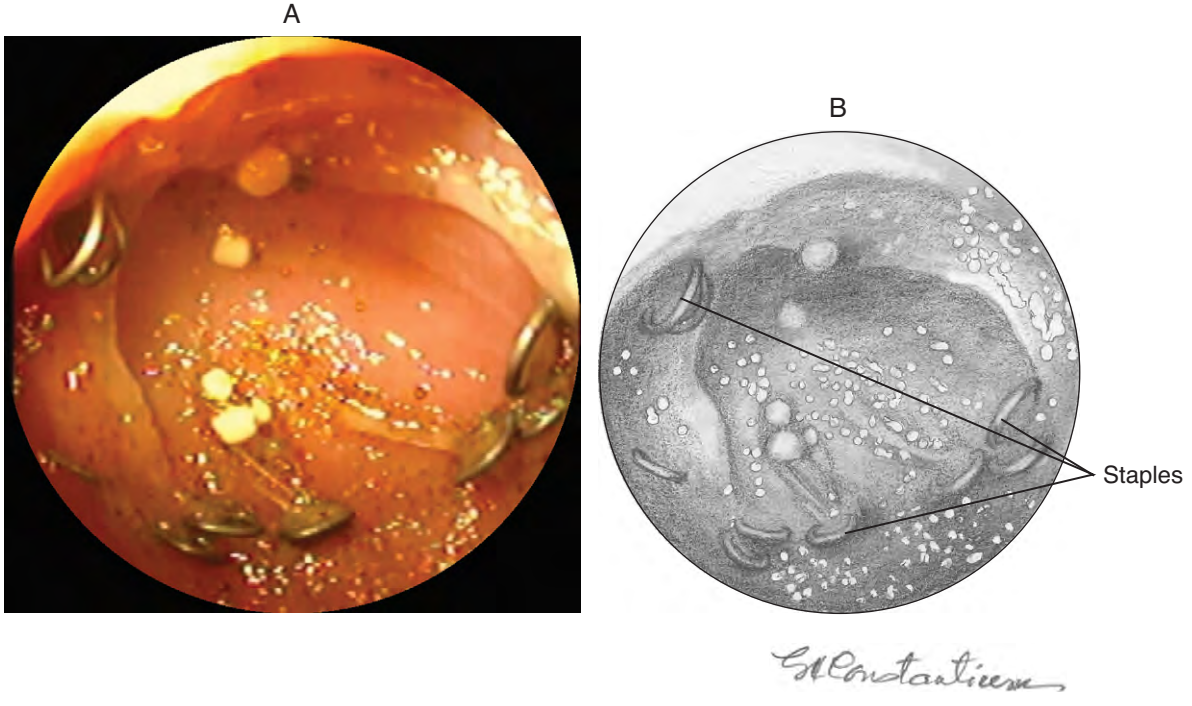



**Fig. 9-60**
Reconstruction of the distal small bowel following total colectomy in a Boxer with histiocytic ulcerative colitis. A pouch was constructed from the jejunum and ileum to create a reservoir for feces. Staples are visible in the lumen.

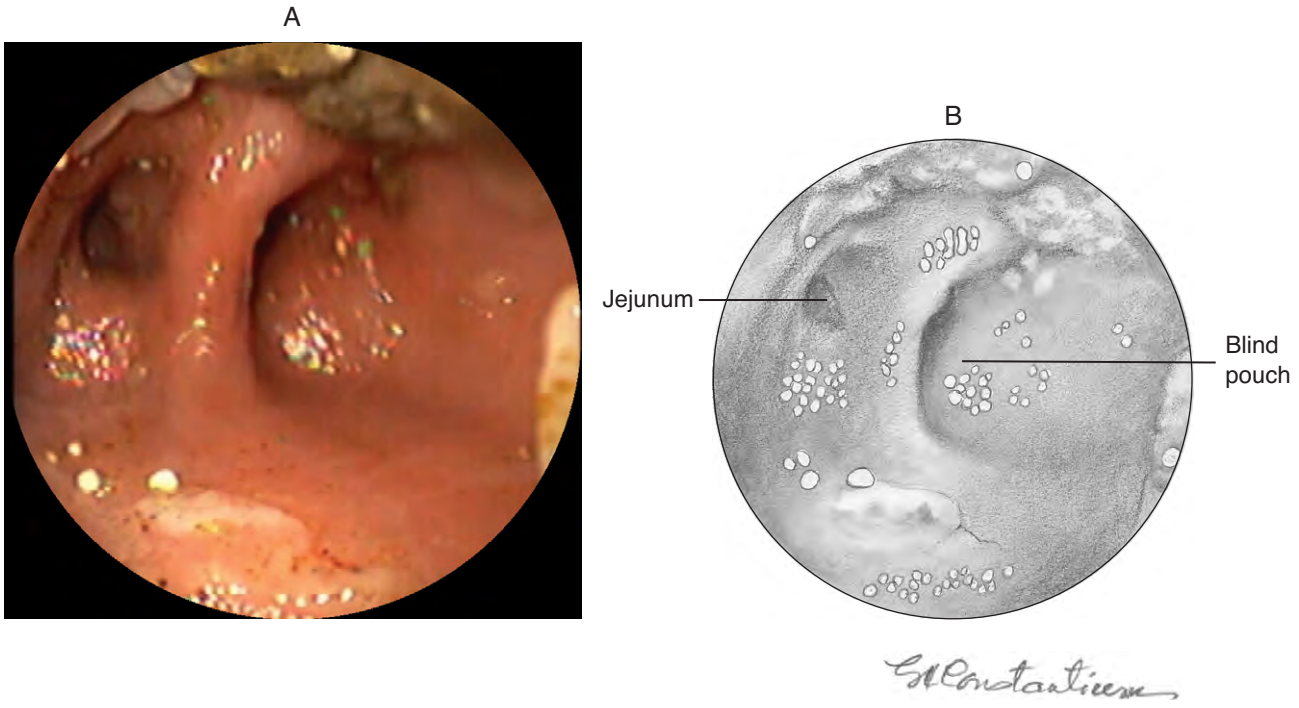



**Fig. 9-61**
Cranial aspect of reconstructed pouch (same dog as in Fig. 9-60). The opening to the jejunum is on the left. The blind end of the pouch is on the right.

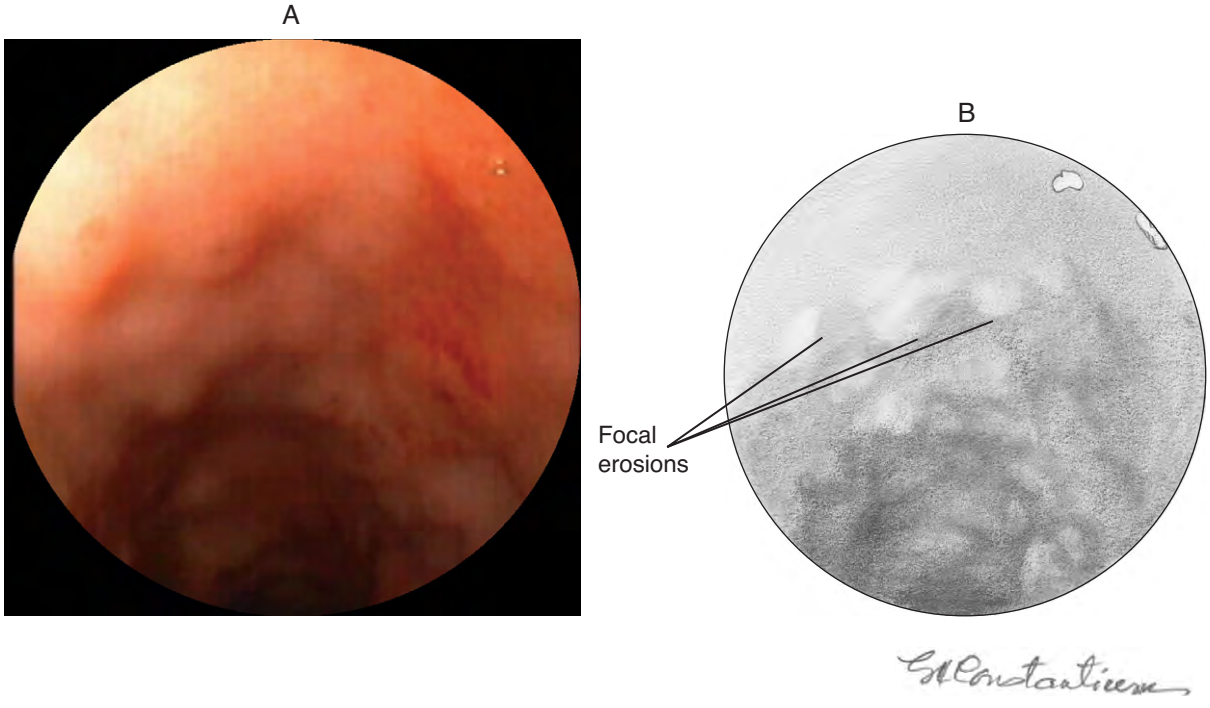



**Fig. 9-62**
Descending colon in a 6-month-old Boxer with histiocytic ulcerative colitis. Note the irregular mucosal surface with focal erosion.

*Table* 9-1 Abnormal Colonoscopic Findings in the Dog and Cat

| Disorder | Endoscopic Appearance |
|---|---|
| Colonic stricture | Narrowed lumen at site of stricture. Surrounding mucosa may be normal or abnormal depending on cause. |
| Colonic ulcer | Variable: Deep or shallow crater, often well demarcated, may have adherent blood or debris, fresh or old hemorrhage. Surrounding mucosa may be normal or abnormal depending on cause. |
| Colonic foreign body | Foreign object in lumen of colon. |
| Acute colitis | Variable: Hyperemia, superficial erosions, patchy color, superficial hemorrhage. |
| Chronic colitis | Variable: Hyperemia, superficial erosions, ulcers, thickened mucosa, patchy color, cobblestone/granular texture, friability, increased pallor. May be normal. |
| Colonic neoplasia | Variable: Rectal masses are usually irregular, raised (exophytic), friable, "cauliflower-like," red/purple, and frequently ulcerated. Other tumors have ulceration, irregular mucosa, hyperemia, patchy color, cobblestone/granular texture, and possibly increased pallor. May be normal in cases of lymphoma (especially in cats). |
| Gastrointestinal parasites | Parasites seen in gastrointestinal lumen. Whipworms are approximately 1 to 2 cm long and can be seen in all regions of the colon, with the highest concentration in the cecum. |
| Ileocolic intussusception | Intraluminal mass effect that does not appear attached to colonic wall. The scope can be inserted around the entire circumference of the intussusceptum for at least a few centimeters. |

## SUGGESTED READING

Willard MD: Colonoscopy. In Tams TR, editor: *Small animal endoscopy,* ed 2, St Louis, 1999, Mosby.

Guilford WG and others: *Strombeck's small animal gastroenterology,* Philadelphia, 1996, WB Saunders.

Tams TR: Endoscopy. In Kirk RW, editor: *Current veterinary therapy X,* Philadelphia, 1989, WB Saunders.

Zimmer JF: Gastrointestinal fiberoptic endoscopy. In Kirk RW, editor: *Current veterinary therapy VI,* Philadelphia, 1977, WB Saunders.

# 10 Laparoscopy: Technique and Clinical Experience

*David C. Twedt, Eric Monnet*

Laparoscopy is a minimally invasive technique for viewing the internal structures of the abdominal cavity. The abdominal cavity is first distended with gas, a portal is placed through the abdominal wall, and a rigid telescope (laparoscope) is used to examine the contents of the peritoneal cavity. With the telescope in place, either biopsy forceps or an assortment of surgical instruments can be introduced into the abdomen through adjacent portals to perform various diagnostic or surgical procedures.

The minimal invasiveness of the procedure, diagnostic accuracy, and rapid patient recovery make laparoscopy a preferred technique over other more invasive procedures. Small animal laparoscopy initially evolved as a diagnostic tool, but it has progressed to where there is now ever increasing interest in the application of minimally invasive laparoscopic surgical procedures.

Laparoscopy is relatively simple to perform and considered to be safe, having few complications. Despite the advent of newer laboratory tests, imaging techniques and ultrasound-directed fine needle biopsy or aspiration capability, laparoscopy remains a valuable tool when appropriately applied in a diagnostic plan. Laparoscopy may also provide accurate and definitive diagnostic and staging information that could otherwise be obtained only through an open surgical exploratory laparotomy.

This chapter covers the basic technique, biopsy method, surgical procedures, and complications of laparoscopy. The normal appearance of abdominal organs and examples of pathology are also presented.

## INDICATIONS AND CONTRAINDICATIONS

Common indications for laparoscopy are to examine and biopsy the abdominal organs or masses or to perform surgical procedures. Laparoscopy does not, however, always replace a complete abdominal exploration but provides a minimally invasive means of accomplishing a number of diagnostic and surgical procedures currently used in small animals (Box 10-1). This list of indications has been evolving over time as more is learned of the potentials of laparoscopy as a diagnostics tool and as a means of minimally invasive surgery.

Diagnostic laparoscopy is commonly used as a method for obtaining liver, pancreas, kidney, splenic, intestinal, and tumor biopsy specimens. It is generally accepted that laparoscopy provides better biopsy tissues than other traditional percutaneous methods. Laparoscopy is also used in oncology to diagnose and stage the extent of malignancy, either primary or metastatic.[1] Laparoscopy may reveal small (0.5 cm or less) metastatic lesions, peritoneal metastases, or organ involvement not easily observed by other techniques. Unexplained abdominal effusion is an additional indication for laparoscopy when other diagnostics to determine the cause are unsuccessful. Full thickness intestinal biopsies can also be performed using laparoscopic assistance. Other ancillary diagnostic techniques include reproductive evaluation of the ovaries and uterus with the capability for direct

**Box 10-1 Basic Laparoscopic Techniques**

**Diagnostic**
- Liver biopsy
- Cholecystocentesis
- Pancreatic biopsy
- Kidney biopsy
- Intestinal biopsy
- Adrenal evaluation
- Splenic evaluation
- Reproductive evaluation

**Surgical**
- Feeding tube placement
- Gastropexy
- Ovariohysterectomy
- Cryptorchid surgery
- Gastric foreign body removal
- Cystoscopy

intrauterine insemination, gallbladder aspiration, splenic pulp pressure measurements, laparoscopic directed splenoportography, and urinary bladder evaluation.[2]

The many advantages of surgical laparoscopy over a conventional open surgical exploratory laparotomy include improved patient recovery because of smaller surgical sites, lower postoperative morbidity, decreased infection rate, and less postoperative pain.[3] Frequently the hospitalization and convalescence times are shorter following a laparoscopic procedure. Less obvious benefits of laparoscopy are related to surgical stress–mediated factors. Physiologic responses that account for improved clinical outcome with laparoscopy have been studied extensively and show less impairment of metabolism, renal and pulmonary workload, bowel motility, and immune function when compared to similar open surgical techniques.[4]

Common surgical techniques currently being performed in small animals include cryptorchid surgery, ovariohysterectomy, and prophylactic gastropexy. Other laparoscopic procedures performed are cystoscopy, jejunostomy or gastrostomy feeding tube placement, abdominal lavage tube placement, gastric foreign body removal, and adrenalectomy. Only current innovation and available surgical instrumentation limit the potential for laparoscopic surgery in veterinary medicine.

There are few contraindications to laparoscopy because of the minimal invasiveness of the procedure. Often, the patients that are at high risk for surgical exploration may be good candidates for a less invasive laparoscopic procedure. Ascites, abnormal clotting times, and poor patient condition are only relative contraindications. Ascitic fluid can be removed before or during the procedure and has little influence over the probability of success of the laparoscopy. Clinical experience suggests that abnormal clotting times may not completely preclude performing laparoscopy. Abnormal coagulation from liver disease does not always correlate with excessive bleeding at biopsy sites.[5] Laparoscopy further makes it possible to visually select areas that appear to be less vascular and to monitor the extent of bleeding following biopsies. If bleeding is considered to be excessive, various laparoscopic techniques can be used to control hemorrhage.

Absolute contraindications for laparoscopy include diaphragmatic hernia, septic peritonitis, and conditions in which obvious conventional surgical intervention is indicated. Even in cases having, for example, an obvious abdominal mass requiring surgical removal, it may be beneficial to perform laparoscopy for a tissue biopsy to obtain a presurgical histopathologic diagnosis to stage the disease and develop a surgical plan. One can use laparoscopy to first evaluate the abdominal cavity and, if deemed necessary, convert the procedure to an open surgical exploratory. In some cases, micrometastasis from a neoplastic process may be identified that has not been detected by other means and that would ultimately change the overall case management plan.

Relative contraindications include patient condition, small body size, and obesity. The procedure would not be done in patients that are either a very poor anesthetic risk or an extreme surgical risk. Laparoscopy can be performed on severely debilitated patients using only local anesthesia and sedation in which general anesthesia and surgical laparotomy were considered too risky. The procedure becomes more difficult in very small patients (less than 2 kg body weight) and in very obese patients. In very small animals, the working space is reduced, necessitating the use of smaller diameter telescopes and instruments. Animals having excessive intraabdominal body fat often obscure the view of many organs, thus making the procedure much more difficult to perform.

## LAPAROSCOPIC EQUIPMENT

The basic equipment required for diagnostic laparoscopy includes the telescope, trocar-cannula units, light source, gas insufflator, Veress (insufflation) needle, and various forceps and ancillary instruments (Box 10-2). Telescopes most frequently used in small animal laparoscopy range in diameter from 2.7 to 10 mm. We recommend and currently use a 5-mm diameter, 0-degree field of view telescope for routine diagnostic laparoscopy.[6] The 5-mm diameter laparoscope is adequate for most small animal procedures. The 0-degree designation means that the visual field is directly in front of and in line with the long axis of the telescope. Angled viewing scopes, such as the most commonly used 30-degree telescopes, view in a downward direction 30 degrees from the axis of the telescope body. Angled telescopes enable the operator to look over the top of or around organs and view in small areas. However, this angulation also makes orientation more difficult for the inexperienced operator. Angled telescopes are not generally recommended for the beginner and are not

**Box 10-2 Basic Diagnostic Laparoscopic Equipment**

- 5-mm Telescope (0 degrees)
- 2 Cannulae
- Veress needle
- Light source
- Light cable
- $CO_2$ insufflator
- Palpation probe
- Oval biopsy forceps
- Punch biopsy forceps
- Grasping forceps
- Video camera and monitor
- Photo documentation (optional)

required when only performing diagnostic laparoscopy. Angled telescopes are useful, however, for certain surgical laparoscopy procedures. Some experienced operators prefer an angled scope over a 0-degree telescope because of the wider viewing range that can be obtained when the telescope is rotated, and the angled telescope enhances the ability to see in small or confined areas.

Smaller diameter (less than 3.5 mm) telescopes have a limited field of view, transmit less light for illumination in the abdominal cavity, and work best in very small animals. Larger diameter telescopes (10 mm) are bulky and awkward when performing procedures in smaller patients, and the increased size is generally not necessary in small animal laparoscopy.

The telescope is attached to a light source using a light guide cable. It is generally recommended that a high-intensity light source such as xenon be used in laparoscopy, especially when video or photographic documentation is being used. Xenon is considered to give the truest colors of the abdominal organs and is recommended.[6] The brightness of the image depends on the reflective quality of the surface being examined and the closeness of the endoscope to the object. Dark tissues such as the liver or blood adsorb light and reduce the illumination, thus making visualization more difficult, especially when using small diameter telescopes or a low-intensity light source or a low light–sensitive video camera.

An endoscopic video camera is attached to the telescope and allows the image to be viewed on a monitor rather than having to look directly through the telescope lens. A video camera is essential when performing surgical laparoscopy but is not required for simple diagnostic techniques. Video guidance does, however, make laparoscopy much easier to learn and perform and is strongly recommended.

After abdominal insufflation, the telescope and instruments are placed through the abdominal wall using a trocar-cannula unit that is of a corresponding size to receive either the telescope or instruments. The trocar is a sharp, pointed instrument, which, when housed in the cannula, is used to penetrate abdominal muscles and peritoneum. When the trocar is removed, the cannula remains in place, traversing the abdominal wall, and becomes a portal for introduction of the telescope or instruments into the abdominal cavity. Laparoscopy cannulae contain an internal valve that prevents loss of insufflation gas once the trocar is removed. There is also a gasket in the cannulae that fits tightly around the telescope or instruments to prevent leakage when instruments are in the cannulae. A Luer-lock adapter valve attaches the carbon dioxide ($CO_2$) line for continued gas insufflation through the cannula.

A Veress needle is used for initial insufflation of the abdominal cavity. The needle consists of an outer sharp needle with a cutting tip. Contained within this needle is a spring-loaded blunt obturator that retracts into the needle shaft as it traverses the abdominal wall and then advances beyond the sharp tip after the needle enters the abdominal cavity. The internal blunt obturator prevents needle injury to internal abdominal organs. The hub of the needle is then attached to insufflation tubing that has been attached to an automatic gas insufflator.

Most automatic insufflators are similar; they dispense gas at a prescribed rate while maintaining a predetermined intraabdominal pressure. $CO_2$ is the gas of choice for insufflation because of its low risk for development of air emboli and for preventing spark ignition during cauterization.[6]

To perform diagnostic laparoscopy, a number of accessory instruments are essential. They are placed through a second puncture cannula. A palpation probe is required to move and palpate abdominal organs (Fig. 10-1). One soon learns to use the probe to "feel" changes in firmness of the organs. Most probes also have centimeter markings so the operator can estimate the relative size of organs or lesions. The palpation probe can also be used to apply pressure over a biopsy site that is bleeding excessively.

For diagnostic laparoscopy, at least one biopsy forceps is essential. We find the 5-mm diameter biopsy forceps with oval biopsy cups to be the most versatile and commonly used for the liver, spleen, abdominal mass, and lymph node biopsy (Fig. 10-2). A second biopsy instrument is the punch type biopsy forceps, which is often preferred for pancreatic biopsies. Core biopsy needles and aspiration needles are also necessary for diagnostic laparoscopy. One can also use long spinal needles for aspiration. A "true-cut" type biopsy needle is required for both kidney and deep tissue biopsies. Biopsy needles are passed directly through the abdominal wall and directed to the area to be sampled without the need for a cannula.

Surgical laparoscopy requires a vast array of instruments designed for specific indications. Common instruments include scissors, grasping forceps, dissectors, irrigation/aspiration tubes, and clip applicators. For surgical laparoscopy in small animals, 5-mm diameter instruments are commonly used; however, certain specialized instruments such as stapling devices are generally 10 mm or larger in diameter. Many of the biopsy and surgical instruments also have capabilities for monopolar electrosurgery at their distal tip.

## LAPAROSCOPIC TECHNIQUE

### Preparation, Restraint, and Surgical Considerations

Once the decision is made to perform laparoscopy there are several presurgical considerations to be made. The patient is fasted for at least 12 hours before the procedure

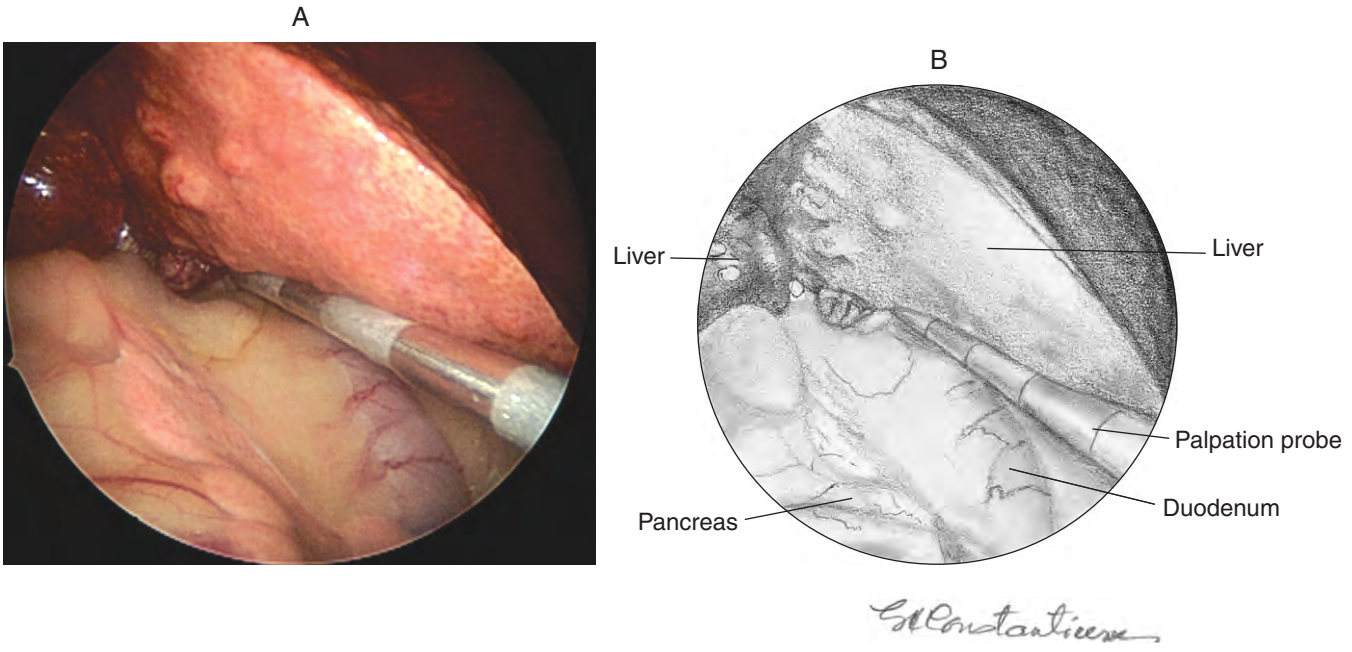



**Fig. 10-1**
A palpation probe shown lifting the right lateral lobe of a liver with chronic hepatitis. The duodenum and right limb of the pancreas are visible below the probe.

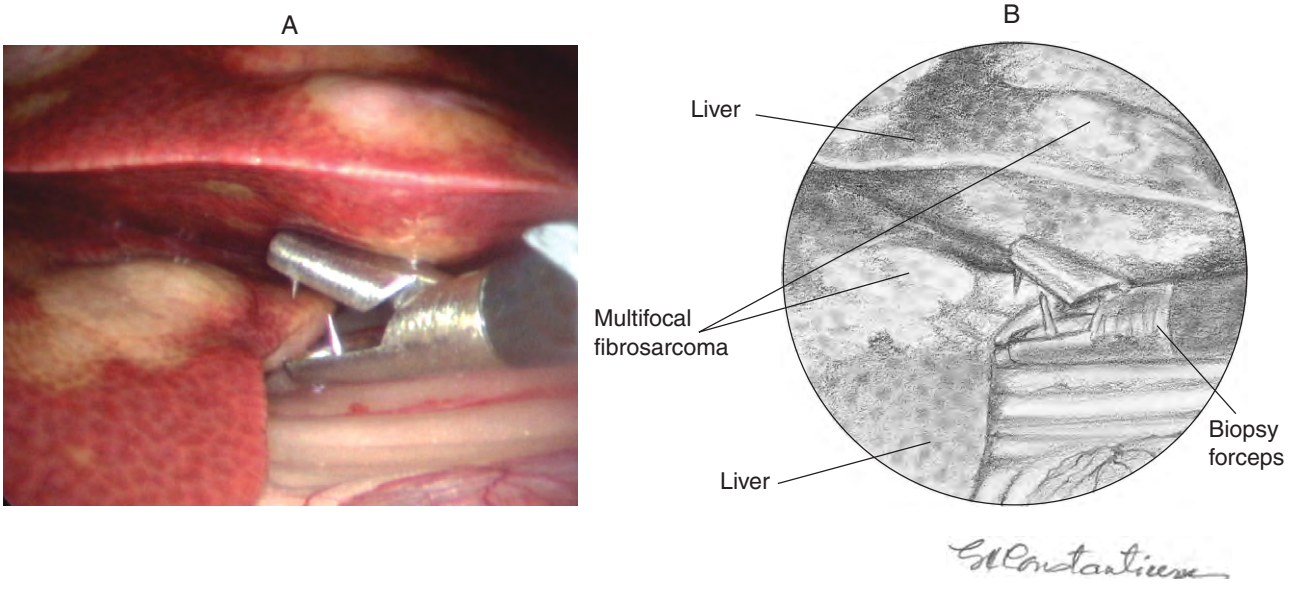



**Fig. 10-2**
Oval cup biopsy forceps is shown taking a biopsy sample of a liver having multifocal hepatic fibrosarcoma.

and the urinary bladder is evacuated. If the stomach or urinary bladder is distended, there is an increased risk of traumatic puncture with either the trocar or Veress needle. A distended stomach makes evaluation of the anterior abdomen more difficult and a distended bladder makes examination in the caudal abdomen more difficult.

Laparoscopy is always performed under sterile conditions. Basic diagnostic laparoscopy is generally performed in the endoscopy suite while surgical laparoscopy is performed in a surgical suite. With surgical laparoscopy and rarely with diagnostic laparoscopy, it may become necessary to convert to an open surgical procedure.

It is helpful to perform laparoscopy with the patient placed on an adjustable surgical table so that the table can be tilted in various directions. Changing the position of the patient is often helpful for examination of certain areas of the abdomen. A room with adjustable lighting is desirable to allow laparoscopy to be performed in a dimly lighted room to make visualization of the video monitor easier.

Laparoscopy is commonly performed using general gas anesthesia. Most patients tolerate general anesthesia well during laparoscopy.[7] It is expected that the pneumoperitoneum from $CO_2$ insufflation will increase intraabdominal pressure and interfere with excursions of the diaphragm. Studies have shown that, in most cases, the $Pa_{O_2}$ concentration decrease and the $Pa_{CO_2}$ concentration increase are minimal and remain within physiologically accepted limits.[8] These physiologic changes can become significant with high intraabdominal pressure insufflation or excessive tilting of the surgical table that would apply undue pressure on the diaphragm. When spontaneous ventilation becomes compromised, assisted ventilation may be necessary.

In some situations, diagnostic laparoscopy may be performed using heavy sedation in conjunction with local anesthesia at the entry sites. Short diagnostic procedures in severely depressed patients have been done with a narcotic-tranquilizer combination in conjunction with local anesthetics at the cannula portals. Heavy sedation is best performed with the patient in lateral recumbency because animals placed in dorsal recumbency tend to struggle during the procedure. Oxygen is routinely given with an oxygen face mask to cases when only sedation is used. Sometimes it is necessary to administer a short-acting intravenous anesthetic such as propofol during the procedure.

Objectives of the laparoscopy procedure are determined before starting to allow selection of appropriate patient position and cannula placement sites. The two most common approaches are right lateral and ventral midline. The right lateral approach is recommended for diagnostic evaluation of the liver, gallbladder, right limb of the pancreas, duodenum, right kidney, and right adrenal gland. A ventral approach is useful for many operative procedures, and offers good visualization of the liver, gallbladder, pancreas, stomach, intestines, reproductive system, urinary bladder, and spleen. For this approach, the primary portal is often placed on or adjacent to the midline near the umbilicus. One disadvantage of the ventral approach is that the falciform ligament may hinder visualization of the anterior abdomen. This can become a problem in very obese patients having excessive falciform fat. A left lateral approach is occasionally performed, but because the spleen lies directly under the normal entry sites, there is potential for splenic trauma by a trocar. With any approach, the entry site may be modified by moving either cranially or caudally to ensure adequate working space for the laparoscope and for the procedure to be performed. For example, when evaluating the liver of a very small animal, the entry site is moved as far caudally as possible to provide an increased working space.

Once the entry site is determined, the area is palpated to locate the spleen, urinary bladder, or intraabdominal abnormalities. A routine surgical prep is performed and the animal is draped. It is important that the opening in the drape be large enough to accommodate the laparoscope and accessory cannulae.

## Technique

The first step in laparoscopy is to establish a pneumoperitoneum. An entry site is selected for placement of the Veress needle either adjacent to the cannula sites or in the same site to be used by the first telescope portal. A small, 2-mm skin incision is made at this site with a scalpel blade through the skin. The needle is placed through the abdominal wall by grasping the outer hub of the needle so that the inner blunt obturator is free to move into the needle as it passes through the abdominal wall. The blunt obturator springs into place once the peritoneum has been penetrated. It is important to be sure that the Veress needle is in the abdominal cavity and is not retained in the muscle planes of the abdominal wall or under the peritoneum. Inadvertent insufflation in the subcutaneous tissues with $CO_2$ makes it almost impossible to continue the procedure.

To be sure that the Veress needle is through the abdominal wall and in the abdominal cavity, the needle is palpated with the needle tip against the inner surface of abdominal wall and by using what is referred to as the "hanging drop test." This test involves placing a drop of saline in the hub of the Veress needle and lifting the abdominal wall; if the needle is properly placed in the peritoneal cavity, the negative pressure within the abdominal cavity pulls the drop of saline into the needle. This confirms that the needle is in the correct location and not resting in an organ, abdominal wall, or mass. Insufflation of gas into a mass, organ, or vessel can result in fatal air emboli.[9] It is also important that the needle tip not be placed deep within the abdominal cavity. If the needle tip lies under the omentum during insufflation, the omentum balloons up and obscures visualization when the telescope is placed in the abdomen.

When correct placement of the Veress needle has been confirmed, the insufflation line is attached to the Veress needle, the automatic insufflator is turned on, and the flow rate is set. When the abdomen is distended with $CO_2$, it becomes tympanic upon palpation. The abdominal pressure should be no greater than 15 mm Hg. In most cases, 10 mm Hg is adequate to maintain abdominal distention and perform laparoscopy in small animals.

Intraabdominal pressures are shown on most automatic insufflators. Care is taken not to overdistend the abdomen with gas because overdistention impairs abdominal venous return and excursions of the diaphragm.

After adequate abdominal distention has been achieved, the cannula that will receive the telescope is placed through the abdominal wall. First an incision is made through the skin large enough to accommodate the diameter of the cannula to be used. To ensure that the skin incision is the correct diameter, an imprint of the cannula tip is made on the skin and is used as a template for incision length. An incision through all skin layers down to the subcutaneous tissues is required or else it is difficult to penetrate the abdominal wall. A hemostat can be used to open the wound and to ensure that the skin incision is the correct diameter and that it extends through all cutaneous and subcutaneous tissues.

The trocar-cannula unit is held with the trocar head firmly against the palm of the hand to prevent the trocar from sliding back into the cannula as it passes through the abdominal wall. With the abdominal cavity adequately insufflated, the tip of the trocar-cannula is placed in the incision and, by using a twisting and thrusting motion, the operator passes the trocar through the abdominal wall. This is a controlled thrust so that the trocar only penetrates the abdominal wall and does not pass deep into the abdominal cavity. The operator's other hand is used to grasp the cannula shaft, thus acting as a stop guide and preventing deep penetration of the trocar-cannula into the abdomen. The index or third finger of the hand holding the trocar cannula can also be extended down the cannula shaft to act as a stop. A hollow "pop" and the sound of air hissing through the trocar are heard when the trocar enters the gas-distended abdomen. Immediately after abdominal entry, the sharp trocar is removed from the cannula to prevent possible organ trauma. The cannula can then be advanced deeper into the abdomen. The Veress needle is removed and the $CO_2$ line attached to the insufflation stopcock of the telescope cannula.

An alternative means of trocar cannula placement is referred to as the *Hasson technique*.[10] This method was developed to avoid the injury to intraabdominal organs that is a potential complication from the Veress needle or the sharp trocar cannula used in the method of placement described previously. The Hasson technique is more time consuming and is often not necessary in simple diagnostic procedures. The Hasson technique uses a specially designed cannula that has a blunt obturator and an external cone (referred to as an *olive* or *Hasson trocar*) that has flanges for suturing it to the abdominal wall. A short ventral midline surgical incision is made through the abdominal wall and the blunt cannula is inserted through the incision into the abdomen. The olive is held in place in the abdominal wall with sutures going from the olive to the abdominal wall muscles and peritoneum to maintain a gas-tight seal. The advantage of this method is that blind placement of the Veress needle and sharp trocar-cannula is not necessary. With the Hassan cannula in place, the insufflator line is attached to the cannula Luer-lock valve, and insufflation is performed through the trocar-cannula to establish a pneumoperitoneum.

Open cannula placement can also be performed by simply incising through the abdominal wall, placing the cannula into the abdomen, and closing the incision around the cannula using a pursestring suture to seal the abdominal wall incision.[10]

Following initial cannula placement, the telescope is prepared for entry into the abdomen. The telescope is first placed in either a pan of warm sterile water or saline to bring it to body temperature and reduce the incidence of lens fogging when the telescope enters the abdominal cavity. The telescope lens should be wiped clean with a saline or sterile water-soaked gauze sponge. The light cable is attached to the telescope and the light guide cable is handed to the assistant for attachment to the light source. The video camera head is then attached to the telescope, and the light source, camera, and monitor are turned on.

Before placing the telescope in the abdominal cavity, the camera is "white balanced" so the colors seen on the monitor are true. The telescope is pointed at a white surface, such as a gauze sponge, and the white balance button on the camera processor is pressed. The TV monitor confirms that white balancing was successful. The camera with the telescope attached is focused to give a sharp, clear image. If the image is not clear, the laparoscope and camera lenses are examined to make sure they are clean. Once the camera is in focus, it is generally not necessary to refocus it during the procedure. The telescope is then advanced through the cannula and into the abdomen.

The image may become blurred as it enters the abdominal cavity. This may be due to tissue, fluid, or blood contaminating the lens as the telescope is passed through the cannula, or from condensation on the lens resulting from temperature change. When this occurs, the tip of the scope is cleaned by carefully wiping it against abdominal tissues such as the intestine or abdominal wall. If the image is still blurred, the telescope is removed and cleaned with saline-soaked gauze. Even though commercial antifog agents are available, they are rarely necessary.

With the telescope in the abdominal cavity, careful examination is performed. For proper orientation, it is important that the camera head always be in a proper orientation so that "up" in the patient is also "up" on the video monitor. It is also important that the video monitor be positioned so that the telescope and operating instruments are pointed toward the monitor. The telescope is moved in and out of the cannula with one hand,

while the other hand prevents the cannula from being inadvertently withdrawn from the abdomen. If the cannula is accidentally removed from the abdominal wall, replacement is difficult because the pneumoperitoneum is lost and it is often hard to find the original trocar cannula opening through the abdominal wall.

The site of entry for a second portal is selected. This location is determined by the procedures that are to be performed. It is important that the secondary cannula be placed far enough away from the telescope so that manipulation of instruments is not hindered by the close proximity of the telescope and second cannula. If an operator is right handed, the operating cannula is generally placed to the right of the telescope. When using both a 5-mm telescope and accessory instruments, it is possible to switch telescope and instruments from one cannula to the other.

The technique for placement of the operative cannula involves visual control by viewing the trocar entry from inside the abdomen with the laparoscope. Once the portal location is determined, the abdominal wall is palpated and the site is viewed internally using the telescope. Entry location is assessed to ensure that underlying organs are not traumatized during the trocar entry. The second cannula is placed through the abdominal wall as described in the procedure for placement of the first cannula, except trocar entry is viewed internally. Once the cannula has entered the abdomen, the trocar is removed. For convenience and to decrease the problem of telescope fogging, the $CO_2$ line is transferred to the operative cannula.

Abdominal exploration is begun using the palpation probe to "feel" and move the organs as needed. A 5-mm palpation probe with 1-cm markings along the shaft is passed through the operative cannula. As the probe, or any instrument, is passed into the abdomen, it is viewed as it exits the cannula and is directed to the area of examination under visual control. Instruments are never blindly passed into the abdomen and manipulated until they come into view. Blind technique often results in serious tissue trauma. All instruments are passed into the abdomen using the same technique.

At the conclusion of the laparoscopic procedure, the instruments and telescope are removed. The pneumoperitoneum is decompressed by opening one of the cannula valves and permitting the $CO_2$ to escape. The cannulae are removed and the puncture sites are sutured with interrupted subcutaneous and skin sutures for 5-mm portal sites and with deep fascia, subcutaneous, and skin sutures for 10-mm portals.

For postoperative pain management, bupivacaine local anesthetic is infiltrated in the trocar cannula sites and systemic analgesia is administered for 12 to 24 hours following the procedure.

## BIOPSY TECHNIQUES

### Liver Biopsy

Laparoscopic liver biopsy is considered by many to be the preferred method of obtaining liver tissue for histopathology.[11] Other diagnostic modalities do not provide as much information on liver characteristics as is obtained through visual inspection of the liver and adjacent organs (Figs. 10-3 and 10-4). A right lateral

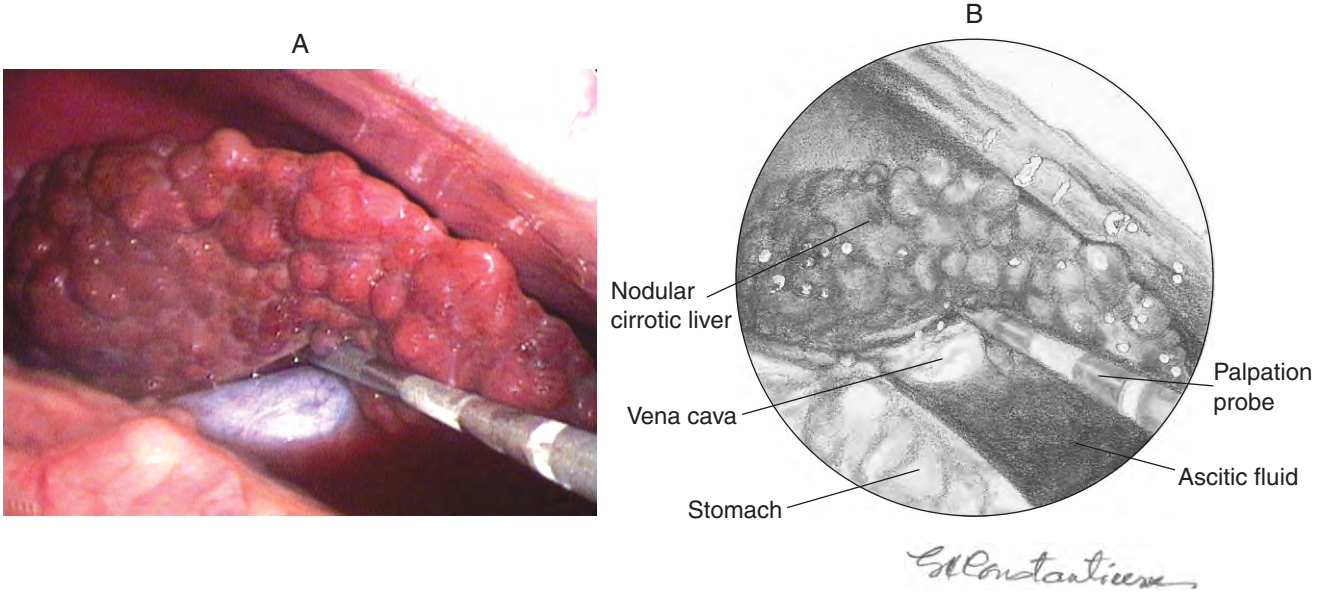



**Fig. 10-3**
Nodular liver typical of cirrhosis with ascites.

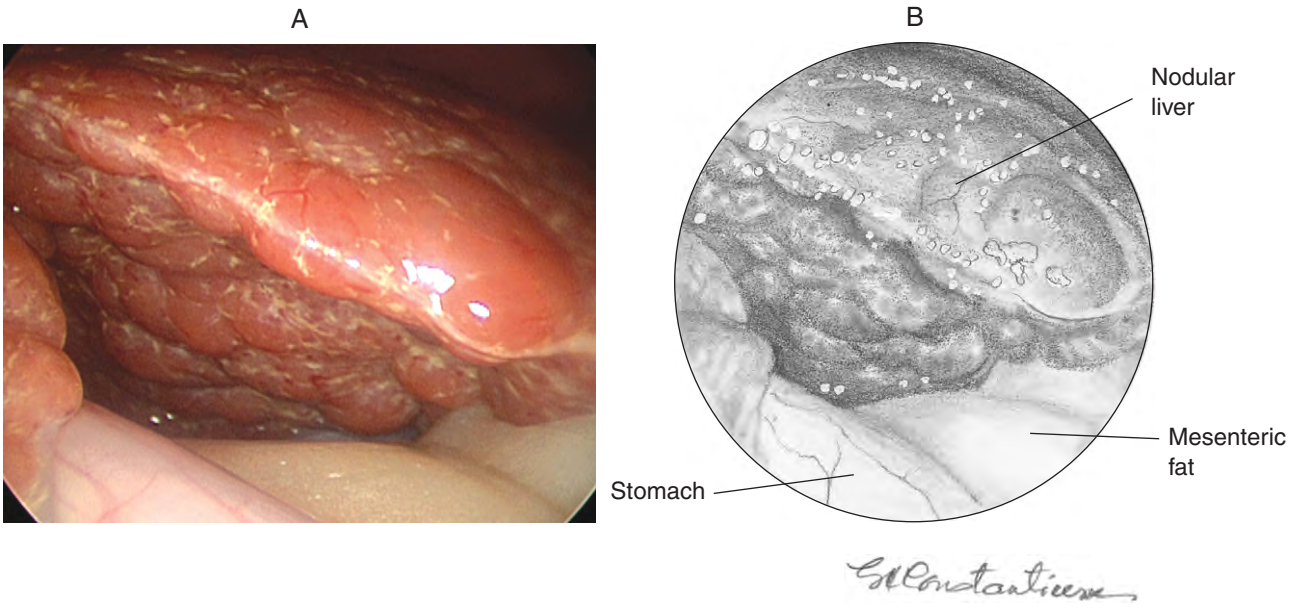



**Fig. 10–4**
Nodular liver resulting from hepatocutaneous syndrome. The nodules are hyperplasia surrounded by hepatic parenchymal collapse.

approach is generally recommended for evaluation of the liver, extrahepatic biliary system, and right limb of the pancreas. With this approach, more than 85% of the liver surface can be examined, directed biopsy specimens taken, and biopsy sites monitored for excessive bleeding. A recent study emphasized the benefit of laparoscopic cup biopsies compared with 18-gauge needle biopsies, finding that the histology results of the smaller needle biopsies correlated only approximately 50% of the time with larger laparoscopic cup biopsies.[12] Not only can larger biopsy samples be obtained, but also biopsy forceps can be directed to specific areas to obtain the samples. With this method, it is possible to obtain enough tissue for histopathology, culture, heavy metal, and other analyses.

Before liver biopsy is done, coagulation parameters (including bleeding time) are evaluated. Coagulopathies are a relative contraindication of laparoscopic liver biopsy; however, laboratory coagulation status does not necessarily predict whether the patient will bleed when a liver biopsy is done. Liver biopsies are frequently performed in dogs and cats with slightly abnormal coagulation times or low platelets counts, and rarely are there problems with excessive bleeding.

After the liver and extrahepatic biliary system have been examined and palpated, and after a decision is made to obtain a liver biopsy, the palpation probe is removed. For liver biopsies, a 5-mm oval cup biopsy forceps is used.[13] The biopsy forceps are directed through the operative cannula to the area of the liver to be sampled. Biopsy samples are taken from the edge of the liver or samples are obtained over the flat surface of the liver. In rare instances when a deep hepatic lesion is suspected but cannot be seen on the surface of the liver, a core biopsy needle is directed into the lesion. It is important to biopsy both normal-appearing liver and abnormal-appearing liver. Biopsy samples taken at the edge of the liver may not reflect deeper lesions but show the normally more reactive and fibrotic subcapsular tissues. Because of the larger sample size taken with cup biopsy forceps, we believe that deeper tissue is obtained and that this is not a major concern.

Once the location of the biopsy site is selected, the biopsy cups are opened and then closed around the sample area. The cups are held tightly closed for approximately 30 seconds before pulling the sample away from the liver. Generally, three to four liver biopsy samples of representative sites in the liver are taken.

The biopsy sites are closely monitored for bleeding (Figs. 10-5 and 10-6). In general, little if any blood is lost from liver biopsy sites. Because of the magnification produced by the telescope, a small amount of blood may look like considerable hemorrhage. If bleeding is considered to be excessive, several steps can be taken. First, the palpation probe is directed into the biopsy site and pressure is applied over the area. Alternatively, a small piece of saline-soaked Gel-Foam can be placed into the biopsy site using either laparoscopic grasping or biopsy forceps. In most cases, this is sufficient to control bleeding. With continued excessive bleeding, electrocoagulation, ligature clip, or loop ligature placement may be required.

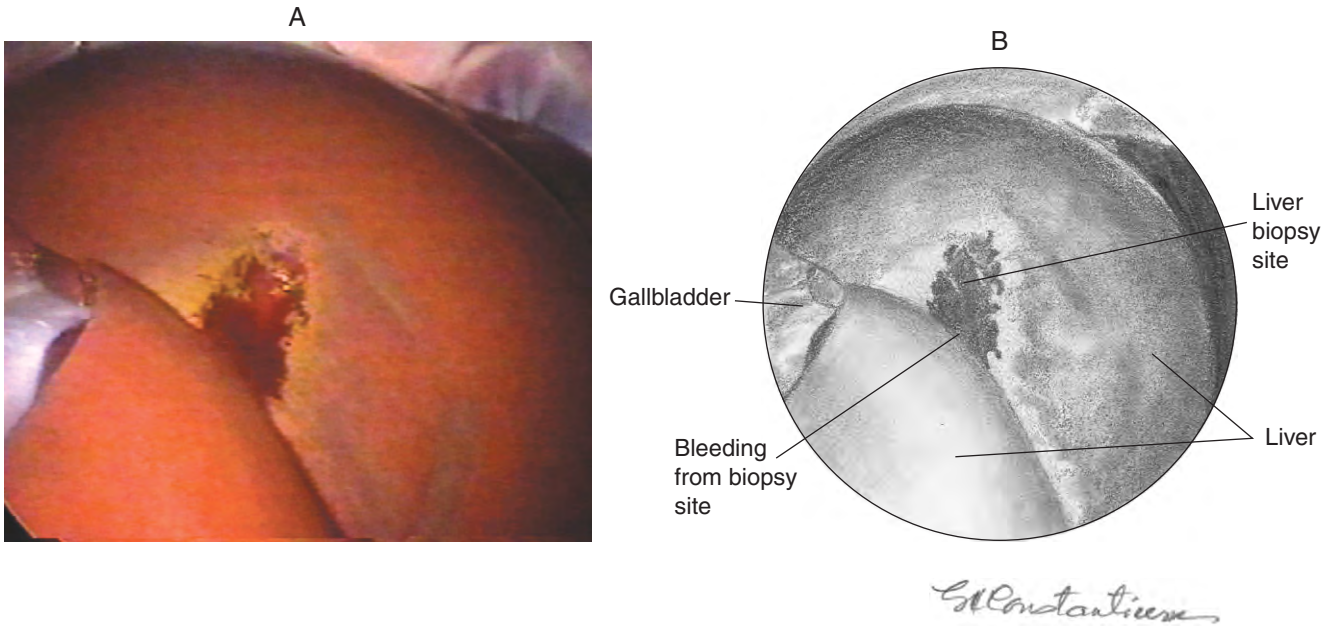



**Fig. 10-5**
A liver biopsy site following a cup forceps biopsy. Note minimal bleeding.

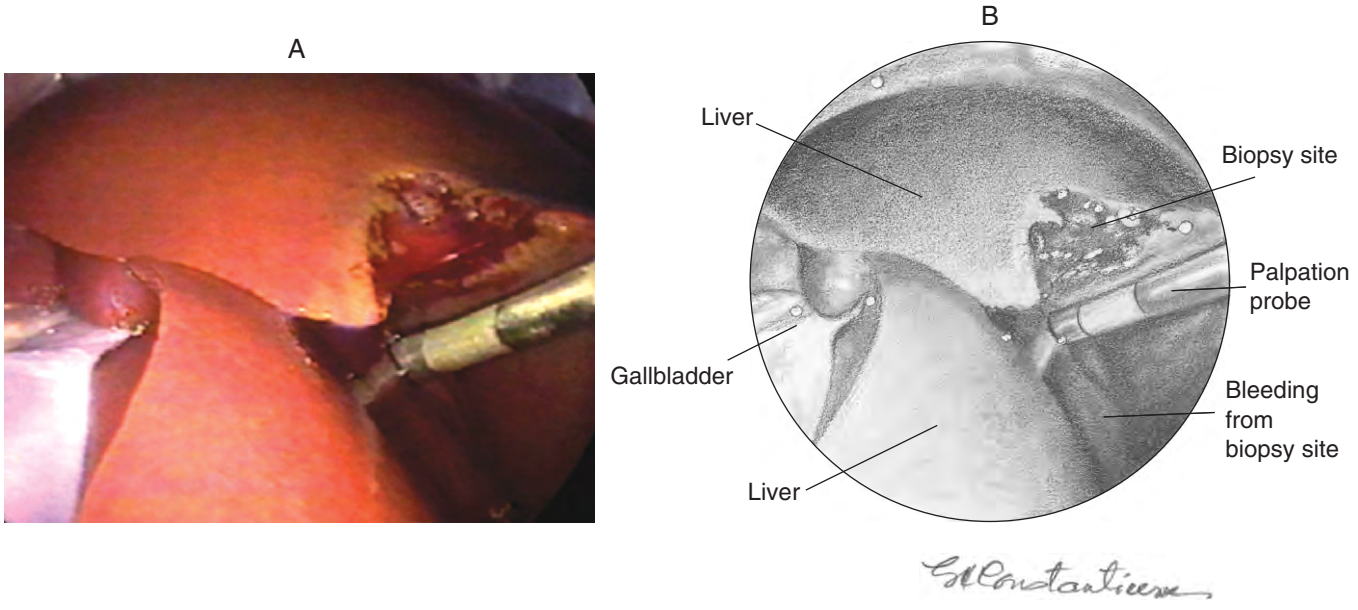



**Fig. 10-6**
Investigating the liver biopsy area with the palpation probe for excessive bleeding.

## Pancreatic Biopsy

Laparoscopy is an effective method for evaluating and taking biopsy samples of the pancreas. Indications for pancreatic biopsies include cases suspected of having either acute or chronic pancreatitis or pancreatic neoplasia. Chronic pancreatitis is a common finding in cats, and we find laparoscopy to be the best means for diagnosing this condition. The adage "never touch the pancreas for fear of causing pancreatitis" does not appear to be true with laparoscopy.[13] Pancreatic biopsies are generally free of complications. A study evaluating laparoscopic pancreatic biopsies in normal dogs found no postoperative complications or indications of secondary pancreatitis.[14] Laparoscopy is often used to confirm the presence of acute pancreatitis and to concurrently place a jejunostomy feeding tube for continued patient management.

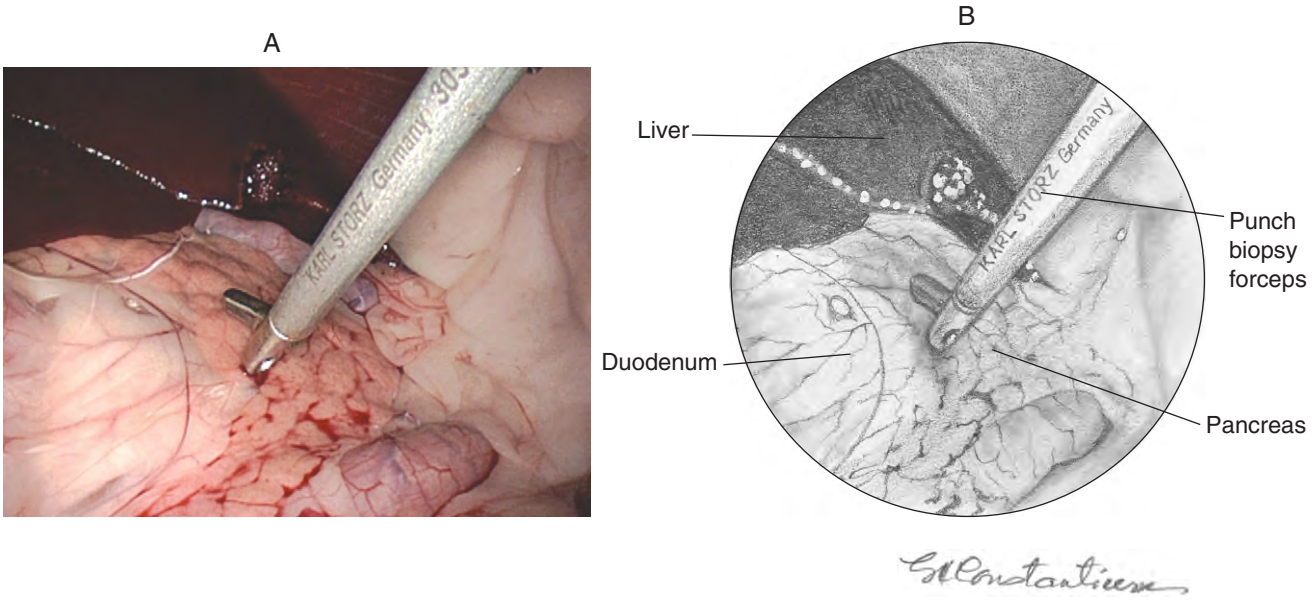



**Fig. 10-7**
Pancreatic biopsy specimen being taken from a normal pancreas using a punch type biopsy forceps.

Punch type biopsy forceps are preferred for pancreatic biopsies (Fig. 10-7). Cup biopsy forceps can also be used. When obtaining a pancreatic biopsy, a right lateral approach is used. This gives an excellent view of the right limb of the pancreas, the duodenum, and the extrahepatic biliary system and liver. The left limb of the pancreas is more difficult to examine from this approach. Biopsy sites are selected on the edge of the pancreas away from the location of the pancreatic ducts that traverse the center of the gland and enter the duodenum (Fig. 10-8). Only one or two representative biopsy samples are taken of the pancreas unless multiple lesions are present.

## Renal Biopsy

Laparoscopy is well suited for evaluation and biopsy of the kidney.[15,16] Biopsy of the kidney requires the use of a core-type biopsy needle (Vet-Core Biopsy Needle, 16-gauge, Cook Veterinary Products, Bloomington, Ind). Cup or punch biopsy forceps are not used for kidney biopsies. Direct visualization of the kidney allows the operator to navigate the biopsy needle to the desired site to be sampled and makes it possible to monitor for excessive postoperative bleeding.

Before biopsy, adequate renal evaluation is necessary, including measuring renal excretory function or doing ultrasonography or intravenous urography. The resultant information is important in selecting which kidney to sample. Unless there are specific indications to biopsy one of the kidneys, the right kidney is preferred because it is less movable. The left kidney is more movable and cannula placement is more difficult with higher risk because of the location of the spleen underlying the usual cannula entry sites.

The right kidney is easily visualized through a right lateral mid-abdominal telescope portal (Fig. 10-9). A second cannula is always placed so that a palpation probe can be used for tamponade at the biopsy site, and the palpation probe is placed in the abdomen near the kidney before the kidney biopsy sample is taken. Once the area to biopsy on the kidney is determined, an entry site for the biopsy needle is selected. This involves external palpation in the right mid-paralumbar region caudal to the last rib. While viewing with the telescope internally, the abdominal wall is palpated for selection of an entry site. A 16-gauge automatic biopsy needle is used for kidney biopsies. A 2-mm skin incision is made at the desired entry site, and the needle is inserted into the abdominal cavity and directed to the kidney. Samples are taken from the cranial or caudal pole of the kidney, being careful to collect predominately cortex with little medulla. The biopsy needle is seated through the renal capsule, the needle is fired, and then the needle is completely removed from the abdominal cavity. Following kidney biopsy, there is generally significant blood flow from the biopsy site. The palpation probe is placed over the biopsy hole and pressure is applied for several minutes to stop bleeding (Fig. 10-10). Additional samples may be taken if the initial sample is not considered to be suitable.

Several precautions are suggested when performing a renal biopsy. First, the patient is not given drugs to increase renal blood flow (e.g., dopamine). Second, the needle entry site is placed caudal to the diaphragm to prevent an iatrogenic pneumothorax from leakage of the pneumoperitoneum into the thorax. Third, it is important to avoid directing the needle into the corticomedullary junction of the kidney where the large arcuate vessels are located.

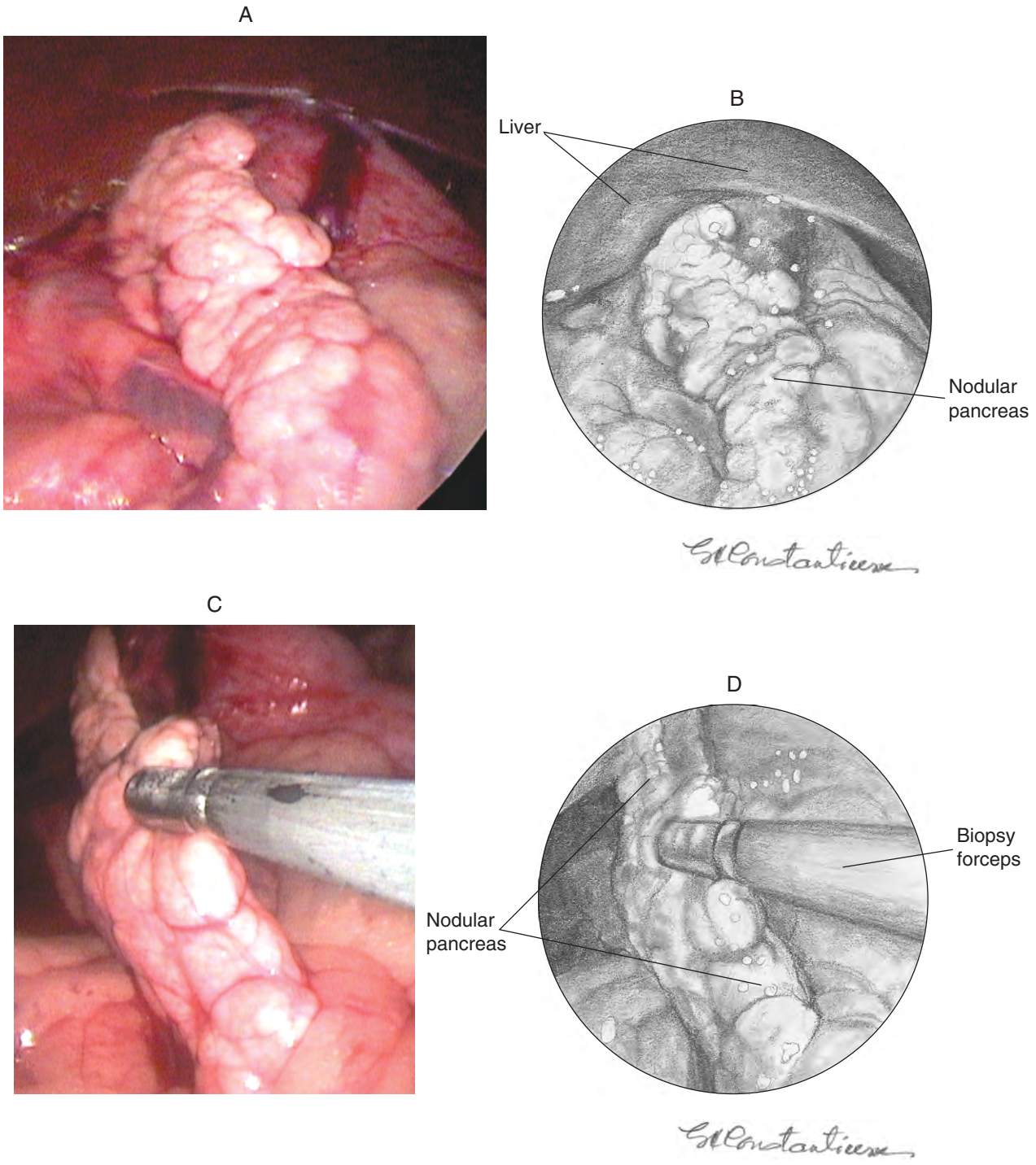



**Fig. 10-8**
A & B, A nodular pancreas in a cat having chronic interstitial pancreatitis and cholangiohepatitis. C & D, A pancreatic biopsy specimen being taken from the edge of the right limb of the pancreas using oval cup forceps.

## Intestinal Biopsy

Full thickness small intestinal biopsies can be obtained using the laparoscope by exteriorizing a piece of intestine through the abdominal wall and then collecting the sample externally with the same technique that would be used for a standard surgical biopsy.[17] This technique is performed using a 10-mm operative cannula that is equipped with a reducer to accommodate 5-mm instruments. A 10-mm instrument can also be used. An atraumatic grasping forceps with multiple teeth is used to grasp the intestine at the site to be biopsied (Fig. 10-11). It may be necessary to "run" the bowel with two grasping

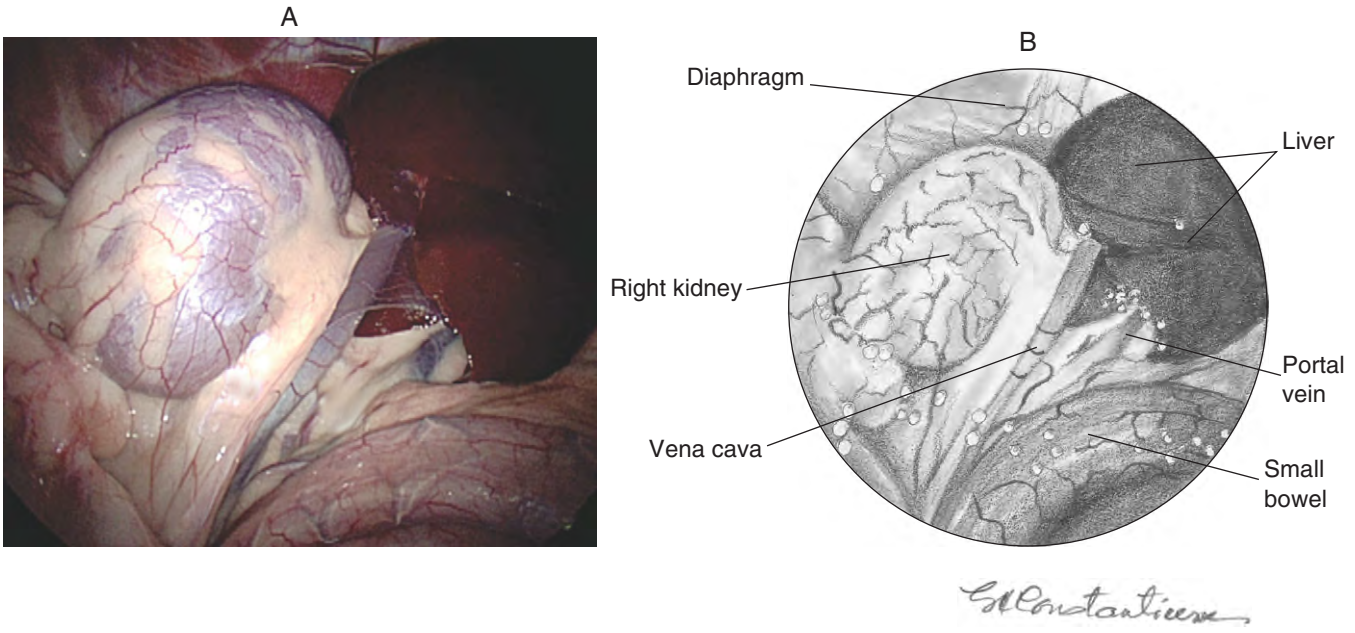



**Fig. 10-9**
A view showing the right kidney from a right lateral approach. Also seen are the vena cava, portal vein, and caudate lobe of the liver. The right kidney is less movable and easier to biopsy.

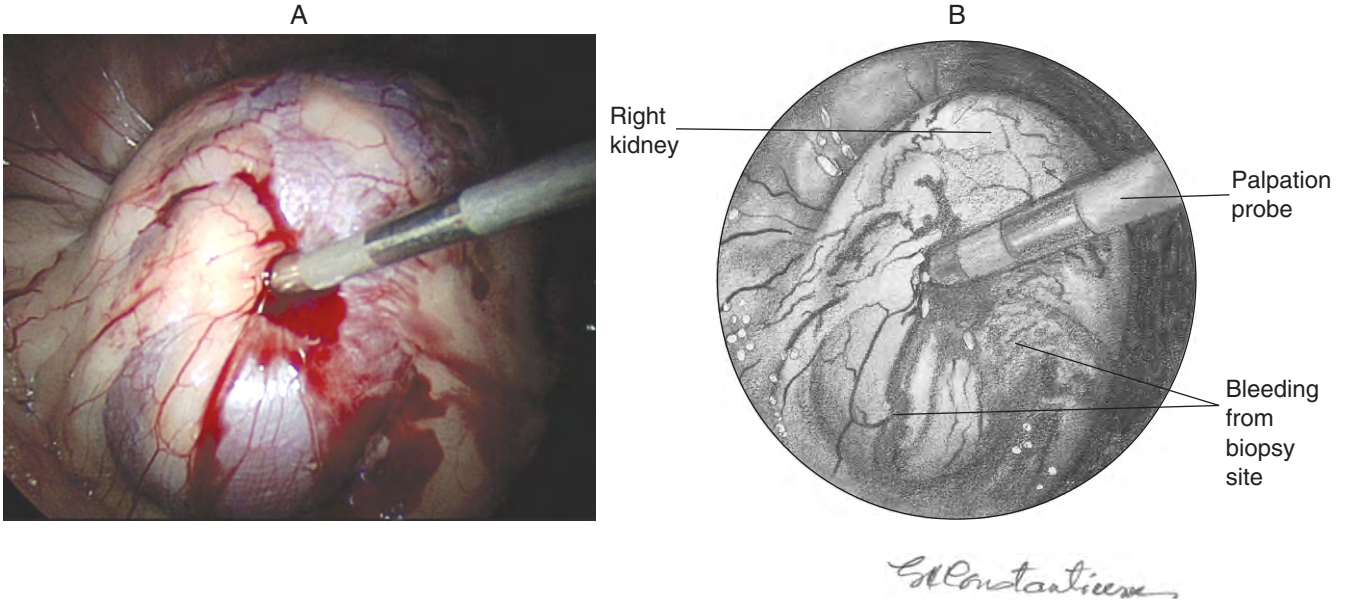



**Fig. 10-10**
The palpation probe applying pressure over a needle biopsy site in the right kidney.

forceps to select a location for biopsy. A second operative portal is required for this technique. The antimesenteric border is firmly grasped with the forceps at the site selected for biopsy and the intestine is pulled up to the cannula. If difficulty is encountered exteriorizing the intestine, the portal is enlarged using a scalpel blade to allow the loop of bowel to pass through the abdominal wall. The scalpel blade is inserted parallel to the cannula shaft and cuts away from the cannula, thus increasing the incision length. This procedure is visualized internally with the telescope (Fig. 10-12). The intestine, grasping forceps, and cannula are pulled through the abdominal wall together to exteriorize a short, 3- to 4-cm section of the intestine.

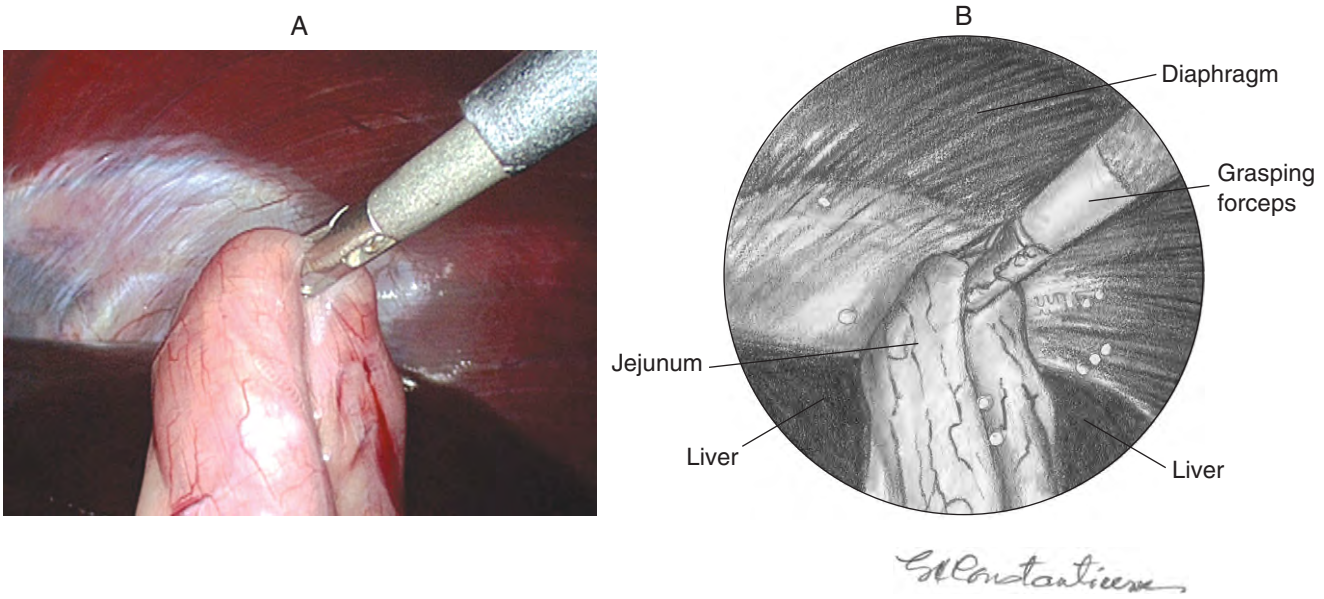



**Fig. 10–11**
A 5-mm atraumatic grasping forceps with multiple teeth grasping the jejunum at the site to be exteriorized and for biopsy.

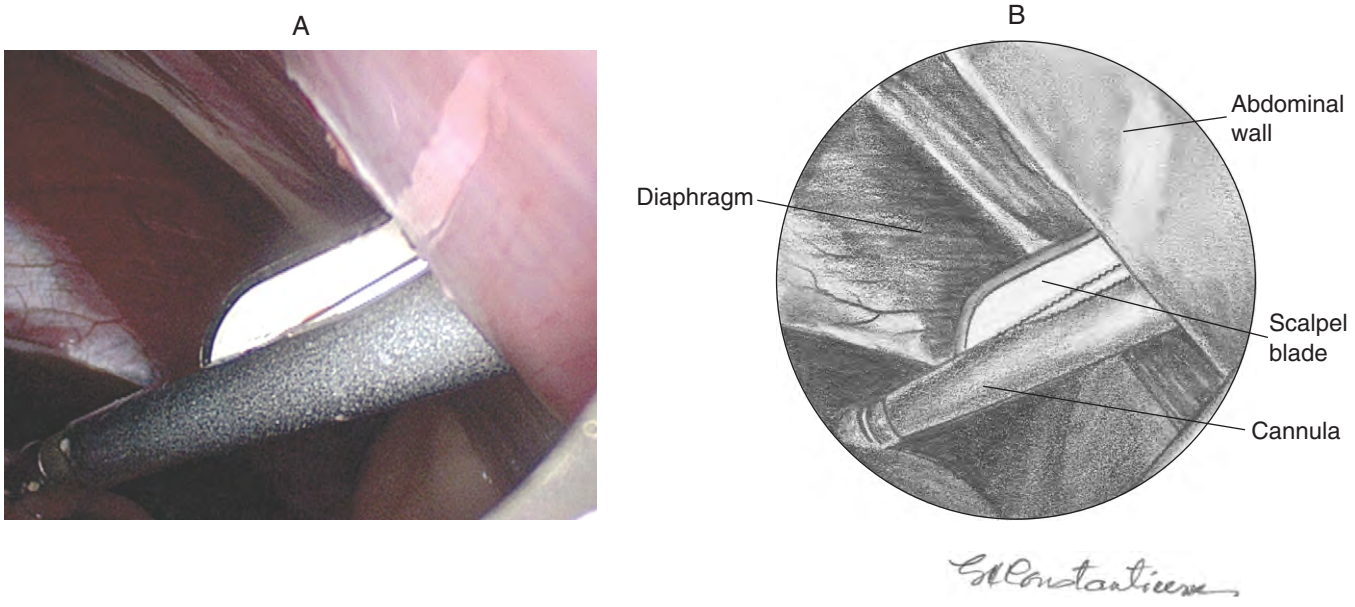



**Fig. 10–12**
A scalpel blade is viewed internally as it enters parallel to the cannula shaft and is used to cut away from the cannula, increasing incision length to allow exteriorization of the intestinal loop.

Stay sutures are placed in the exteriorized loop of intestine to prevent it from falling back into the abdominal cavity. A small full thickness biopsy sample is obtained and intestinal closure is performed in the same manner as would be used when performing an open abdominal surgical technique. The intestine is returned to the abdominal cavity. If too much intestine is exteriorized, it is difficult to return it to the abdominal cavity through a small incision.

Intestinal biopsies are performed as the last laparoscopic procedure because the pneumoperitoneum is lost during the procedure. If additional intestinal biopsies or other laparoscopic procedures are to be performed, then the trocar cannula must be reintroduced through the abdominal incision and a pneumoperitoneum reestablished. A technique for multiple biopsies of the intestine using a serosal patch graph has also been described.[17] This is done by retaining

each segment of exteriorized bowel that is biopsied using stay sutures and then the different biopsy sites are sutured together to create a serosal patch graft.

## Other Biopsy Techniques

A number of other biopsy techniques can also be performed using laparoscopic direction. This includes biopsy of mass lesions, lymph nodes, spleen, and adrenal gland (Fig. 10-13). Splenic biopsies are generally safe to perform using the cup-type biopsy forceps (Fig. 10-14). The technique, precautions, and coagulation control are similar to those for liver biopsy. Adrenal biopsies are sometimes performed when an adrenal mass is identified. Excessive bleeding following adrenal biopsy is common and hemostatic precautions are necessary. Cup forceps are used to obtain adrenal biopsy samples.

Laparoscopy may also be used to determine the cause of unexplained abdominal effusion. The fluid is aspirated

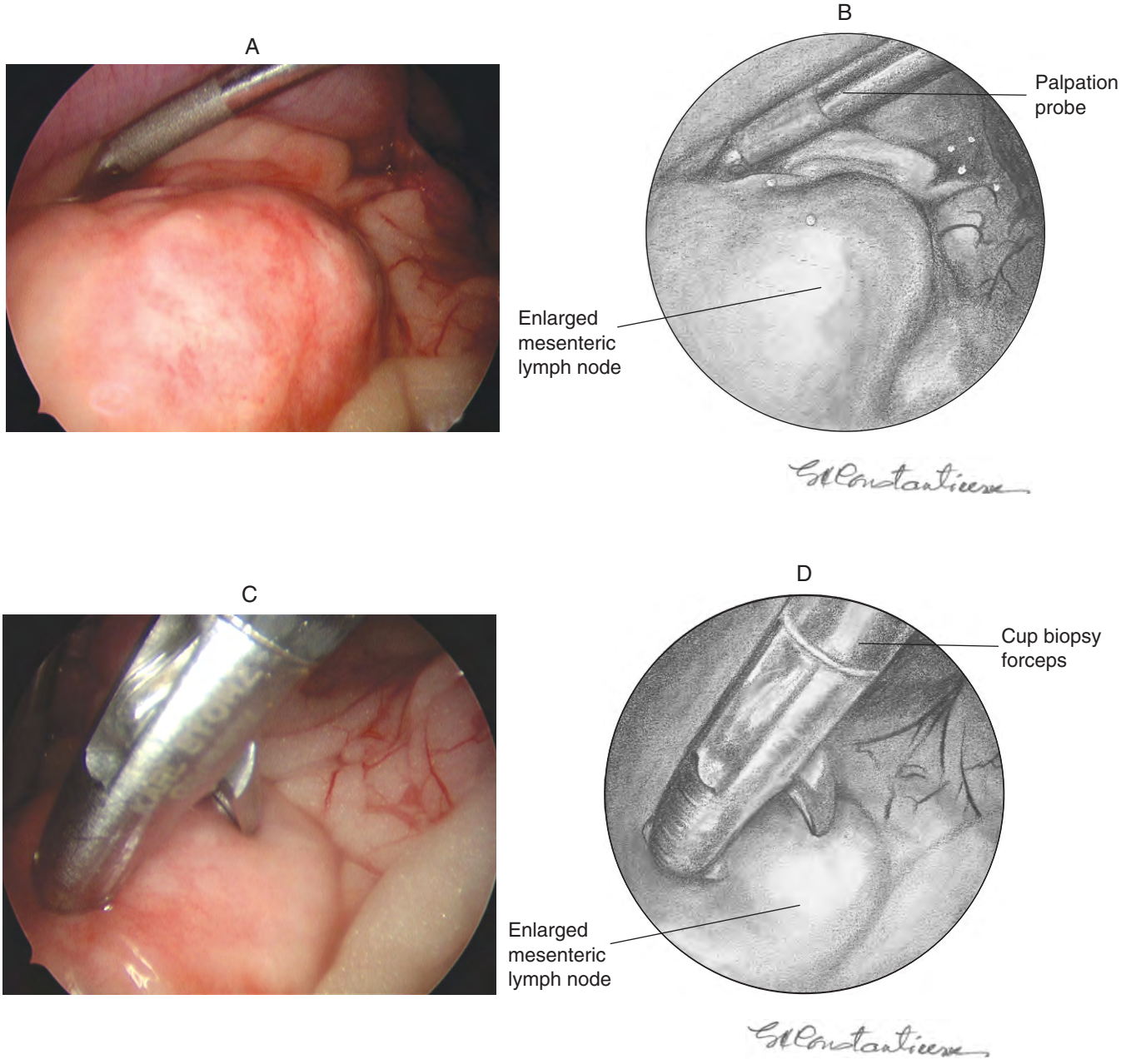



**Fig. 10-13**
A & B, A large mesenteric lymph node in a cat having unexplained abdominal effusion (also see Fig. 10-15). Ultrasound guided needle aspirates were not diagnostic. C & D, Cup biopsy forceps taking the mesenteric lymph node biopsy. Histopathology revealed lymphoma.

under endoscopic direction to enable examination of the abdominal contents (Fig. 10-15).

## ANCILLARY LAPAROSCOPIC-ASSISTED DIAGNOSTIC PROCEDURES

Additional diagnostic procedures that can also be performed using laparoscopic guidance are cholecystocentesis, cholecystography, portography, and reproductive procedures.

### Cholecystocentesis and Cholecystography

The gallbladder is best evaluated in a right lateral or ventral approach. The normal gallbladder is soft and fluctuant with the ductal system not distended (Fig. 10-16). Obstructive biliary tract disease is often associated with

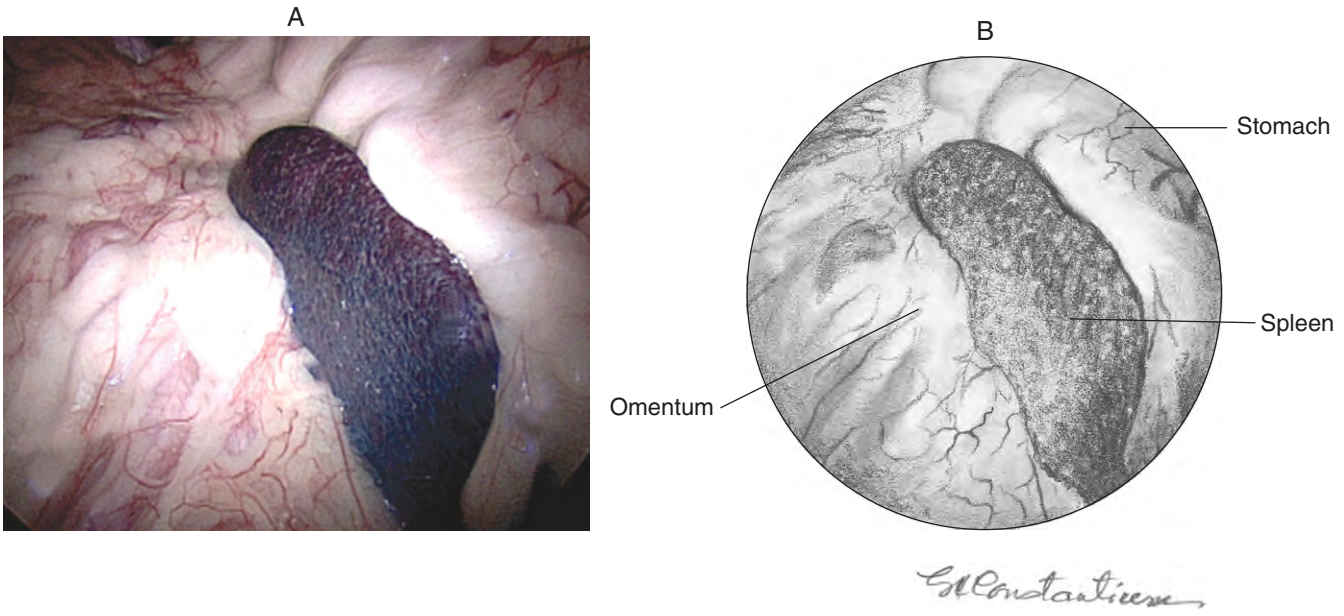



**Fig. 10-14**
A view showing a normal spleen from a right lateral approach.

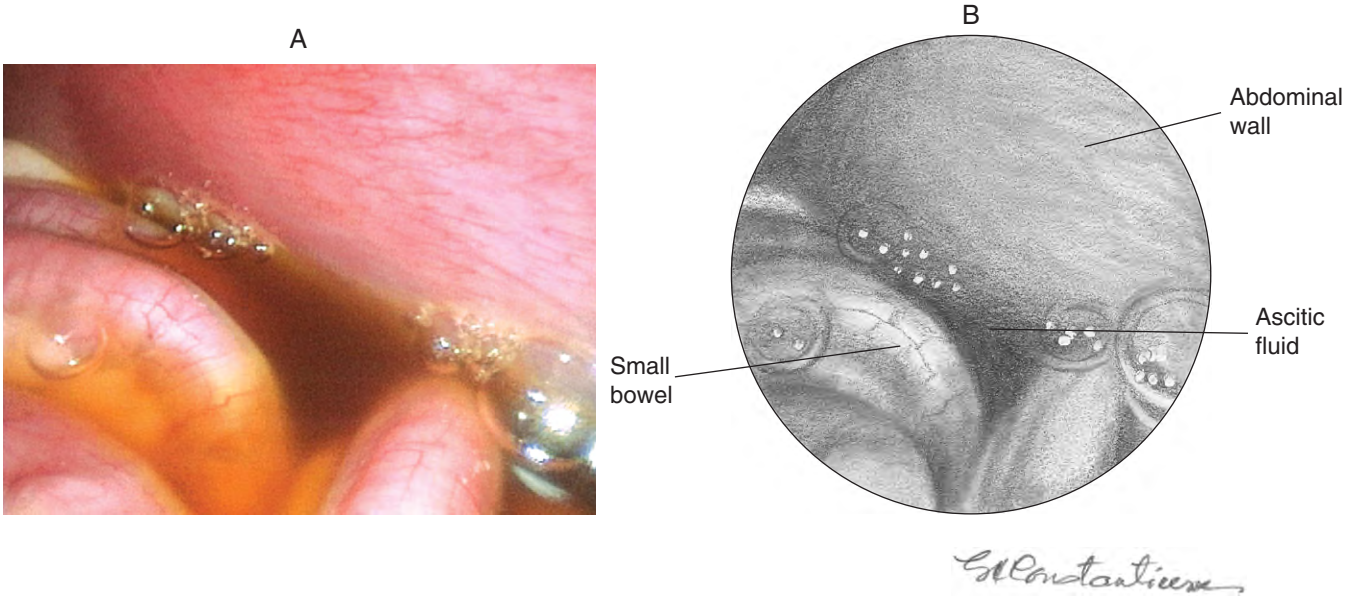



**Fig. 10-15**
Abdominal effusion secondary to mesenteric lymphoma in the cat shown in Fig. 10-13.

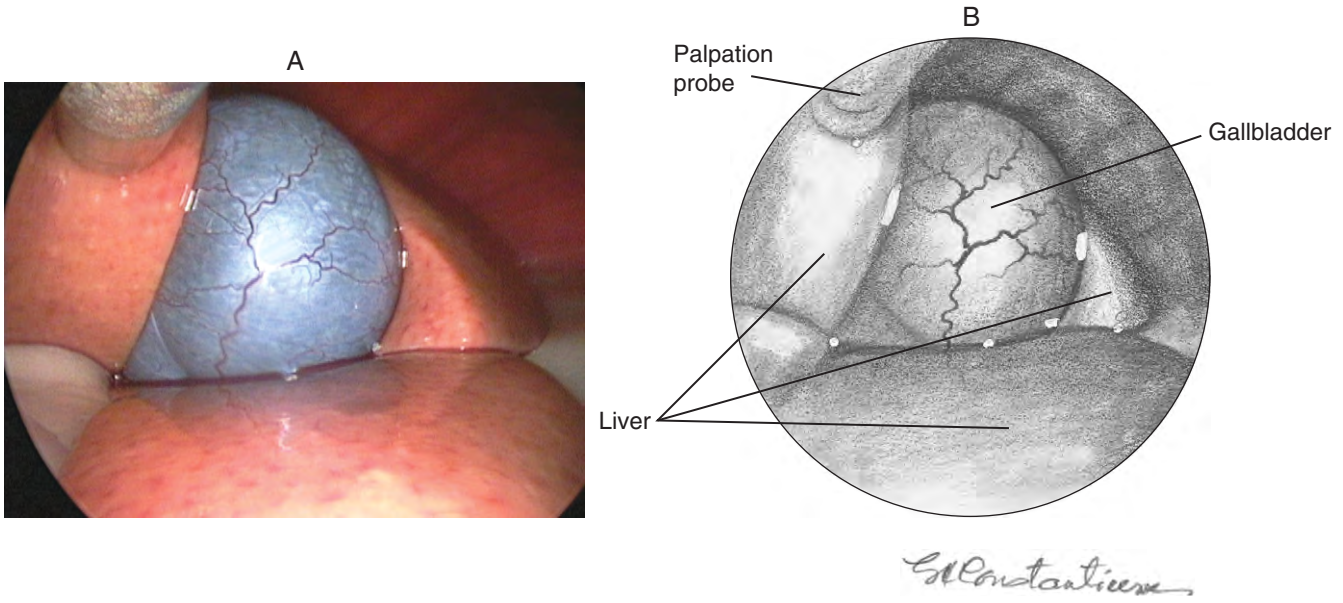



**Fig. 10-16**
Normal distended but nonturgid gallbladder of a cat having idiopathic hepatic lipidosis. Note the characteristic yellow color of a lipidosis liver.

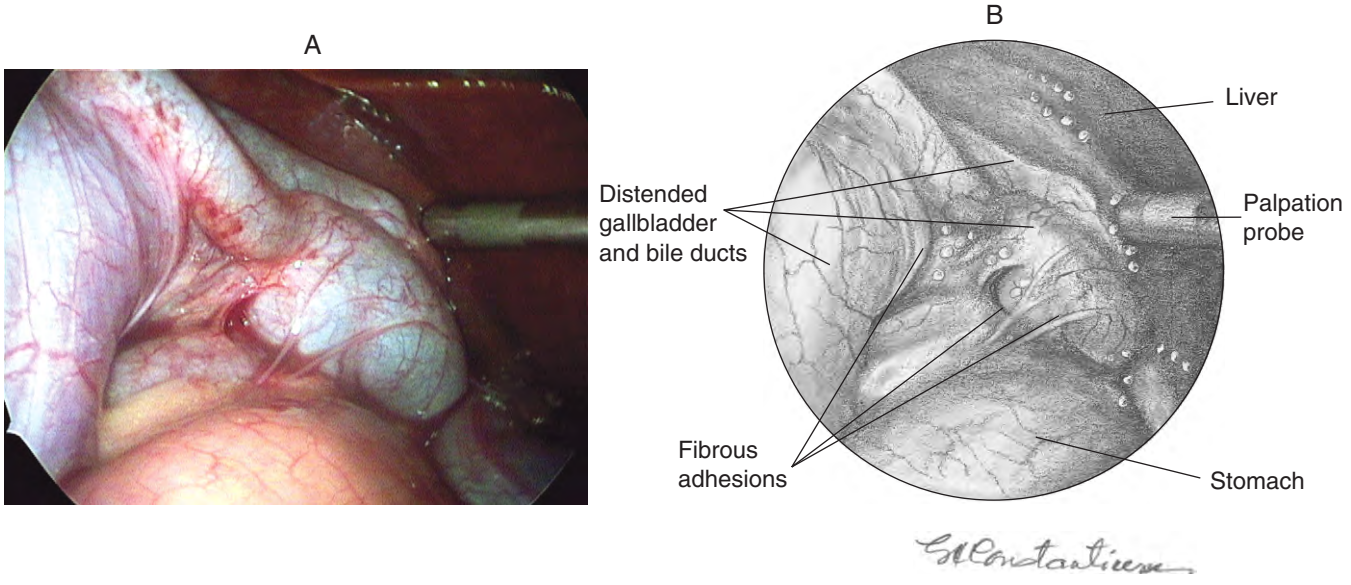



**Fig. 10-17**
A right lateral approach showing a distended gallbladder and common bile duct. Fibrous adhesions can be seen over the biliary system. These fibrous adhesions caused an obstruction in the distal duct.

a large, firm gallbladder and distended duct system (Fig. 10-17). The liver and ducts are often bile stained in color and the biliary lymphatics are generally distended.

When inflammatory or infectious biliary tract disease is suspected, laparoscopic-guided cholecystocentesis using a 20- to 22-gauge, 10 cm or longer needle is indicated for culture and cytology.[13] The needle is directed through the abdominal wall, the gallbladder is punctured under laparoscopic guidance, and the contents are aspirated (Fig. 10-18). As much bile as possible is removed to empty the gallbladder and minimize leakage when the needle is removed. The bile can be submitted for culture and cytology. Two precautions are taken when doing this procedure. First, the needle must be placed through

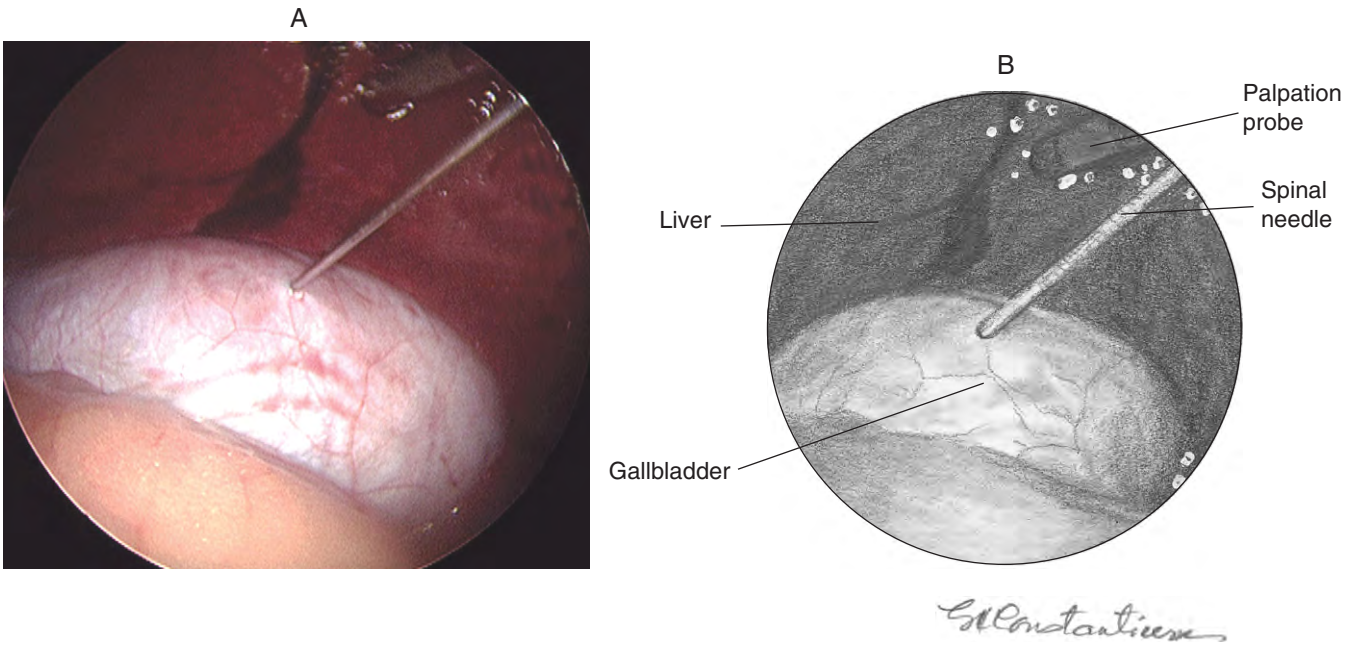



**Fig. 10-18**
A 20-gauge spinal needle is seated in the lumen of the gallbladder to collect bile for culture and cytology.

the abdominal wall caudal to the diaphragm to avoid producing a pneumothorax by pneumoperitoneum gas escaping through the diaphragm via the needle track. Second, the gallbladder is decompressed as much as possible to prevent bile leakage.

An alternative technique is to aspirate the gallbladder by passing the needle through the right middle lobe of the liver and then into the gallbladder in the area where it is attached to the liver. If bile leakage occurs using this technique, the bile simply drains back into the liver and not into the peritoneal cavity. It is, however, difficult to direct the needle into the gallbladder using this technique without traversing the diaphragm.

If obstruction of the extrahepatic biliary system is suspected, an iodine contrast study can be performed following cholecystocentesis (Fig. 10-19). To perform cholecystography, a needle is directed into the gallbladder as described earlier, as much bile as possible is removed, and sterile radiopaque iodine contrast agent designed for intravenous use is injected into the gallbladder.[10] A volume of 5 to 15 ml is usually adequate to delineate abnormalities. Care is taken to not overly distend the gallbladder because that can result in leakage. Static radiographs or fluoroscopy are used to evaluate the bile duct system for blockage. The contrast normally flows freely into the duodenum.

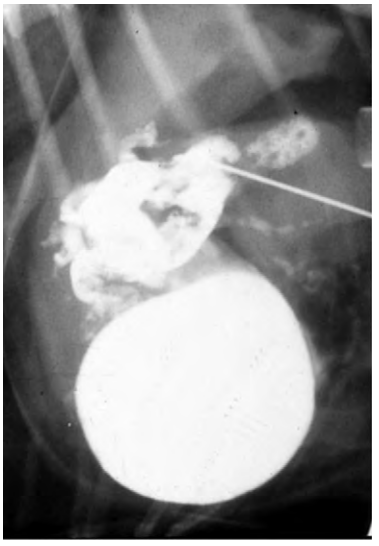


**Fig. 10-19**
Radiograph obtained following injection of iodine contrast agent into the gallbladder of a dog suspected of having a bile duct obstruction. The extrahepatic biliary system is dilated and radiopaque calculi are present in the distal bile duct. The injection needle is still present in the gallbladder.

## Portography

Portal system contrast studies can be performed using laparoscopic direction.[13] Congenital and acquired vascular anomalies can be diagnosed using this technique. Liver biopsies are always performed in conjunction with this procedure. Splenoportography involves placement of iodine radiographic contrast into the portal vascular system via the spleen to outline portal blood flow cranial to where

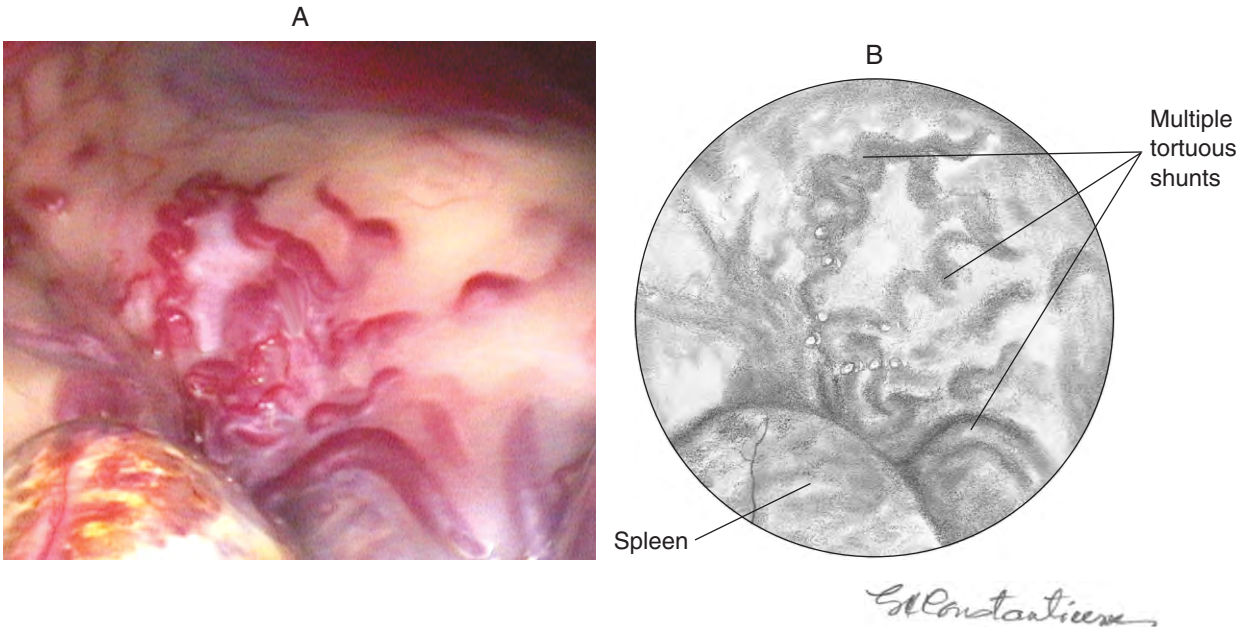



**Fig. 10–20**
Multiple tortuous collateral portosystemic shunts secondary to portal hypertension seen with a right lateral approach. The tip of the spleen is seen in the foreground.

the splenic vein enters the portal vein. Laparoscopic splenoportography is performed in the radiology suite so that radiographs can be obtained immediately following injection.

Splenoportography requires a left lateral approach. The spleen is located and an 18-gauge, 10-cm spinal needle with stylet is inserted through the ventrolateral abdominal wall near the area of the spleen. The needle is inserted into the body of the spleen parallel with the long axis of the spleen. The needle is inserted 1 to 3 cm into the center of the splenic parenchyma. Once the needle is firmly seated in the spleen, the telescope is withdrawn and the pneumoperitoneum is evacuated. The needle hub is attached to extension tubing and gently flushed with several millimeters of heparinized saline. It is then possible to measure the splenic pulp pressure in centimeters of water by attaching the extension tubing to a standard water manometer system that is used to measuring central venous pressures. The zero point of the manometer is placed at the level of the right atrium. Normal pressures in the spleen range from 10 to 15 cm $H_2O$.[13] Animals with portal hypertension have much higher pressures. On a right lateral approach, one often sees acquired collateral shunts in the area of the right kidney in animals having portal hypertension (Fig. 10-20).

After obtaining pressure measurements, an intravenous iodine contrast agent is injected by hand at a dose of 0.25 to 0.5 ml/kg body weight slowly over approximately 10 to 20 seconds. Radiographs are obtained halfway through the injection and immediately after completion of the injection (Fig. 10-21). In most cases, it is possible to delineate portal blood flow and document congenital or acquired shunting. This procedure is safe and has been associated with minimal complications.

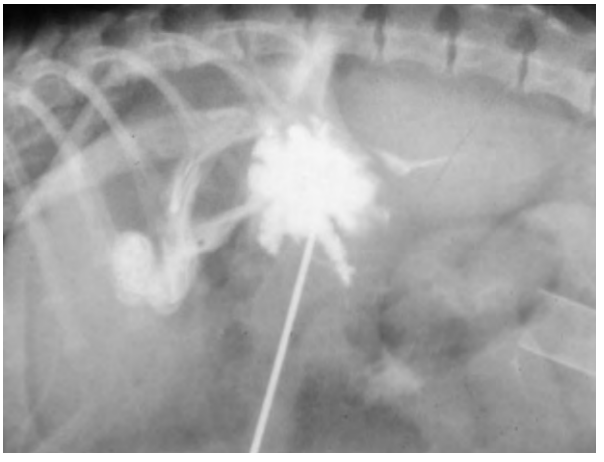


**Fig. 10–21**
Splenoportography performed during laparoscopy demonstrating a congenital portal vein to vena cava shunt.

An additional method for performing portography involves exteriorizing a jejunal vein for direct catheter placement. The method of jejunal vein presentation is similar to that used for the intestinal biopsy technique.

## Reproductive Procedures

A number of laparoscopic reproductive procedures can be performed including documentation of ovarian activity, aspiration of ovarian or parovarian cysts, uterine biopsy, and artificial insemination. Ovarian cyst aspiration can be performed using laparoscopic guidance of a transabdominally placed aspiration needle. Laparoscopy has also been used for in utero insemination of fresh, chilled, or fresh-frozen semen using either of two techniques. One technique exteriorizes the uterus as described for biopsy of the small intestine.[2] The other technique is performed entirely within the abdomen. The uterus is grasped and stabilized with forceps and a through-the-needle catheter is placed through the abdominal wall and into the lumen of the uterine body. The needle is removed and semen is injected through the catheter. Uterine biopsies, culture collection, or even uterine infusion can also be performed using this technique.

# SURGICAL LAPAROSCOPY

There are a number of minimally invasive surgical procedures that are currently performed using laparoscopy. Many of these procedures require multiple cannula portals, specific laparoscopic surgical instruments, loop ligatures, clip applicators, and monopolar electrosurgery. The techniques described in the following section are the "tip of the iceberg" and are just the beginning for laparoscopic surgery in veterinary medicine.

## Intestinal Feeding Tube Placement

Duodenostomy or jejunostomy feeding tubes can be placed using the laparoscope by exteriorizing a piece of intestine through the abdominal wall and inserting the tube externally.[17] The technique for bowel exteriorization is the same as that described for intestinal biopsy. For intestinal feeding tube placement it is necessary to locate either the proximal part of the jejunum for jejunostomy placement or distal duodenum for duodenostomy tube placement. Two instrument portals are required so that two grasping forceps can be used to run the bowel to identify the appropriate segment of the bowel (Fig. 10-22). Two 5-mm atraumatic grasping forceps with multiple teeth are used to manipulate the intestines. When the location of the bowel for tube placement is determined, the antimesenteric border is firmly grasped with forceps (see Fig. 10-11). The intestine is pulled close to the cannula in which the intestine will be exteriorized. The incision for the cannula is extended with the cannula still in place using a scalpel blade. Placement of the scalpel blade is observed with the laparoscope internally as it enters parallel to the cannula shaft (see Fig. 10-12) and as it cuts away from the cannula, increasing incision length enough to allow exteriorization of the intestine. The intestine is



**Fig. 10-22**
Placement of the three cannulae to perform a jejunal biopsy. The cannulae are placed in the caudal part of the abdomen. Two instrument ports are required to be able to run the bowel in the abdominal cavity. The cannula in the middle is used for the telescope.

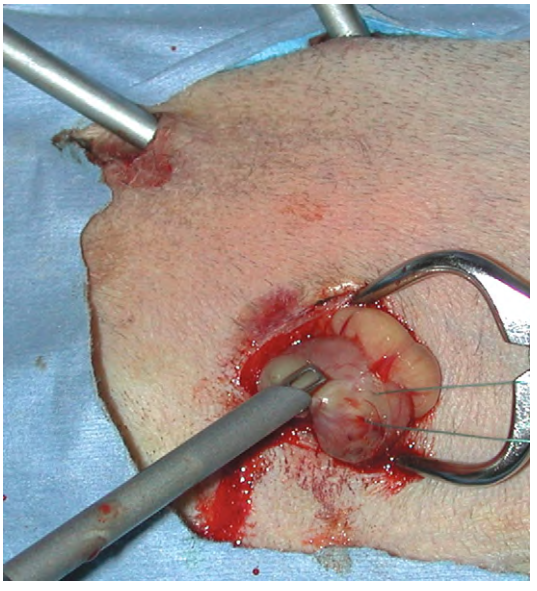


**Fig. 10-23**
After identification of the loop of bowel to biopsy, the loop is exteriorized through the abdominal wall at one of the cannula sites. A stay suture is placed in the loop as soon as it is exteriorized.

firmly seated against the cannula; the intestine, grasping forceps, and cannula are pulled through the abdominal wall simultaneously to present a small section of intestine (Fig. 10-23). When exteriorizing the loop of intestine, it is important to remember the oral to aboral orientation of the loop of bowel for directing the feeding tube aborally.

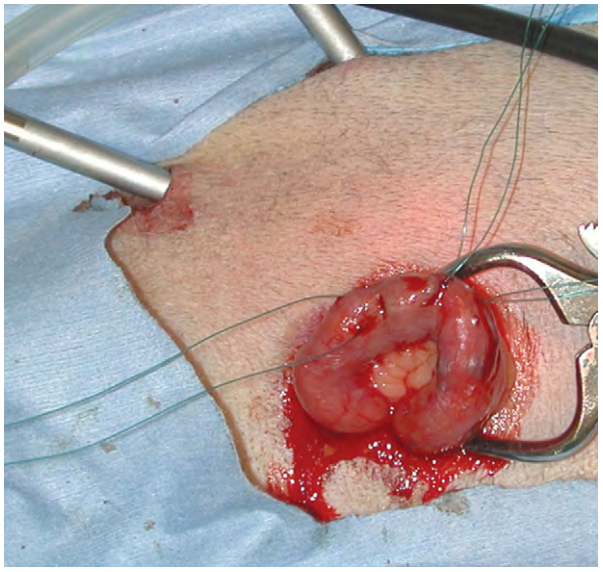


**Fig. 10-24**
After the loop is adequately exteriorized for jejunostomy tube placement, four stay sutures are placed in the exposed loop of bowel.

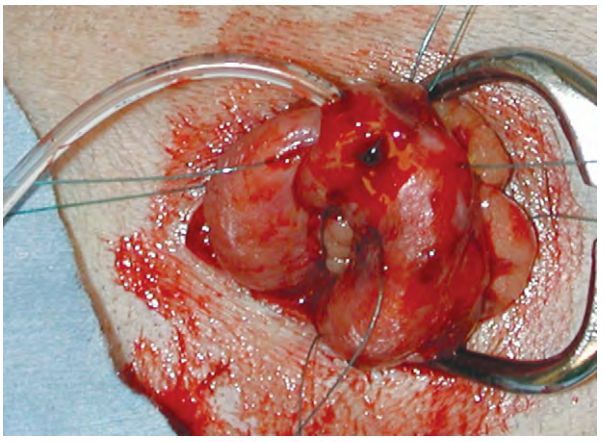


**Fig. 10-25**
A pursestring suture (3-0 monofilament absorbable suture) has been placed on the antimesenteric border of the jejunum, the jejunostomy feeding tube has been inserted in the middle of the pursestring, and the pursestring suture has been tightened and tied.

A 3- to 4-cm loop of intestine is exteriorized and four stay sutures (4-0 monofilament absorbable) are placed in the intestine to prevent the intestine from falling back into the abdominal cavity (Fig. 10-24). A pursestring suture is placed on the antimesenteric border of the intestine. A number 11 scalpel blade is used to puncture the intestine in the middle of the pursestring suture, the jejunostomy feeding tube (5 French for cats and 8 French for dogs) is introduced into the loop of bowel in the aboral direction, and the pursestring suture is tightened and tied (Fig. 10-25). The intestine is returned to the abdominal cavity except for the segment containing the feeding tube. The 4-0 monofilament absorbable stay sutures are then used to pexy the intestine to the abdominal wall. The abdominal wall is closed with a simple continuous suture pattern. Subcutaneous tissue and skin are closed in a routine fashion. The feeding tube exits through the incision (Fig. 10-26).

Jejunostomy feeding tube placement is the last laparoscopic procedure performed because the pneumoperitoneum is lost during the procedure. If additional laparoscopic procedures are to be performed, the operative portal cannula is repositioned and the pneumoperitoneum reestablished before proceeding.



**Fig. 10-26**
The abdominal fascia, subcutaneous tissue, and skin are closed in a routine fashion. A Chinese finger trap suture is used to secure the jejunostomy tube.

## Gastrostomy Feeding Tube Placement

A gastrostomy feeding tube can be placed using laparoscopy by exteriorizing the small patch of stomach wall in the body area of the stomach through the left abdominal wall and then inserting the tube externally.

A telescope port and one instrument port is all that is required. The cannula port for the grasping forceps is placed 2 cm behind the last rib on the left side and at the level of the junction of the distal and proximal third of the last rib. A 5-mm atraumatic grasping forceps with multiple teeth is used to grasp the body of the stomach at the site selected for placement of the feeding tube. The stomach is pulled close to the cannula. A minimal

amount of tension should be present when the body of the stomach is pulled against the body wall. The abdominal wall incision for the cannula is extended with a scalpel blade as described for intestinal biopsy or feeding tube placement. The stomach is firmly seated against the cannula and the stomach, the grasping forceps, and the cannula are pulled through the abdominal wall simultaneously to exteriorize a small section of the stomach wall.

Four stay sutures are placed in the stomach wall to prevent the stomach from falling back into the abdominal cavity. A pursestring suture is placed in the wall of the stomach. A number 11 blade is used to puncture the stomach in the middle of the pursestring suture, the catheter (16 French for cats and 20 French for dogs) is introduced into the stomach, and the pursestring is tied. Foley catheters, mushroom-tipped feeding tubes, or other gastrostomy tube catheters can be used for this purpose. The four stay sutures are used to pexy the stomach wall to the body wall. The abdominal wall is closed with a simple continuous suture pattern. Subcutaneous tissue and skin are closed in a routine fashion. The feeding tube exits through the incision line.

Gastrostomy feeding tube placement is the last laparoscopic procedure performed because the pneumoperitoneum is lost during the procedure. If additional laparoscopic procedures are to be performed, pneumoperitoneum is reestablished and the operative portal cannula is reintroduced.

## Gastropexy

A preventive gastropexy can be performed using laparoscopy by exteriorizing the pyloric antrum region of the stomach through the right abdominal wall.[18,19] The animal is placed in dorsal recumbency and the telescope portal is placed on the midline at the level of the umbilicus.

A single instrument portal, used to localize and grasp the pyloric antrum, is placed on the right side 2 cm caudal to the last rib and at the junction of distal and proximal third of the last rib (Fig. 10-27). A 5- or 10-mm atraumatic grasping forceps with multiple teeth is used to grasp the pyloric antrum midway between the lesser and the greater curvature. The stomach is pulled close to the cannula. If there is too much tension to bring the pyloric antrum to the body wall, the pyloric antrum is grasped again closer to the body of the stomach. Deflation of the pneumoperitoneum is also helpful to reduce tension on the stomach wall. The incision for the cannula is extended through the abdominal wall (Fig. 10-28). The scalpel blade is observed internally as it enters parallel to the cannula shaft and cuts away from the cannula, increasing the incision to approximately 5 cm in length in a direction parallel to the last rib. Electrocautery can be used to perform the dissection through the abdominal wall. It is important not to touch the cannula with the cautery during the dissection because it can cauterize the stomach wall. The stomach is firmly seated against the cannula and the stomach, and the grasping forceps and cannula are pulled through the abdominal wall simultaneously to exteriorize a section of the stomach wall.



**Fig. 10-27**
Position of the cannulae for gastropexy. The dog is in dorsal recumbency. The cannula on the right is used for the telescope. The instrument cannula is placed 4 cm away from the midline and from the last rib.



**Fig. 10-28**
After localization of the pyloric antrum, the abdominal wall is incised from the instrument cannula toward the midline following a line parallel to the last rib. A 5-cm incision is sufficient.

Two stay sutures are placed in the stomach wall to prevent it from falling back into the abdominal cavity (Fig. 10-29). An incisional gastropexy is performed using a number 15 scalpel blade to incise the serosa and the muscularis layers for a 5-cm length, leaving the submucosa and mucosa intact. Metzenbaum scissors are used to elevate the serosa-muscularis from the submucosa to create a free margin of tissue (Fig. 10-30). A cruciate suture pattern of 3-0 monofilament absorbable suture material is used to suture the serosa-muscularis layer to

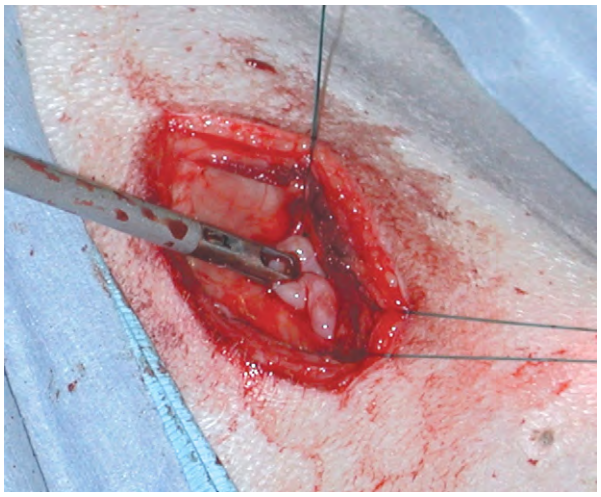


**Fig. 10-29**
A portion of the stomach wall is exteriorized and two stay sutures are placed in the stomach wall.

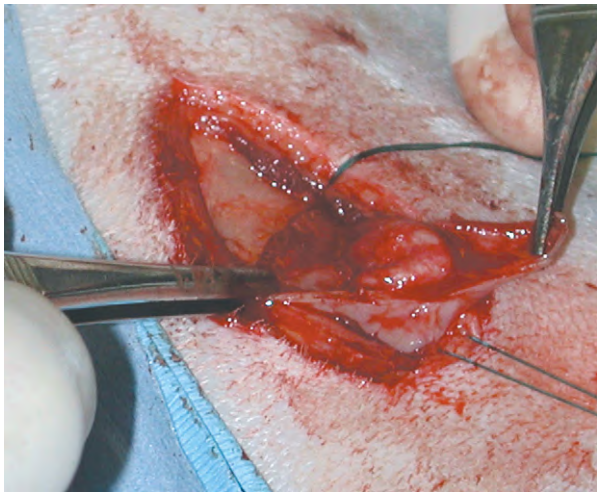


**Fig. 10-30**
An incisional gastropexy is performed after dissection of a seromuscular flap from the stomach wall. The seromuscular margin is sutured to the transverse abdominal muscle with cruciate or simple interrupted sutures of 2-0 monofilament absorbable suture material.

the transverse abdominal muscle. The external and internal oblique muscles are closed over the gastropexy with a continuous suture pattern. Subcutaneous tissue and skin are closed in a routine fashion. The telescope is removed and the portal site closed.

## Ovariohysterectomy

Ovariohysterectomy can be performed using laparoscopy in medium and large size dogs.[20] Limitations of laparoscopic-assisted ovariohysterectomy relate to the size of the patient. The space in the abdominal cavity of small dogs and cats make the procedure technically more difficult. The advantage of this technique is rapid patient recovery following the procedure, decreased tissue trauma, and decreased postoperative pain.

Ovariohysterectomy is most commonly performed in dorsal recumbency. Lateral recumbency requires repositioning the patient for the second ovarian pedicle and moving the equipment to maintain the alignment for the operator viewing the monitor located at the end of the table behind the patient's rear legs. When the dog is placed in dorsal recumbency, both ovarian pedicles and the uterine body can be visualized without moving either the patient or the monitor. The operator moves from one side of the patient to the other to dissect and ligate each ovarian pedicle. With the dog in dorsal recumbency, the table is tilted at approximately 15 degrees with the head of the patient down (Trendelenburg position) to shift the abdominal organs into the cranial abdomen and facilitate visualization of the ovarian pedicles and the uterine body dorsal to the bladder. The patient or table can also be rotated from side to side to assist visualization and manipulation of the ovarian pedicles. Mechanical ventilation is suggested to assist ventilation because of the weight of the organs on the diaphragm and intra-abdominal insufflation pressure.

Following abdominal insufflation, the telescope cannula is introduced cranial to the umbilicus. Instrument ports are then placed at the level of the umbilicus on the edge of the rectus abdominis muscle. The uterus is visible in the caudal abdomen lying over the colon (Fig. 10-31). Intestine and omentum that are covering the ovarian pedicle are moved and one uterine horn is grabbed with fine-toothed graspers and pulled caudally to expose the ovarian pedicle (Fig. 10-32). The graspers are introduced into the cannula on the side of the ovary that is to be ligated. The suspensory ligament is transected with Metzenbaum scissors using electrocautery while cutting. A hole is made in the mesovarium to isolate the ovarian pedicle. The ovarian pedicle can be ligated with a suture or the vessels occluded with vascular clips (Fig. 10-33). Five-millimeter and 10-mm clips and clip applicators make the procedure much easier. For ligation, an absorbable suture is passed through a cannula, around the ovarian pedicle, and then out through the same cannula. With the ends of the suture outside the abdominal cavity, a one-way slipknot (Roeder knot) is tied.[21] The knot is pushed into the abdominal cavity with an instrument called a *knot pusher* and tightened snugly around the pedicle. The suture is cut with endoscopic suture scissors. After placing two ligatures on the ovarian pedicle, it is transected between the ligatures with Metzenbaum scissors. The second ovarian pedicle is dissected and ligated in a similar fashion. The mesovarium is cut with scissors and electrocautery or torn with forceps. Next, a

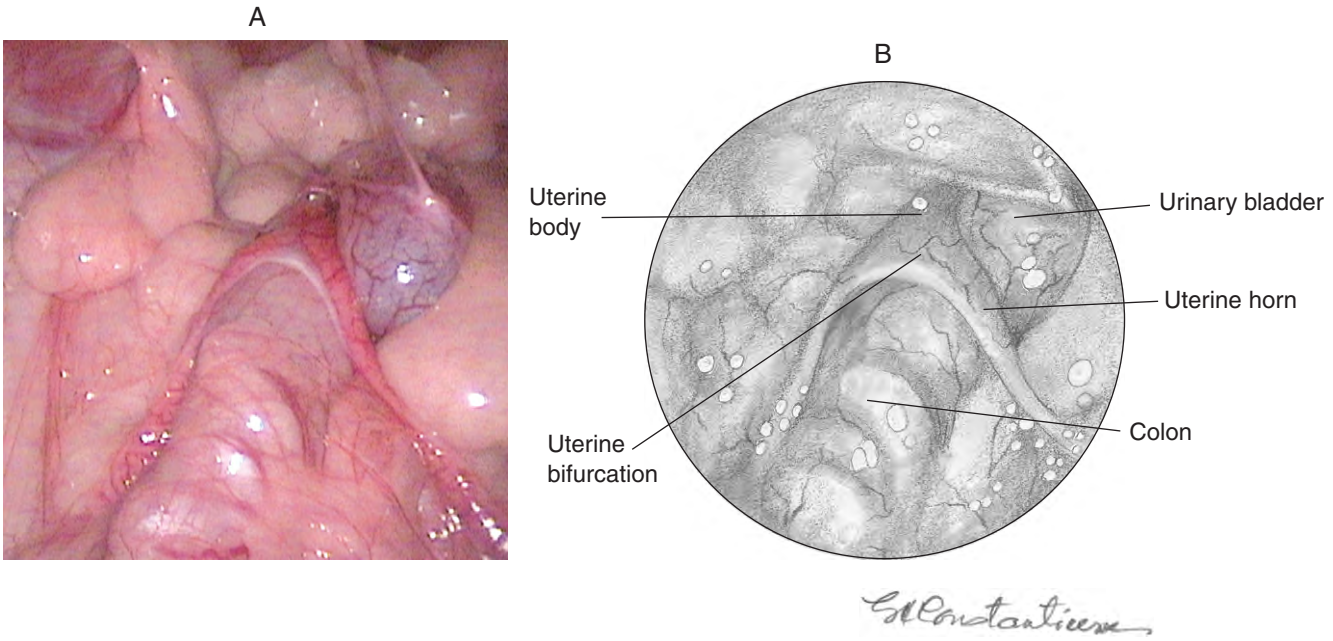



**Fig. 10-31**
The caudal abdomen with the bifurcation of the uterus lying over the colon.

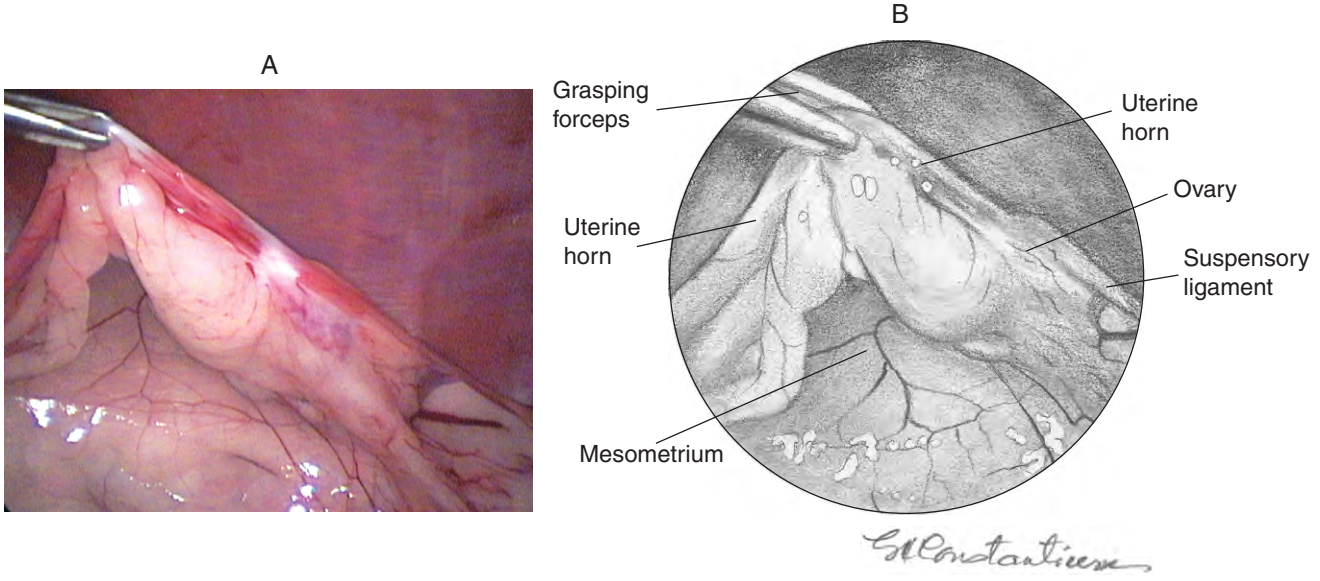



**Fig. 10-32**
The right ovarian pedicle exposed with caudal traction on the uterine horn.

pretied suture loop (Endoloop Suture or Loop Ligature) is placed in the abdominal cavity through one of the cannulae, both ovaries and uterine horns are passed through the loop (Fig. 10-34), and the loop is tightened down at the level of the cervix. Metzenbaum scissors are used to transect the cervix cranial to the suture. Both ovarian pedicles and the cervix are inspected for bleeding. If bleeding is present, the bleeding pedicle or cervix is isolated with graspers and ligated again. The uterus and both ovaries are removed through one of the cannula holes that is enlarged to allow passage of the uterus and ovaries. The enlarged cannula site is closed with suture layers of 2-0 monofilament absorbable suture material in the abdominal fascia, subcutaneous tissue, and skin. The other 5-mm cannula sites require only subcutaneous and skin sutures.

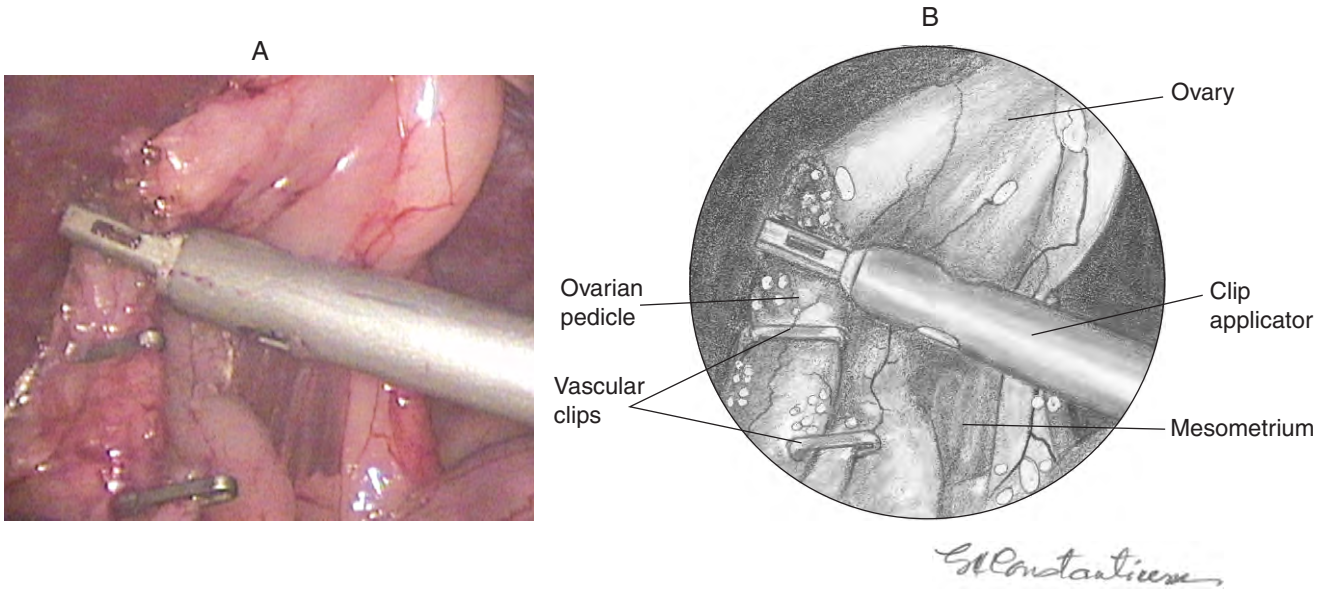



**Fig. 10-33**
Vascular clips being placed on the ovarian pedicle.

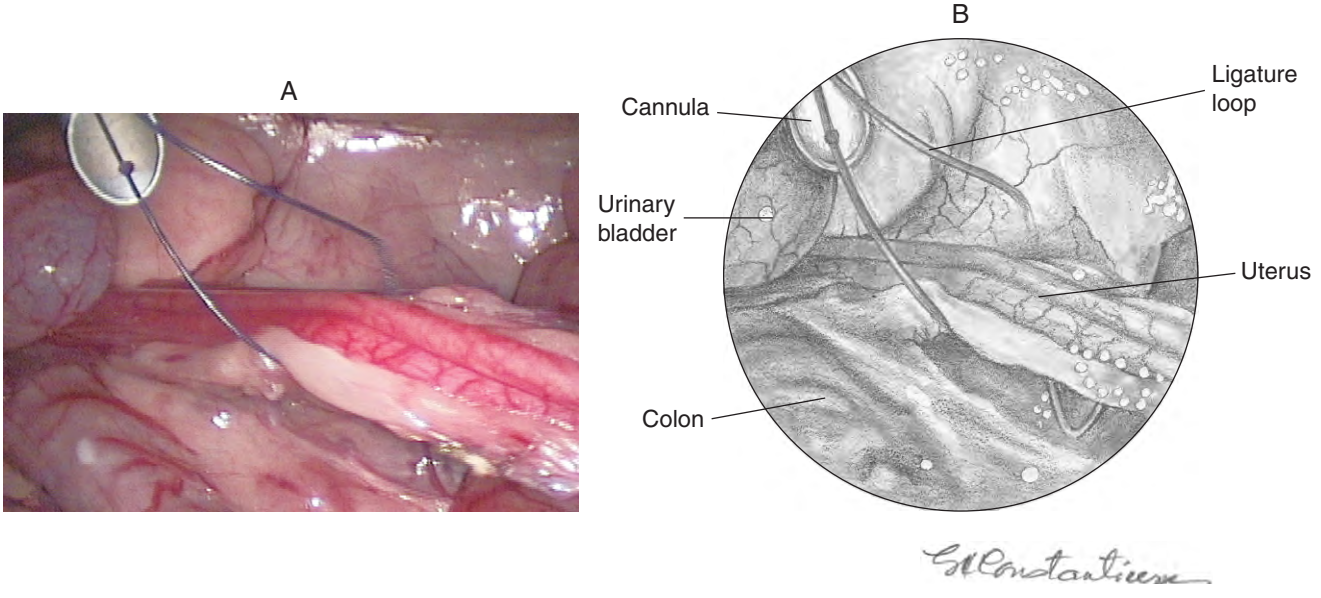



**Fig. 10-34**
Both uterine horns have been placed through an Endoloop.

## Cryptorchid Surgery

Intraabdominal testicles can be removed easily with laparoscopy.[22] Laparoscopic vasectomy can also be performed with this technique.[23] The dog or cat is placed in dorsal recumbency with the table tilted at 15 degrees with the head of the patient down. Gravity displaces the abdominal organs into the cranial abdomen, which facilitates visualization of the internal inguinal canals. The monitor is placed at the caudal end of the table as described for ovariohysterectomy.

The abdominal cavity is insufflated and the telescope cannula is introduced cranial to the umbilicus. Instrument ports are placed at the level of the umbilicus on the edge of the rectus abdominis muscle. Both internal inguinal rings are inspected to determine the presence of vas deferens and testicular arteries. If these structures are present the testicle on that side has escaped from the abdomen, the testicles are in the inguinal area, or the dog has already been castrated. Absence of the vas deferens and testicular artery in the inguinal canal means the

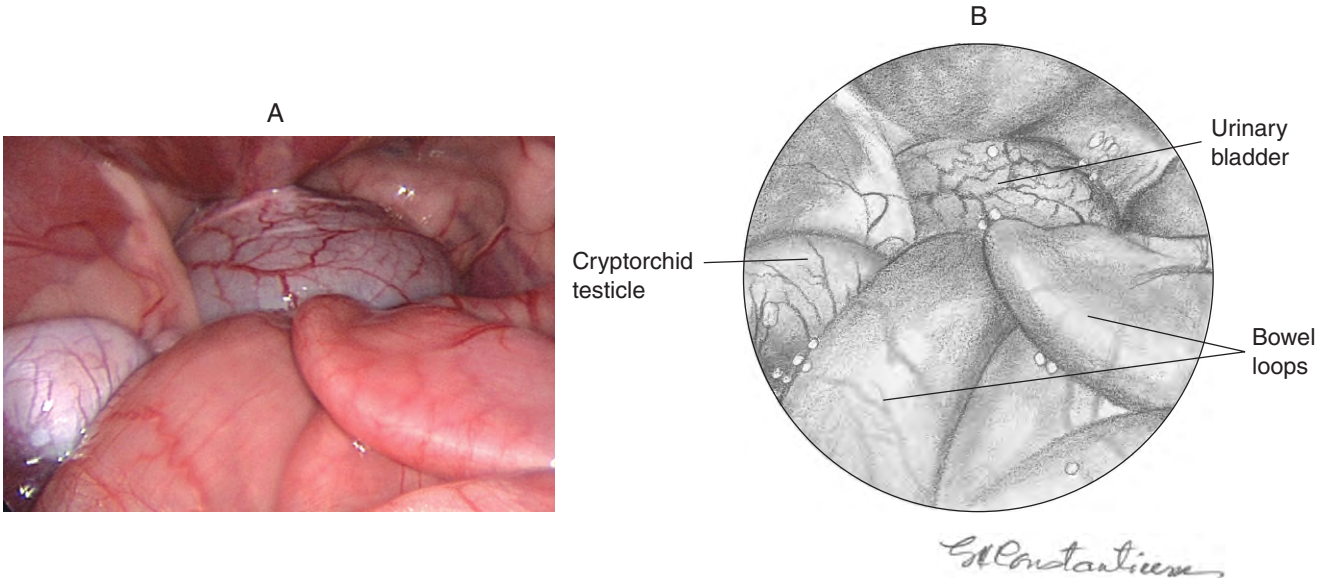



**Fig. 10-35**
Right cryptorchid testicle cranial to the bladder.

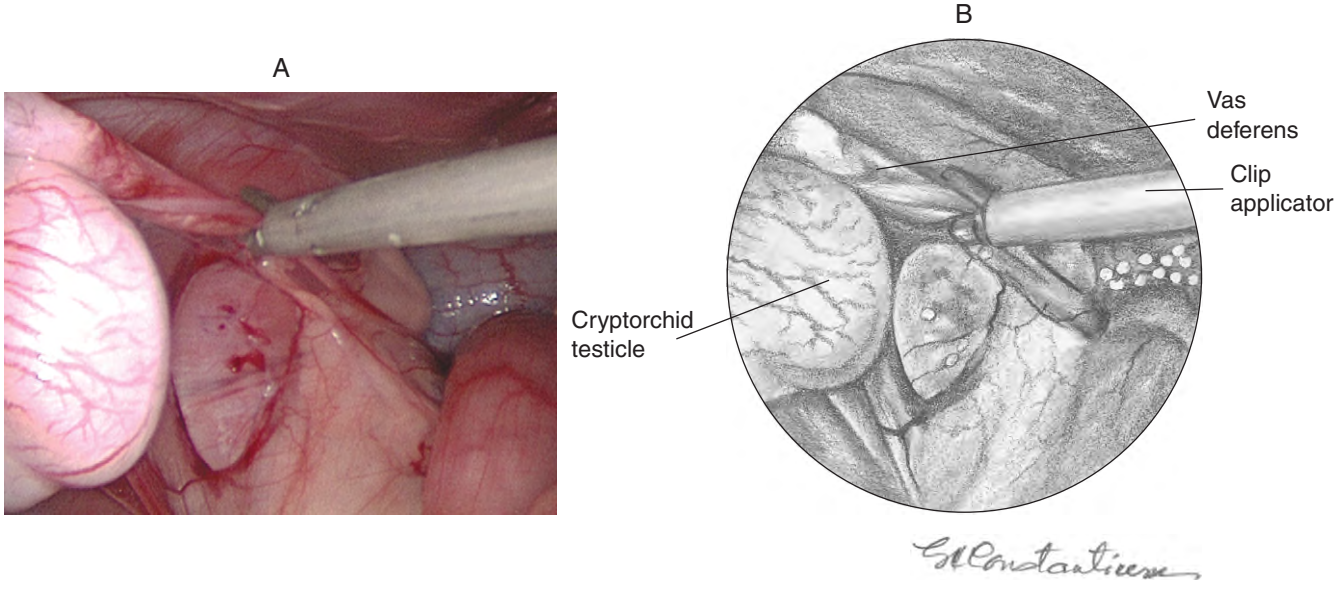



**Fig. 10-36**
The vas deferens is ligated with vascular clips.

testicle is still within the abdomen. The retained testicle may be readily visible on entering the abdominal cavity (Fig. 10-35) or it may be hidden under small bowel loops. The testicle can be found anywhere from the internal ring to the level of the caudal pole of the kidney. The ectopic testicle of one side rarely ever crosses the midline but stays on the affected side. If the retained testicle is readily visible, it is grabbed with fine-toothed graspers. If the testicle is not readily visible, the gubernaculum is followed cranially until the testicle is found. The gubernaculum is divided with Metzenbaum scissors and electrocautery if needed. The vascular pedicle and the vas deferens are ligated with a pretied suture loop or clips (Figs. 10-36 and 10-37). The ectopic testicle is removed through one of the cannula holes, which is enlarged as needed to allow passage of the testicle. The enlarged cannula site is sutured with 2-0 monofilament absorbable suture material in the abdominal fascia, subcutaneous

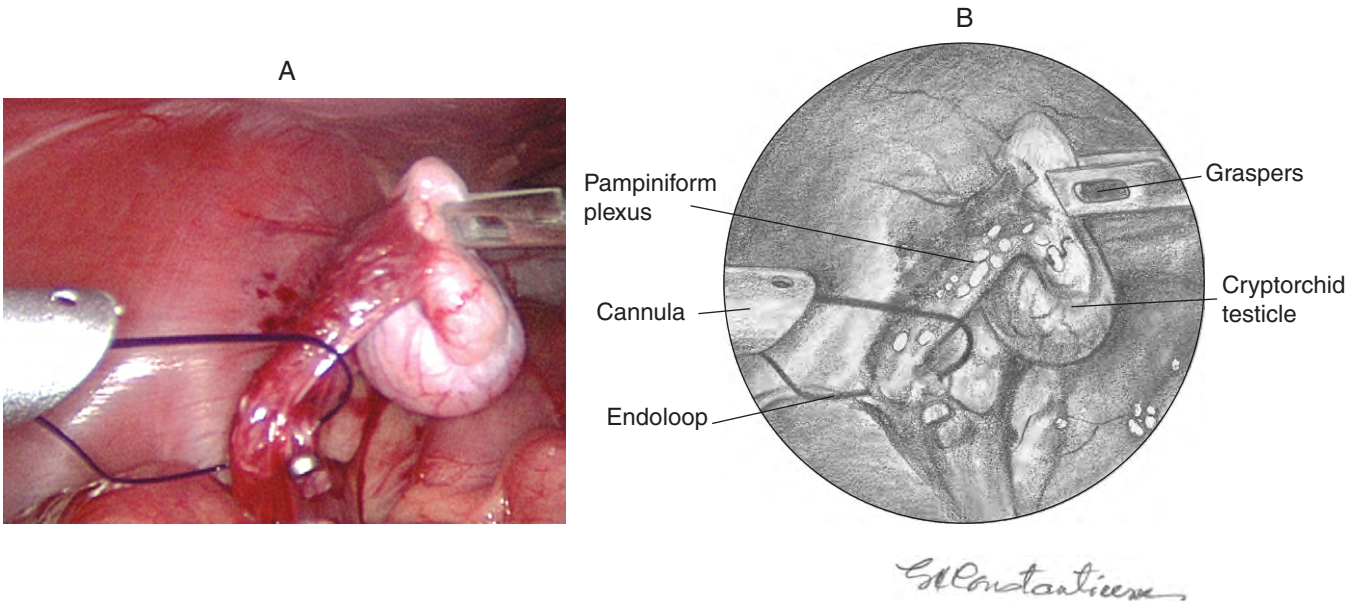



**Fig. 10-37**
The pampiniform plexus is ligated with an Endoloop.

tissue, and skin. The other 5-mm cannula sites require only subcutaneous and skin sutures.

## Laparoscopic Cystoscopy

It is possible to examine the lumen of the urinary bladder and perform operative procedures using laparoscopic technique. The bladder of most female dogs and cats can easily be evaluated using rigid transurethral cystoscopy and precludes the need for laparoscopic evaluation. Male dogs and cats are more difficult to evaluate because of their urethral anatomy. A transabdominal cystoscopy technique is previously described which involves direct placement of small diameter telescopes directly through the abdominal wall and into the lumen of the urinary bladder.

Laparoscopic cystoscopy is an alternate method that allows placement of a laparoscopic telescope into the urinary bladder that has been exteriorized through the abdominal wall. The bladder and proximal urethra can be examined and biopsy and calculi removal performed. This technique involves standard laparoscopic entry with the telescope placement on the abdominal midline at the umbilicus. The urinary bladder is visualized and a second cannula is placed directly over the urinary bladder at the location for exteriorization. Using atraumatic forceps with multiple teeth, the bladder is grasped and pulled into the trocar cannula as described for intestinal biopsy. Either a 5-mm cannula or a 10-mm cannula with a reducer to accommodate 5-mm instruments can be used for this technique. The secondary cannula incision is extended to allow presentation of the bladder. The apex of the bladder is exteriorized and stay sutures are placed from the bladder wall to the skin. A small incision is made in the bladder wall, the bladder is flushed with sterile saline, and the telescope is removed from the abdominal cannula and introduced directly into the bladder. Examination of the bladder mucosa and proximal urethra is performed. Forceps can be placed into the lumen along with the telescope to obtain biopsy specimens or to remove calculi or tumors. At the conclusion of the procedure, the bladder is closed in a standard manner and placed back into the abdomen. The cannula ports are then closed. This technique is similar to a previously described cystopexy technique.[24]

## Gastric Foreign Body Removal

Gastric foreign bodies that cannot be removed with gastroscopy can be accessed for removal with minimally invasive laparoscopic technique.

The dog or cat is placed in dorsal recumbency and the telescope portal is placed on the midline at the level of the umbilicus. A single 5- or 10-mm instrument portal is placed on the right side 2 cm behind the last rib at the junction of the middle and distal thirds of the last rib. A 5- or 10-mm atraumatic grasping forceps with multiple teeth is used to grasp the ventral gastric wall midway between the lesser and the greater curvature. The stomach is pulled up to but not contacting the cannula, the portal is extended as previously described for the gastropexy technique, the pneumoperitoneum is deflated,

and the stomach is pulled through the abdominal wall to exteriorize a section of the stomach wall. Stay sutures are placed from the stomach wall to the skin to prevent the stomach from falling back into the abdominal cavity. A gastrotomy incision is performed of sufficient size for removal of the foreign material. Gastric contents are aspirated and gastric lavage is performed as indicated. The telescope is removed from the abdominal wall cannula and is introduced directly into the stomach for examination. Forceps are placed into the stomach adjacent to the telescope for removal of the foreign material. Large forceps for open surgery, such as Vulsellum forceps, can be used. When all foreign material has been removed, the stomach is closed in a standard manner and placed back into the abdomen. The enlarged portal is closed with a simple continuous suture pattern with 2-0 monofilament absorbable suture material. Subcutaneous tissue and skin are closed in a routine fashion. The 5-mm telescope cannula site requires only subcutaneous and skin closure.

### Other Potential Surgical Procedures

Adrenalectomy, removal of ovarian remnants (Fig. 10-38), correction of hiatal hernias, and nephrectomy are other surgical procedures possible to perform using laparoscopy. Laparoscopic removal of pancreatic neoplasia is possible (Fig. 10-39). Small animal surgical laparoscopy is limited only by one's imagination and available instrumentation to accomplish the procedure. For example, we have used laparoscopic-assisted cryoablation of adrenal hyperplasia in several dogs with Cushing's disease.[25]

## COMPLICATIONS OF LAPAROSCOPY

The complication rate of laparoscopy is low. In a review of more than 360 consecutive cases involving diagnostic laparoscopy, we found less than a 2% complication rate. Potential complications are listed in Box 10-3. Serious complications include anesthetic or cardiovascular related death, bleeding, or air embolism.[26]

Complications resulting from either Veress needle placement or trocar insertion include injury to vessels in the abdominal wall, penetration of organs, or perforation of a hollow viscus. Careful attention to technique minimizes these concerns. Surgical placement of a Hasson cannula would lessen this potential complication.

Complications also may occur during the insufflation process. If the Veress needle is not through the abdominal wall, subcutaneous emphysema or peritoneal tenting is produced. If the needle is placed under the omentum during insufflation, omental insufflation occurs. With inappropriate insufflation, one is unable to visualize the abdominal cavity adequately, making the procedure much more difficult than necessary. Serious complications associated with insufflation include gas embolism and pneumothorax. Gas embolism was reported during insufflation in a dog when the Veress needle was inserted in the spleen.[9] When large amounts of gas travel to the

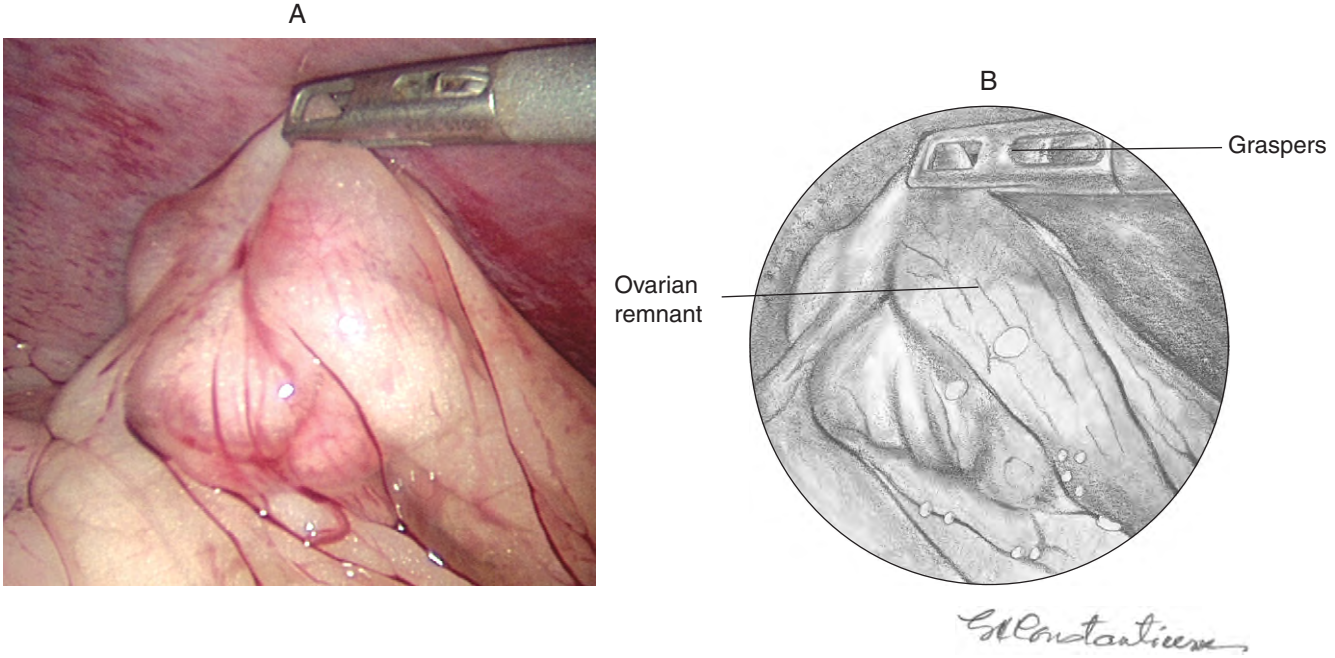



**Fig. 10-38**
An ovarian remnant caudal to the right kidney.

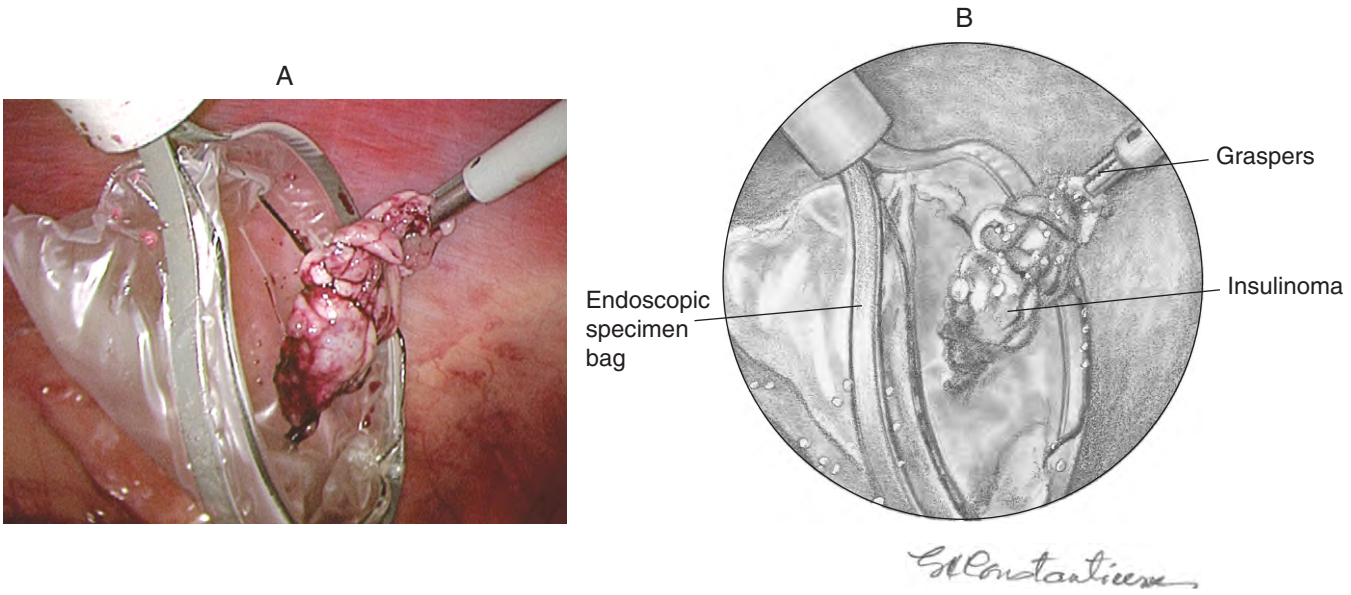



**Fig. 10-39**
A pancreatic insulinoma that has been removed from the right limb of the pancreas and is being placed into a specimen bag for extraction from the abdomen. *(Courtesy Dr. Timothy McCarthy.)*

right ventricle, it causes an outflow obstruction resulting in cardiovascular collapse. If this happens, the animal should be placed in left lateral recumbency with the head down to help the gas travel to the lungs.[26] A pneumothorax can occur from accidental penetration of the diaphragm, overinsufflation, or through a diaphragmatic hernia.

**Box 10-3 Potential Laparoscopic Complications**

**Anesthesia Related**

**Veress Needle/Trocar Insertion**
- Injury to abdominal wall vasculature
- Penetration of organs
- Perforation of hollow viscus

**Insufflation**
- Subcutaneous emphysema
- Peritoneal tenting
- Inappropriate insufflation
- Pneumothorax
- Gas embolism

**Operative Complications**
- Bleeding
- Tissue injury

**Technical Problems**
- Lack of experience
- Equipment-related problems

Minor complications are generally operative and result from the operator's lack of technical skills, being unfamiliar with the technique, having inadequate knowledge of the limitations and potential complications of a procedure, or having insufficient equipment.

Complications are thought to be similar to those occurring with open surgical procedures. Cardiovascular and respiratory complications can result from abdominal insufflation and from Trendelenburg positioning of the patient such as during ovariohysterectomy, in which the abdominal organs compressing the diaphragm limit its excursions. Use of a ventilator is recommended during prolonged procedures and those that require tilting the patient in the head-down position to prevent these complications.

## CONCLUSION

Laparoscopy is a minimally invasive technique for diagnostic and surgical procedures. Once the basic technique of laparoscopy is mastered and the appropriate indications are applied to the procedure, it becomes a simple and rewarding addition to small animal veterinary medicine and surgery. As our ability advances, newer diagnostic and therapeutic procedures will be developed.

## REFERENCES

1. Johnson GF, Twedt DC: Endoscopy and laparoscopy in the diagnosis and management of neoplasia in small animals, *Vet Clin North Am* 7:77-92, 1977.

2. Wildt DE: Laparoscopy in the dog and cat. In Harrison RM, Wildt DE, editors: *Animal laparoscopy,* Baltimore, 1980, Williams & Wilkins.
3. Rothuizen J: Laparoscopy in small animal medicine, *Vet Q* 3:225-228, 1985.
4. Bessler M and others: Is immune function better preserved after laparoscopic versus open colon resection? *Surg Endosc* 8:881-883, 1994.
5. Richter KP: Laparoscopy in dogs and cats, *Vet Clin North Am Small Anim Pract* 4:707-727, 2001.
6. Magne ML, Tams TR: Laparoscopy: instrumentation and technique. In Tams TR, editor: *Small animal endoscopy*, ed 2, St Louis, 1999, Mosby.
7. Bufalari A and others: Evaluation of selected cardiopulmonary and cerebral responses during medetomidine, propofol, and halothane anesthesia for laparoscopy in dogs, *Am J Vet Res* 12:1443-1450, 1997.
8. Duke T and others: Cardiopulmonary effects of using carbon dioxide for laparoscopic surgery in dogs, *Vet Surg* 1:77-82, 1996.
9. Gilroy BA, Anson LW: Fatal air embolism during anesthesia for laparoscopy in a dog, *J Am Vet Med Assoc* 5: 552-554, 1987.
10. Kolata RJ, Freeman LJ: Access, portal placement and basic endosurgical skills. In Freeman LJ, editor: *Veterinary endosurgery,* St Louis, 1999, Mosby.
11. Twedt DC, Johnson GF: Laparoscopy in the evaluation of liver disease in small animals, *Am J Dig Dis* 22:571-580, 1977.
12. Cole TC and others: Diagnostic comparison of needle and wedge biopsy specimens of the liver in dogs and cats, *J Am Anim Hosp Assoc* 220(10):1483-1490, 2002.
13. Twedt DC: Laparoscopy of the liver and pancreas. In Tams TR, editor: *Small animal endoscopy*, ed 2, St Louis, 1999, Mosby.
14. Harmoinen J and others: Evaluation of pancreatic forceps biopsy by laparoscopy in healthy Beagles, *Vet Ther* 3(1): 31-36, 2002.
15. Grauer GF, Twedt DC, Morrow KN: Evaluation of laparoscopy for obtaining renal biopsy specimens from dogs and cats, *J Am Vet Med Assoc* 183:677-679, 1983.
16. Grauer G: Laparoscopy of the urinary tract. In Tams TR, editor: *Small animal endoscopy,* ed 2, St Louis, 1999, Mosby.
17. Rawlings CA and others: Laparoscopic-assisted enterostomy tube placement and full-thickness biopsy of the jejunum with serosal patching in dogs, *Am J Vet Res* 63(9):1313-1319, 2002.
18. Rawlings CA: Laparoscopic-assisted gastropexy, *J Am Anim Hosp Assoc* 38(1):15-19, 2002.
19. Rawlings CA and others: A rapid and strong laparoscopic-assisted gastropexy in dogs, *Am J Vet Res* 6:871-875, 2001.
20. Minami S and others: Successful laparoscopy assisted ovariohysterectomy in two dogs with pyometra, *J Vet Med Sci* 9:845-847, 1997.
21. Stoloff DR: Laparoscopic suturing and knot tying techniques. In Freeman LJ, editor: *Veterinary endosurgery,* St Louis, 1999, Mosby.
22. Pena FJ and others: Laparoscopic surgery in a clinical case of seminoma in a cryptorchid dog, *Vet Rec* 142(24): 671-672, 1998.
23. Silva LD and others: Laparoscopic vasectomy in the male dog, *J Reprod Fertil Suppl* 47:399-401, 1993.
24. Rawlings CA and others: Laparoscopic-assisted cystopexy in dogs, *Am J Vet Res* 63(9):1226-1231, 2002.
25. Schulsinger DA and others: Acute and chronic interstitial cryotherapy of the adrenal gland as a treatment modality, *J Endourol* 4:299-303, 1999.
26. Freeman LJ: Complications. In Freeman LJ, editor: *Veterinary endosurgery,* St Louis, 1999, Mosby.

# 11 Video-Otoscopy

Rod A.W. Rosychuk

Diseases of the ear are some of the most commonly encountered problems in small animal veterinary medicine. They frequently pose both diagnostic and therapeutic challenges. Video-otoscopy has revolutionized the practice of otology in veterinary medicine. For the operator, it has provided the ability to better visualize changes within the ear canal, in the area of the tympanic membrane, and especially within the middle ear. It has allowed students of veterinary medicine to better appreciate both normal anatomy and pathologic changes. Through this technology, pet owners are able to visualize their dog or cat's ear disease in the examination room. Direct visualization by the client has improved compliance with prescribed therapies and, on reexamination, offers positive reinforcement for therapeutic efforts.

Video-otoscopy provides for direct observation of various operative procedures that can be performed through the endoscope. These include ear cleaning, biopsies, intralesional injections, foreign body removal, and myringotomy. Video monitor images can also be captured as conventional photographic prints, digital photographs, or as video movies. These may be given to the client as documentation of the disease process and procedures performed. They may also be added to the patient's medical record. Their value for teaching purposes is immense.

## ANATOMY OF THE EAR

The horizontal and vertical ear canals are surrounded by cartilage (Fig. 11-1). On the lateral edge of the entrance to the vertical ear canal there is a notch called the *intertragic notch* that is the starting point for placement of the tip of the video-otoscope into the vertical ear canal (Fig. 11-2). A prominent cartilaginous ridge separates the vertical from the horizontal ear canal in the dog (Fig. 11-3). Its prominence varies between breeds and between individuals within breeds. It creates the corner around which the otoscope must pass to allow access into the horizontal canal. Contact with this sensitive prominence may result in a painful response on the part of the patient and may reduce the possibility of performing a successful otoscopic examination. Pulling the pinna up and out, away from the base of the skull can minimize the prominence of this ridge. In the Shar Pei, the angle between the vertical and horizontal canals may be more acute than in other breeds, forcing the otoscopist to direct the otoscope more vertically and somewhat backward in order to pass beyond this cartilaginous ridge and gain access to the horizontal canal.

Immediately adjacent to the tympanic membrane, the horizontal ear canal is supported by bone. In this relatively short area, the horizontal canal may narrow slightly in the dog.

The ear canals contain cerumen, which consists of desquamated corneocytes, ceruminous (apocrine) secretions, and sebaceous secretions. It is a mixture of proteins, lipids, amino acids, and mineral ions. Waxy debris is usually not found along the walls in normal dogs and cats. However, in dogs, it is common to see a small amount of wax on the floor of the horizontal canal, adjacent to the tympanic membrane. This is likely caused by the acute angle created by the floor of the horizontal canal and the tympanic membrane, which has an angle of 30% to 45% from top to bottom. Debris is thought to be moved out of the ear through the process of epithelial migration. Epithelial cells are noted to grow outward through the ear canal, originating in the area of the tympanic membrane, especially the pars flaccida and manubrium of the malleus.[1]

The ear canals are lined by skin containing hair follicles, sebaceous glands in the superficial dermis, and fewer small modified apocrine (ceruminous) glands in the deeper dermis. Whereas all dog breeds have hair follicles throughout the external ear canal, the density of follicles and the sizes of hairs differ significantly between breeds and individual dogs. Relatively dense growth may be seen throughout the canals in breeds such as the Poodle. Hairs may be seen growing adjacent to the tympanic membrane in some breeds such as the Labrador Retriever, when they are not visible in the rest of the ear canal (Fig. 11-4).

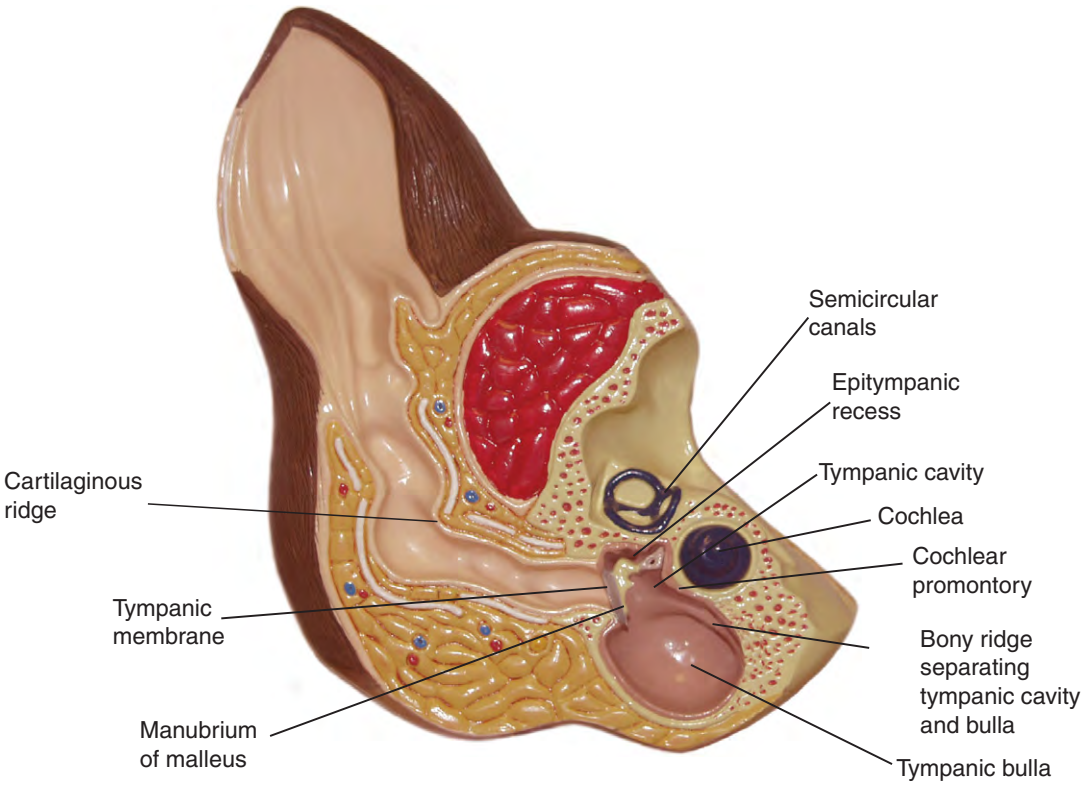



**Fig. 11-1**
Normal canine ear model.



**Fig. 11-2**
The video-otoscope in the intertragic notch. This is the starting point landmark for video-otoscopic examination.

In the cat, hair follicles are sparse or absent in the external ear canal.[2]

Sebaceous gland density decreases from the vertical canal to the tympanic membrane, whereas ceruminous glands increase.[3] The number of glands varies greatly from dog to dog.[3] Increases in apocrine gland area are noted in breeds of dogs predisposed to otitis externa such as the Cocker Spaniel and Labrador Retriever.[4] The number of sebaceous glands is increased in closer proximity to the tympanic membrane.[5]

In the dog, chronic inflammation often results in the ceruminous glands becoming widely dilated.[3] This contributes to dermal thickening and narrowing of the ear canal lumen. These dilated glands may appear as small bumps on the surface of the canals or may become confluent to give the canal a rough texture (Fig. 11-5). When ceruminous glands become cystic or undergo neoplastic transformation (ceruminous adenoma or adenocarcinoma), they often appear bluish in color (Fig. 11-6).

The horizontal canal of some breeds (e.g., English Bulldog, Pug) and some individuals in certain breeds (e.g., Chow Chow) may be narrower than expected. The horizontal ear canal in some breeds (e.g., Basset Hound) may be very long.

The tympanic membrane of the dog is made up of the pars flaccida and the pars tensa (Fig. 11-7). The pars flaccida is a small area of the dorsal to anterodorsal portion of the tympanic membrane, which is relatively flaccid and quite vascular. This structure is often noted to bulge out into the ear canal and appear like a cyst (see Fig. 11-7). This may be a product of increased air pressure within the middle ear. The outpouching of the pars flaccida is

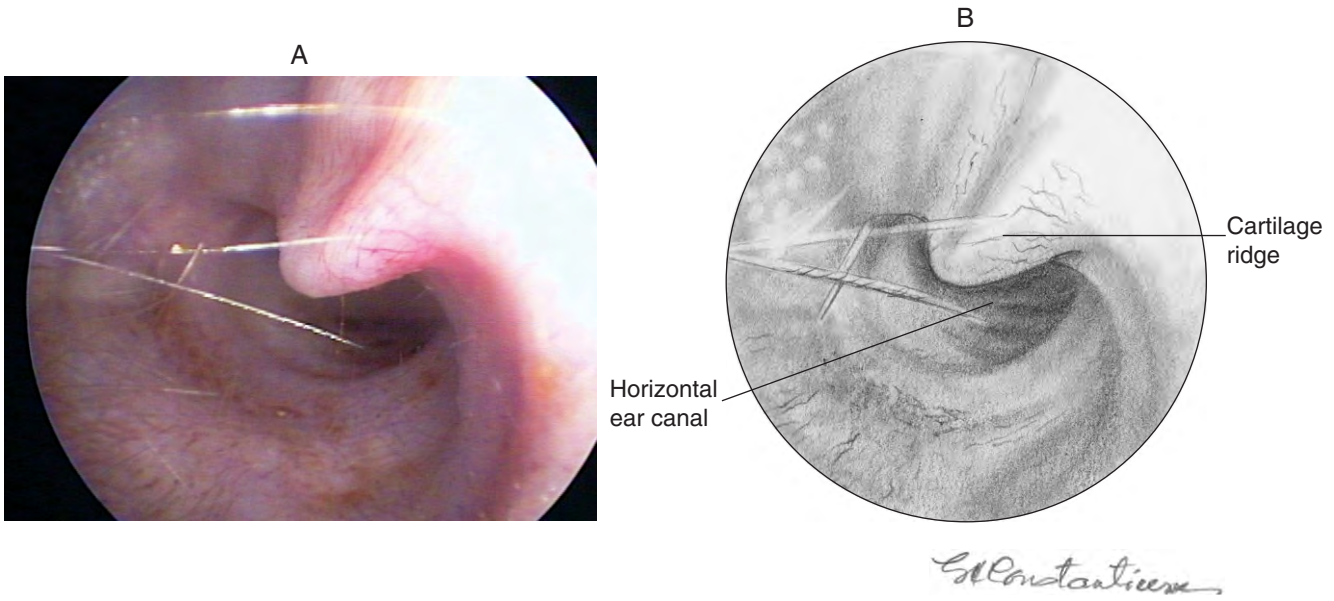



**Fig. 11-3**
Cartilage ridge at the entrance to the horizontal ear canal. This prominence can be minimized by pulling the pinna up and out, away from the base of the skull.

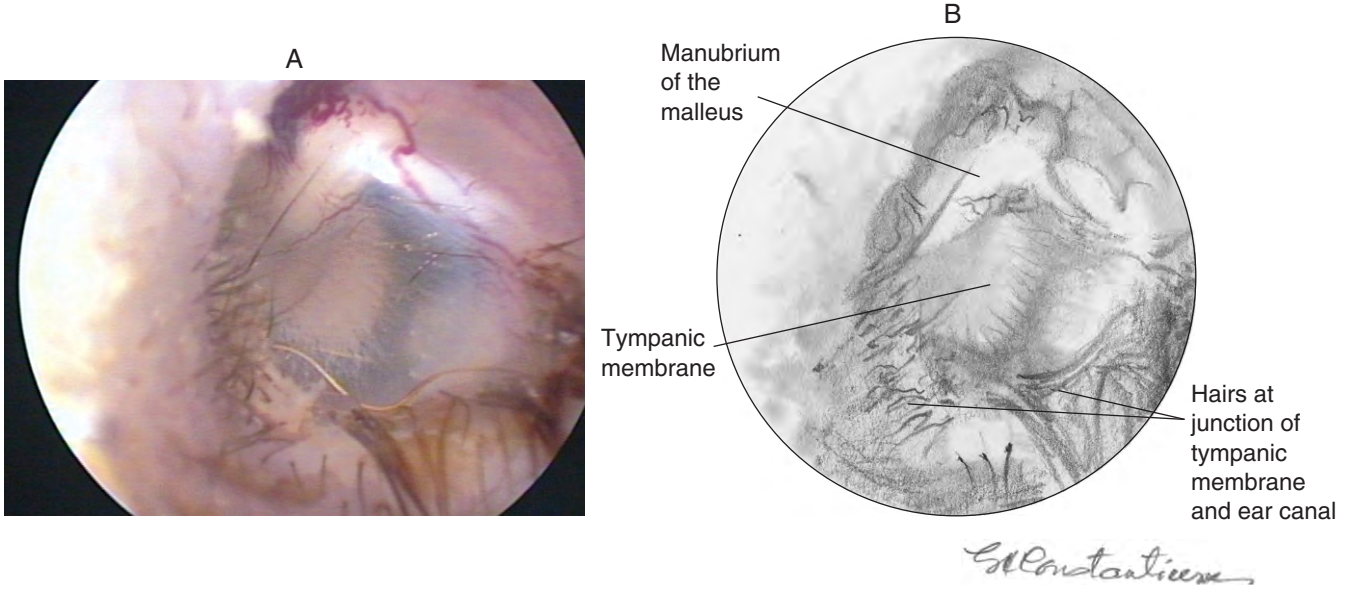



**Fig. 11-4**
Hairs growing at the junction of the tympanic membrane and horizontal ear canal in a normal Labrador Retriever.

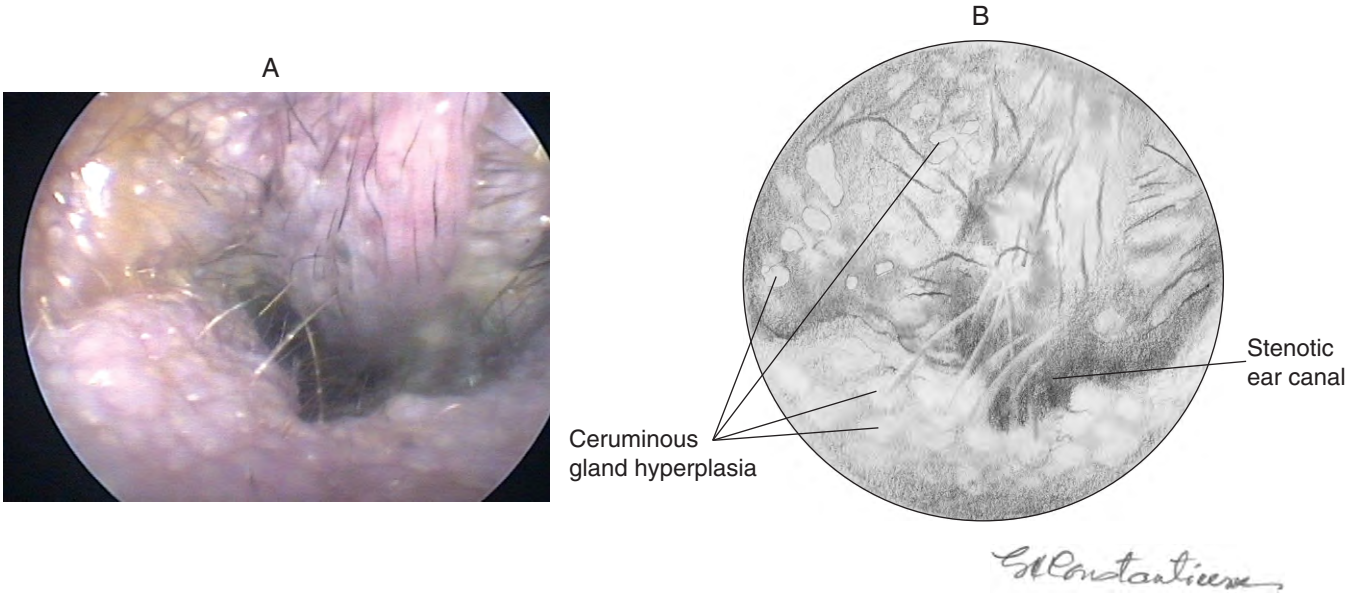



**Fig. 11-5**
Ceruminous (apocrine) gland hyperplasia and ectasia in a dog with chronic otitis externa.

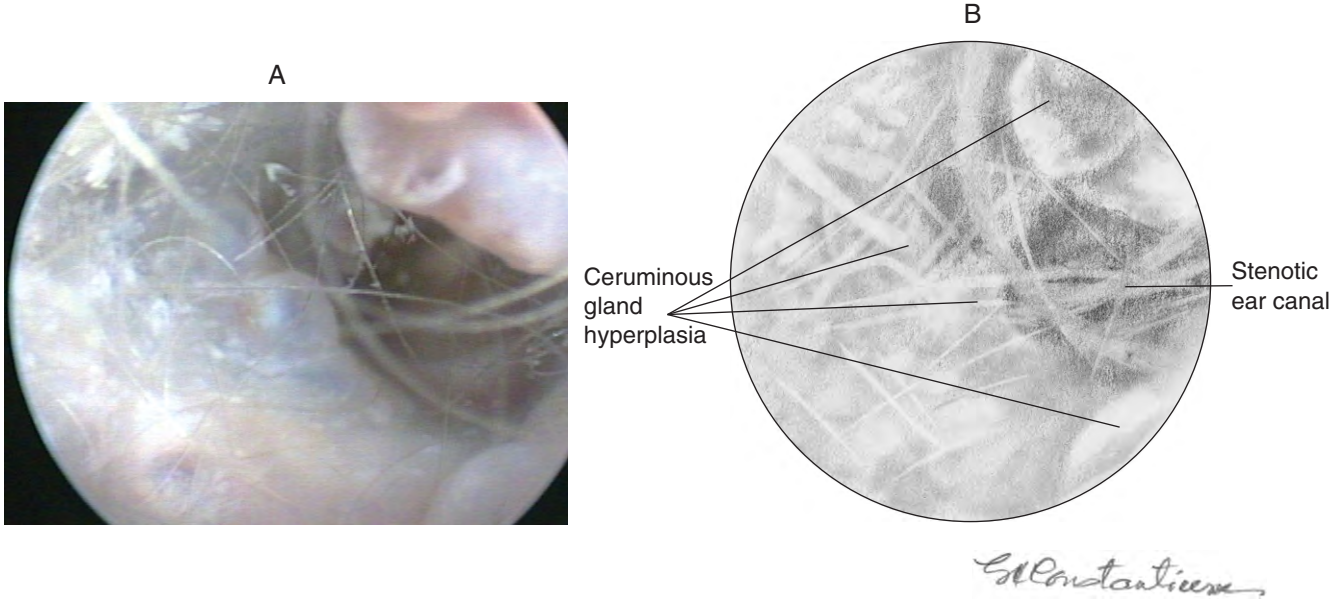



**Fig. 11-6**
Ceruminous gland hyperplasia with accumulation of characteristic bluish colored secretions in a dog with chronic otitis externa.

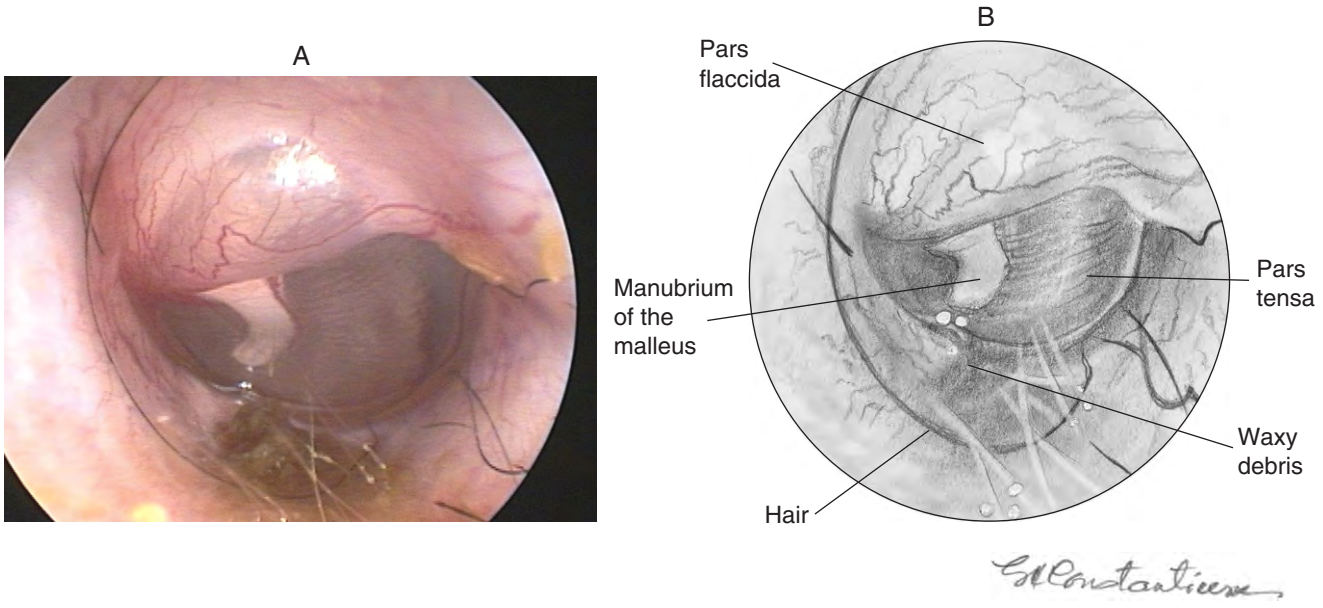



**Fig. 11-7**
Normal canine tympanic membrane with a dilated pars flaccida.

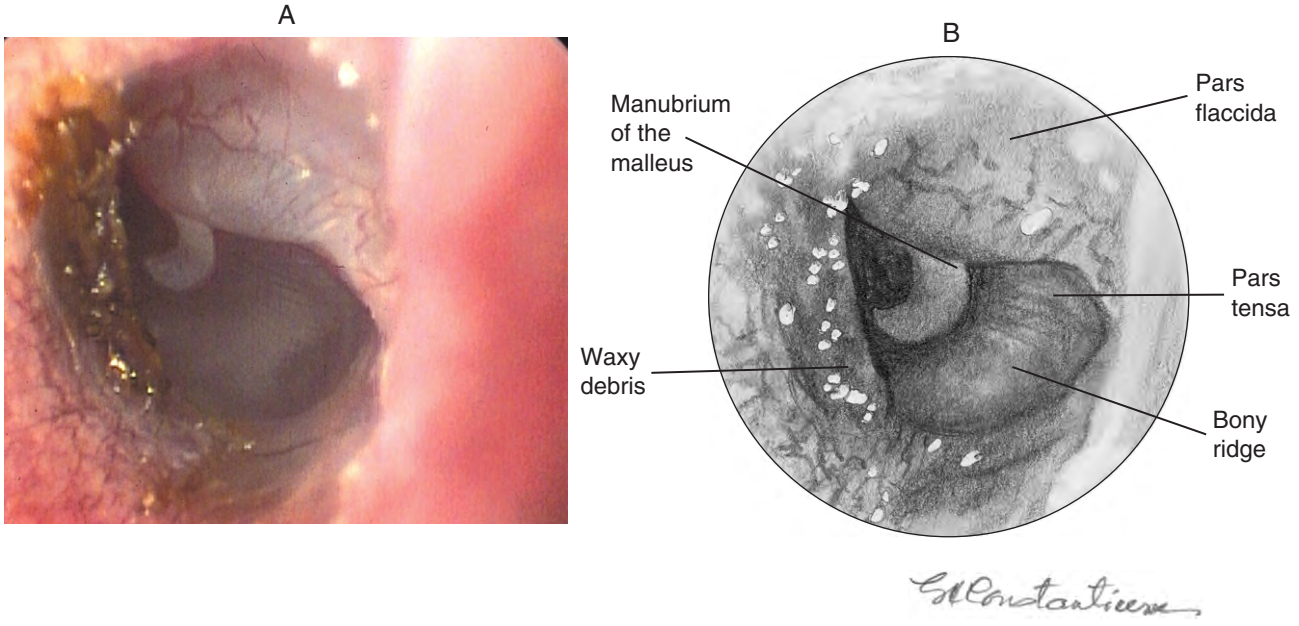



**Fig. 11-8**
Bony ridge separating the tympanic cavity from the tympanic bulla seen faintly through an intact pars tensa of the tympanic membrane.

commonly seen in dogs who are shaking their heads due to allergic otitis and can also be seen when the middle ear is fluid filled. If perforated, this structure tends to heal quickly. Most of what is seen of the tympanic membrane when it is examined through the otoscope is the large pars tensa (see Fig. 11-7). A normal pars tensa is translucent, with striations seen extending from the manubrium of the malleus outward to the periphery. A whitish appearing discoloration can sometimes be seen through the lower to mid section of the tympanic membrane (Fig. 11-8); this whitish structure is the bony ridge that separates the tympanic cavity from the tympanic bulla (Figs. 11-1, 11-9, and 11-10). The pars tensa is under considerable tension and, once perforated, takes longer to heal than the pars flaccida. Following complete destruction of the pars tensa in normal dogs, complete regrowth is noted within 21 to 35 days.[6]

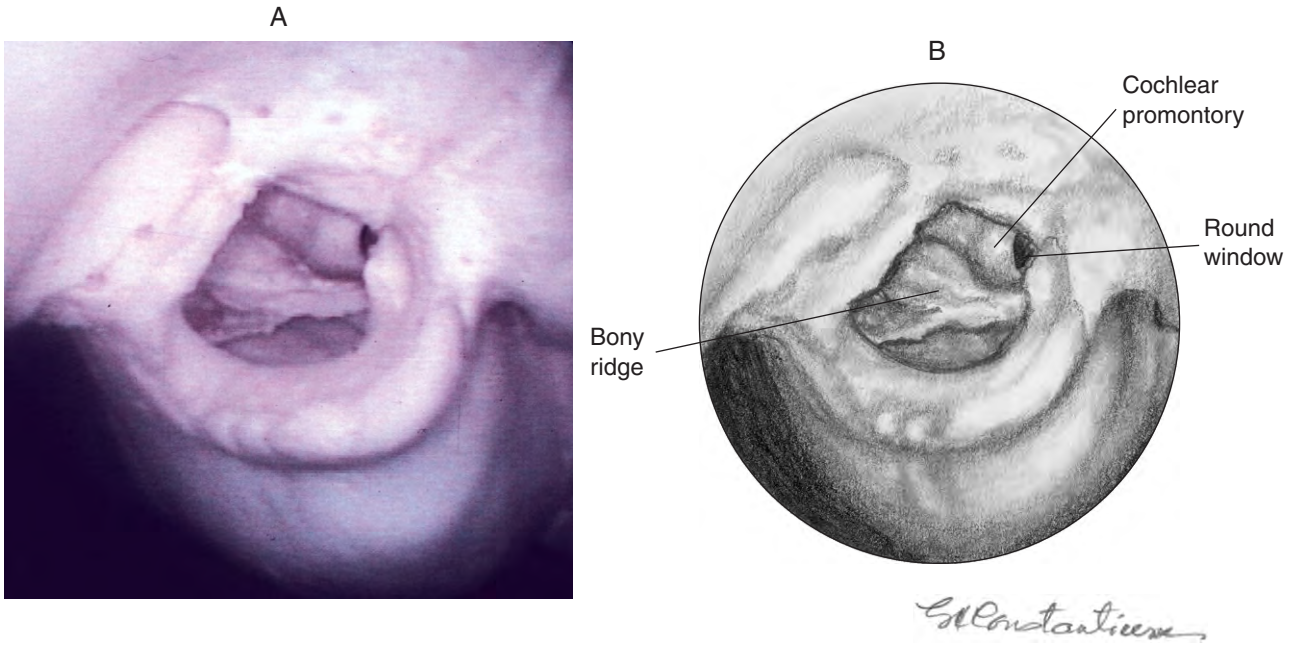



**Fig. 11-9**
Bony ridge separating the tympanic cavity and the tympanic bulla in a skull preparation.

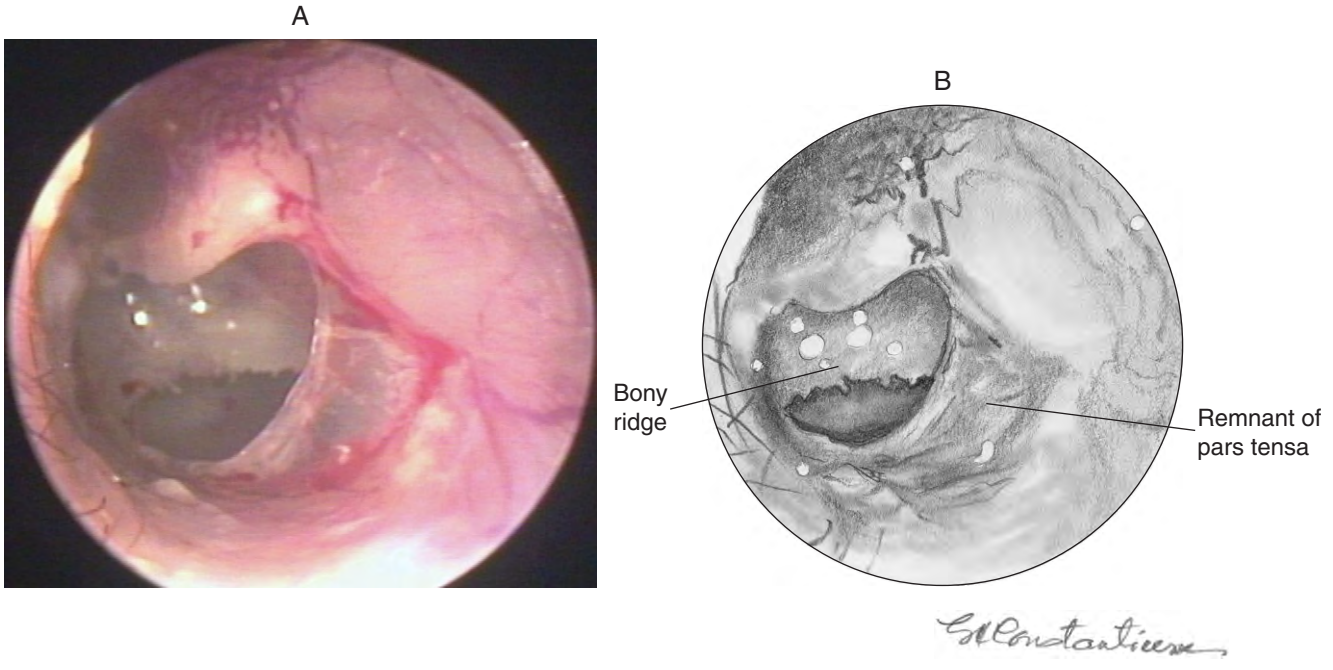



**Fig. 11-10**
The bony ridge separating the tympanic cavity and the tympanic bulla seen through a myringotomy in a cadaver skull.

The periphery of the tympanic membrane attaches to the annulus, which is a fibrocartilaginous ring that attaches to the surrounding bone.

The manubrium, or handle, of the malleus is situated within the fibrous layer of the tympanic membrane (see Fig. 11-7). The manubrium is C-shaped, with the open end of the "C" pointing rostrally, and is located in the anteromedial aspect of the tympanic membrane. It is not visible on all otoscopic examinations. In the dog, it may also be covered by a dilated pars flaccida. Tension on the manubrium gives the tympanic membrane a mildly concave outer contour. The tympanic membrane is oriented

at about a 30- to 45-degree angle from perpendicular going from dorsolateral to ventromedial (see Fig. 11-7). This creates a groove on the ventral floor of the horizontal ear canal, adjacent to the tympanic membrane, where small amounts of wax accumulate in normal dogs.

The tympanic membrane of the cat also consists of a pars tensa and pars flaccida, but the pars flaccida does not dilate like it does in the dog. The manubrium of the malleus, although C-shaped as in the dog, is much straighter than in the dog (Fig. 11-11).

The middle ear, starting from dorsal to ventral is made up of the epitympanic recess, the tympanic cavity, and the tympanic bulla. The epitympanic recess houses the three small middle ear ossicles (malleus, incus, and stapes). The stapes attaches to the oval (vestibular) window leading to the inner ear. This is dorsal and rostral to the cochlear promontory. The tympanic cavity is the area just inside the tympanic membrane. The dorsomedial surface of this cavity is primarily made up of the barrel shaped, cochlear promontory (see Figs. 11-1 and 11-9). The cochlea (responsible for hearing) sits within this structure. The promontory is situated opposite to about the mid dorsal aspect of the tympanic membrane. At the caudal end of the promontory is the cochlear (round) window, which communicates with the bony labyrinth of the cochlea (see Fig. 11-9). It is conceivable that this structure could be damaged by passing a needle or catheter in a caudodorsal direction through the very top of the tympanic membrane (i.e., incorrectly performed myringotomy). The opening of the auditory tube (eustachian tube) lies in the rostromedial part of the tympanic cavity and opens into the nasopharynx, serving to equalize pressure on either side of the tympanic membrane. The tympanic bulla is the largest of the three cavities of the middle ear. It is separated dorsally from the tympanic cavity by a partial septum (bony ridge), which is most prominent over the medial and anterior aspects of the bulla (see Figs. 11-9 and 11-10). This ridge varies in width among dogs. It can often be seen through the tympanic membrane as an area of whitish discoloration (see Fig. 11-8). The darker area caudoventral to this is the opening to the bulla. The ridge is often wide enough to prevent passage of a catheter into the bulla proper. In the cat, the septum is almost complete, with communication between the tympanic cavity and the bulla being through only a small opening.

The middle ear and auditory canal are covered by a mucous membrane type of respiratory epithelium, which is a pseudostratified, ciliated, columnar epithelium containing goblet cells. Obstruction of the auditory canal results in accumulation of mucoid secretions within the middle ear. The middle ear also has a normal bacterial flora that includes *Escherichia coli*, staphylococci, *Branhamella* spp, and yeast.[7]

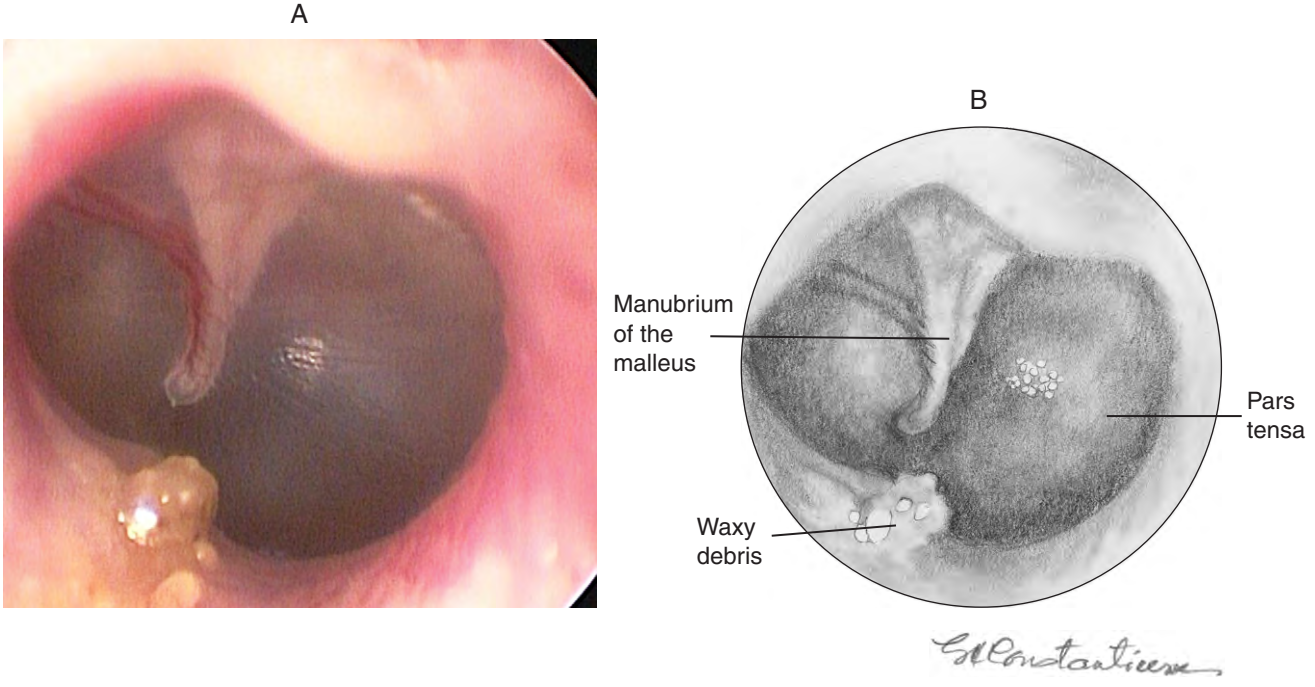



**Fig. 11-11**
Normal feline tympanic membrane.

## CONVENTIONAL OTOSCOPY

Conventional otoscopy is often used in conjunction with video-otoscopy to maximize examination and therapeutic potential. Some patients will not allow examination with a video-otoscope, but may tolerate the use of a conventional otoscope. The speed of cleaning the deep portion of the horizontal ear canal may be significantly facilitated by use of a conventional operating otoscope, which has greater mobility than a video-otoscope. Use of a conventional operating otoscope also allows for the more rapid removal of large amounts of debris from the canals.

Adherence to the established principles of conventional otoscopy greatly facilitates ear examination and cleaning. A good conventional otoscope has a bright halogen light source. For otoscopy to be effective, the light needs to be so bright that it is not comfortable to look directly at the light. Successful otoscopy in the awake, nonsedated patient in the examination room stresses the need for proper restraint. The holder directs the muzzle slightly into the thoracic inlet. The pinna is pulled up and out, away from the base of the skull, thus minimizing the angle that must be negotiated at the junction of the vertical and horizontal ear canals. The tip of the scope is placed in the intertragic notch, which is the natural groove in the lateral wall of the entrance to the vertical canal. The otoscope is moved slowly into the vertical canal, visualizing as it is inserted, and is then rotated downward so that the otoscope cone approaches a horizontal position, to visualize into the horizontal canal and allow for advancement into the horizontal canal. Deep penetration into the horizontal canal is not necessary to visualize the tympanic membrane. The head is held high enough to allow the observer to move the otoscope into the horizontal position. Examinations are best done on a table to allow for appropriate orientation of the scope. To perform otoscopy in the cat, minimal restraint is often preferred when compared to examinations in the dog. The examination is often done with the person who is holding the cat simply stabilizing the shoulders and rear of the cat. The pinna is pulled up and out, away from the base of the skull, and the otoscope is inserted with technique similar to that used in the dog. It is usually possible to readily observe only the ventral one half to two thirds of the tympanic membrane in the awake cat.

Otoscopy is always done before taking samples with a cotton-tipped swab for cytologic examination. If cytology sample collection is done first, this may drive debris further down into the horizontal canal, obscuring structures within the deeper ear canal. If debris is obscuring visualization of the degree of wall inflammation or proliferation, a cotton-tipped swab may be passed into the canal to move debris away from the wall or penetrate through the debris to facilitate a deeper examination of the ear. This maneuver may push debris further into the canal and may obscure the tympanic membrane.

## VIDEO-OTOSCOPY

### Video-Otoscopes

When compared with conventional otoscopy, video-otoscopy allows superior visualization of normal and pathologic changes within the ear through both enhanced magnification and improved clarification of images. This is especially true for the deep portion of the horizontal canal and for the middle ear. Because the light and lens are at the end of the otoscope, instrumentation does not interfere with visualization.

Even though there are several video-otoscopes available for veterinary use, two have been most widely marketed to veterinarians: the Veterinary Otoendoscope (Karl Storz Veterinary Endoscopy, American, Goleta, Calif) and the Video Vetscope (MedRx, Seminole, Fla). The Storz Veterinary Otoendoscope is an 8.5-cm long conical telescope with a 5-mm diameter tip (Fig. 11-12). This telescope has a 2-mm working channel, which exits the tip of the probe at the 12-o'clock position. The telescope has a 0-degree lens angle with a field of vision of 100 to 120 degrees. A miniature, handheld color video camera is attached to the eyepiece of the telescope (see Fig. 11-12). Both one- and three-chip cameras are available. One-chip cameras are most commonly used, although three-chip cameras provide improved clarity. The unit is also attached to an external halogen or xenon light source. Halogen light sources are used most commonly, although the more expensive xenon sources provide a more natural white light. Xenon lights are more likely to be needed if the system will also be used for other endoscopic procedures. The working channel of the




**Fig. 11-12**
Video-otoscope with attached video camera and flexible fiberoptic light guide.

otoendoscope allows passage of 5-French catheters for irrigation and suction, biopsy forceps, foreign body graspers, laser fibers, and a specially designed semirigid ear curette made by Storz. Flushing and suction can be performed without removing the catheter from the working channel by using a three-way stopcock arrangement (Fig. 11-13). The Storz otoscope also comes with a double-port adapter, which is attached to the working channel and allows for simultaneous passage of fluid and either suction or instrumentation (Fig. 11-14). Catheters that have been used with this system include an open-ended tomcat catheter (4.5 inch), a 16-gauge Teflon intravenous catheter (Abbocath), and a 5-French red rubber feeding tube. This telescope and video camera unit is a manual focus system, but the depth of focus need only be established at the beginning of a procedure and additional adjustment is usually not needed.

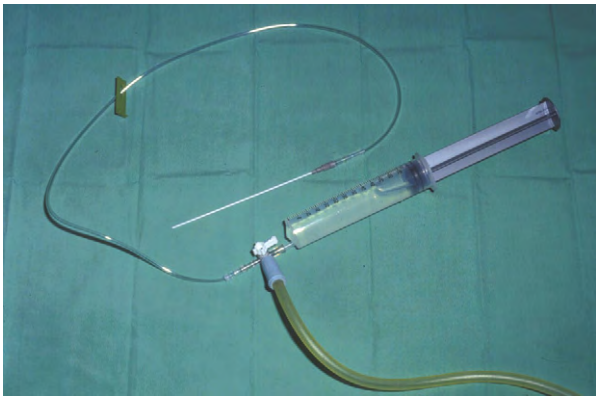


**Fig. 11-13**
Flush and suction apparatus using a three-way stopcock, syringe, intravenous extension set, catheter, and suction hose attached to a suction pump. This allows for the catheter to be passed through the video-otoscope operating channel and for alternating flushing and suction without removing the catheter.

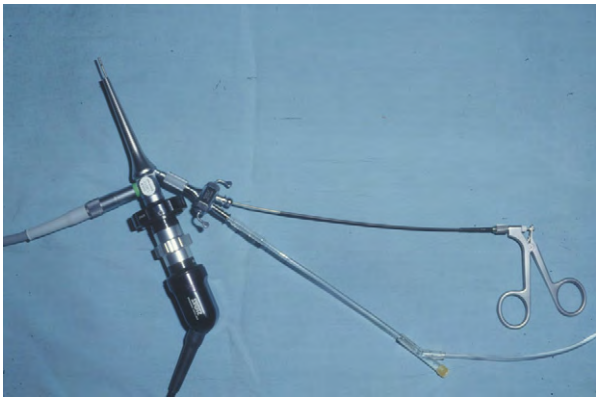


**Fig. 11-14**
Storz video-otoscope with adaptor that allows simultaneous irrigation and instrumentation through the operating channel.

The Video Vetscope has a probe that is 7 cm in length with a tip that is 4.75 mm in diameter, and it has a 2-mm working channel. Light is supplied by connection to a variable 150-W halogen light source. This system has an auto focus feature.

The telescope video camera units are connected to a color video monitor for viewing and images may be captured as photographic prints, saved as digital files, or saved on videotapes.

## Use in the Examination Room

Successful use of the video-otoscope in the examination room is largely dictated by operator expertise. For the neophyte, hand-eye coordination required can prove frustrating. Expertise is only developed through routine performance of the procedure. It is preferable to begin visualization with the more normal of the two ears.

It is important that video-otoscopic examination be done before taking samples for cytologic examination with cotton-tipped swabs. If cytology is done first, debris may be driven further down into the horizontal canal, obscuring structures within the deeper ear canal. If debris is seen that obscures visualization at the beginning of the procedure, a cotton-tipped swab can be passed into the canal to move some of this material away from the wall of the canal to facilitate visualization. The video-otoscopic examination is then repeated. This maneuver may push debris further into the canal and obscure deeper structures within the ear.

Proper animal restraint is important and should be done, whenever possible, by a technician who has been properly trained for this procedure. This facilitates a quick procedure with less discomfort for the patient. Examinations are best done on an examination table, with larger dogs being in sternal recumbency. It is best to have the person restraining the dog direct the muzzle slightly into the thoracic inlet. The operator grasps the pinna and pulls it up and out, away from the skull, to minimize the prominence of the fold of cartilage that separates the horizontal from the vertical ear canals. The tip of the video-otoscope is placed in the intertragic notch as the starting place for the examination. Once in the canal, advancement into the vertical canal and around the cartilage fold is facilitated by visualization on the screen. Once in the horizontal canal, the video-otoscope is rotated to a horizontal position. It is not necessary to penetrate deeply into the horizontal canal to visualize the tympanic membrane. For cats, restraint is usually minimal, consisting of an individual holding the shoulders and back of the cat to keep it from moving.

The operator pulls the pinna up and out with significant force, which may have an immobilizing effect on the cat, and the scope is advanced. Although it is possible to do a good examination on many cats, it may be difficult to see the entire dorsal portion of the tympanic membrane on a fully awake cat. In both the dog and the cat, a more complete examination may be achieved by restraining the patient in lateral recumbency with the otoscopist working from the top of the head.

During video-otoscopic examination, the degree of inflammation, nature of debris, color of debris, degree of proliferation (narrowing of canals), proliferative changes, masses, and the nature and integrity of the tympanic membrane are assessed. If the patient has a normal ear, it can be used to demonstrate the significant changes in the pathologic ear. When both ears are abnormal, it is ideal to have pictures of normal canals and tympanic membranes in the examination room for demonstration purposes. Examples of pathologic changes seen during video-otoscopy done in awake patients in the examination room are depicted in Figs. 11-15 through 11-35.

If the first of the ears examined is purulent, then at least the outer aspect of the scope is cleaned with alcohol or a germicidal scrub (e.g., Hibiclens) before proceeding to the next ear.

Some awake dogs and cats simply do not accept use of the video-otoscope, regardless of the otoscopist's experience and adequacy of restraint. In addition, the pain associated with severe inflammation may preclude successful visualization. Sedation may mitigate these problems. Large amounts of debris within the ears or severe stenotic changes within the canals may also be impediments to examination.

## Lens Fogging

Lens fogging is perhaps the most significant source of frustration during most routine examinations with the video-otoscope. Fogging is caused by the temperature differential between a cold video-otoscope and a warm ear. The more the ear is inflamed, the more fogging tends to occur. Warming the scope end in warm water can minimize this phenomenon. A small warming box can be constructed that contains a bulb in one end and a hole for placement of the otoscope tip in the other end. During the working day, the scope end is left in the box to keep it warm. Even so, fogging will continue to be a problem. Wiping the tip of the scope with a cotton ball soaked in 70% isopropyl alcohol is an effective method of defogging and cleaning the scope. To minimize the irritating effect of alcohol on inflamed tissues, excess amounts are wiped off with tissue paper before placing the scope in the ear. This may have to be done several times during an examination to complete the procedure.

## Deep Ear Visualization and Cleaning

Heavy sedation may be necessary to adequately visualize changes within the deeper ear canal of intractable individuals and may allow for the successful completion of minor procedures such as uncomplicated foreign body removal or for suctioning samples from within the depths of the horizontal canal or middle ear for cytology or culture and sensitivity testing. However, deep ear cleaning,

*Text continued on p. 407.*

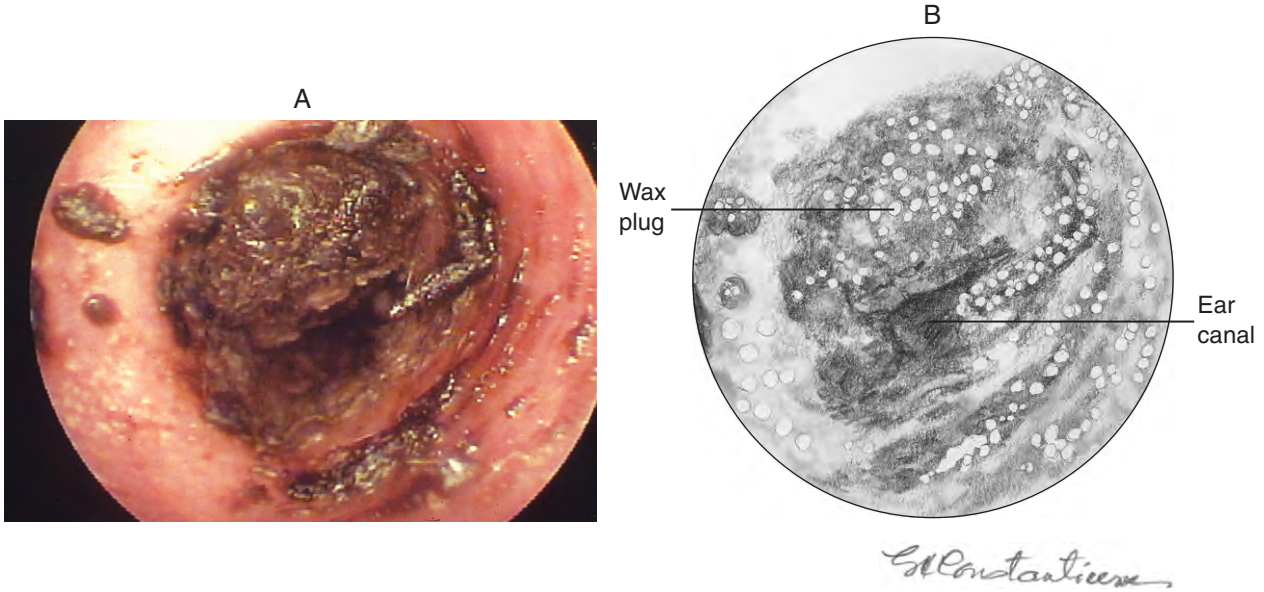



**Fig. 11-15**
Otitis externa in an atopic dog with secondary *Malassezia* infection.

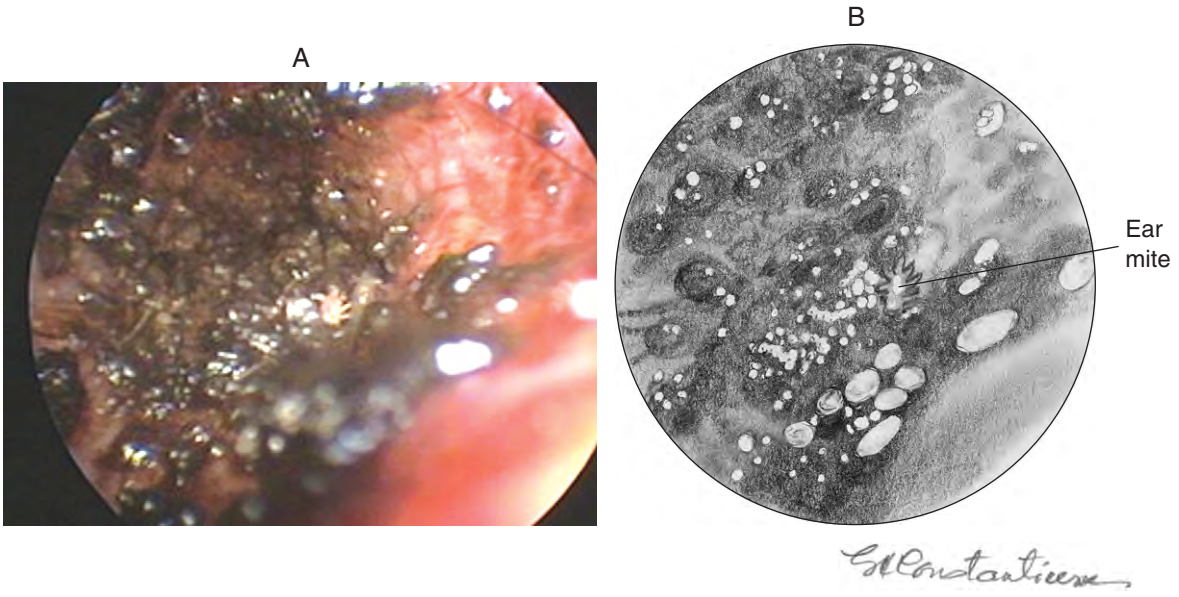



**Fig. 11-16**
Ear mite in a dog with secondary *Malassezia* infection.

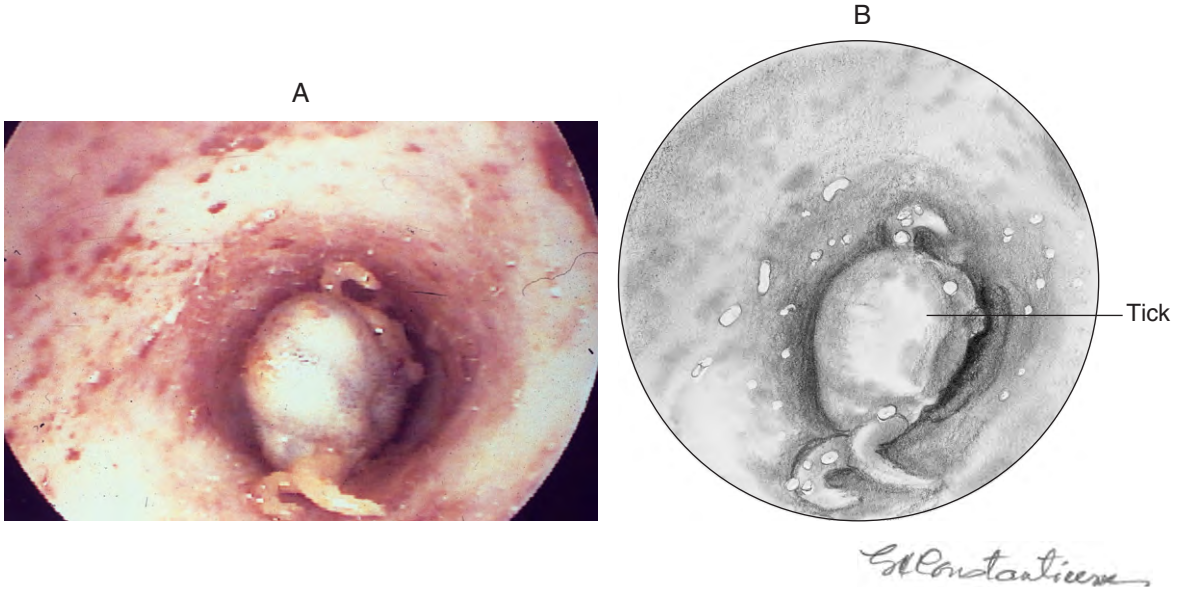



**Fig. 11-17**
Tick in the horizontal ear canal of a cat.

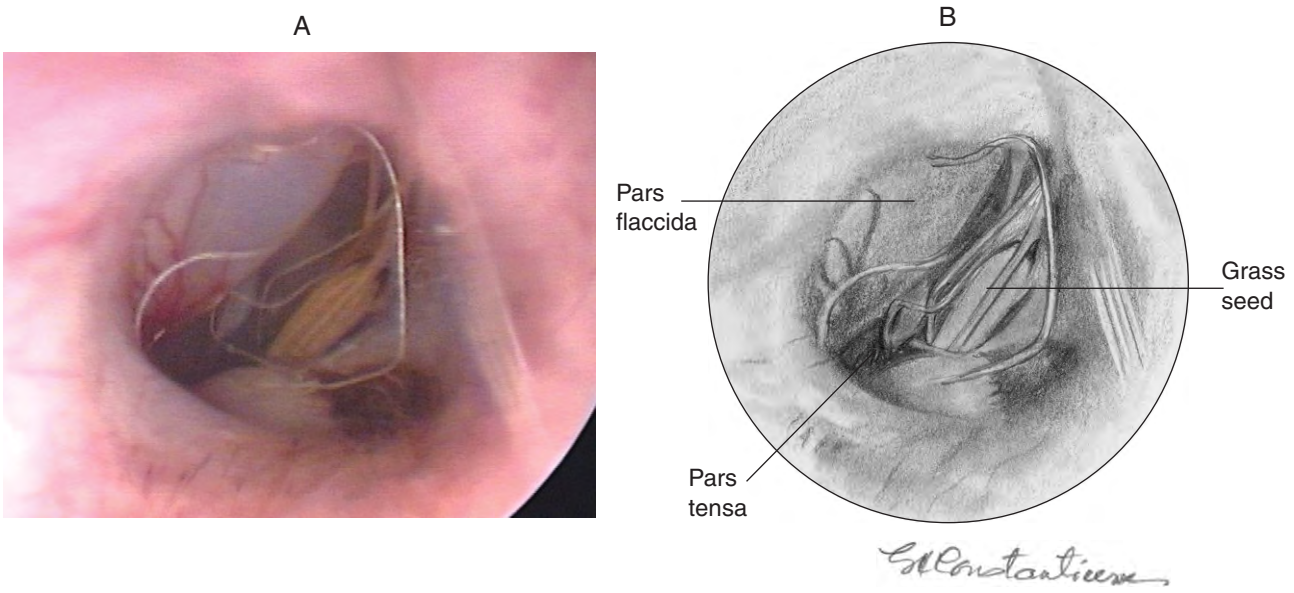



**Fig. 11-18**
Grass seed foreign body adjacent to the tympanic membrane in a dog. The pars flaccida is dilated.

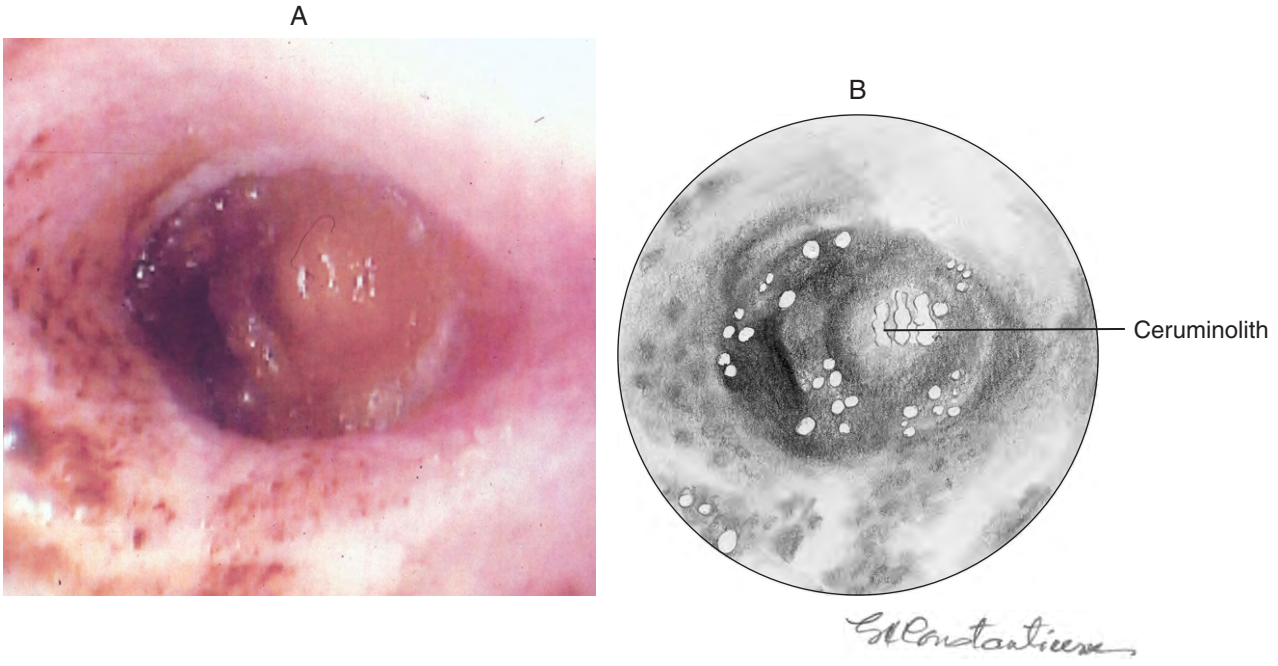



**Fig. 11-19**
Ceruminolith filling the horizontal ear canal in a cat with atopic otitis externa and mild secondary infection with staphylococci and *Malassezia*.

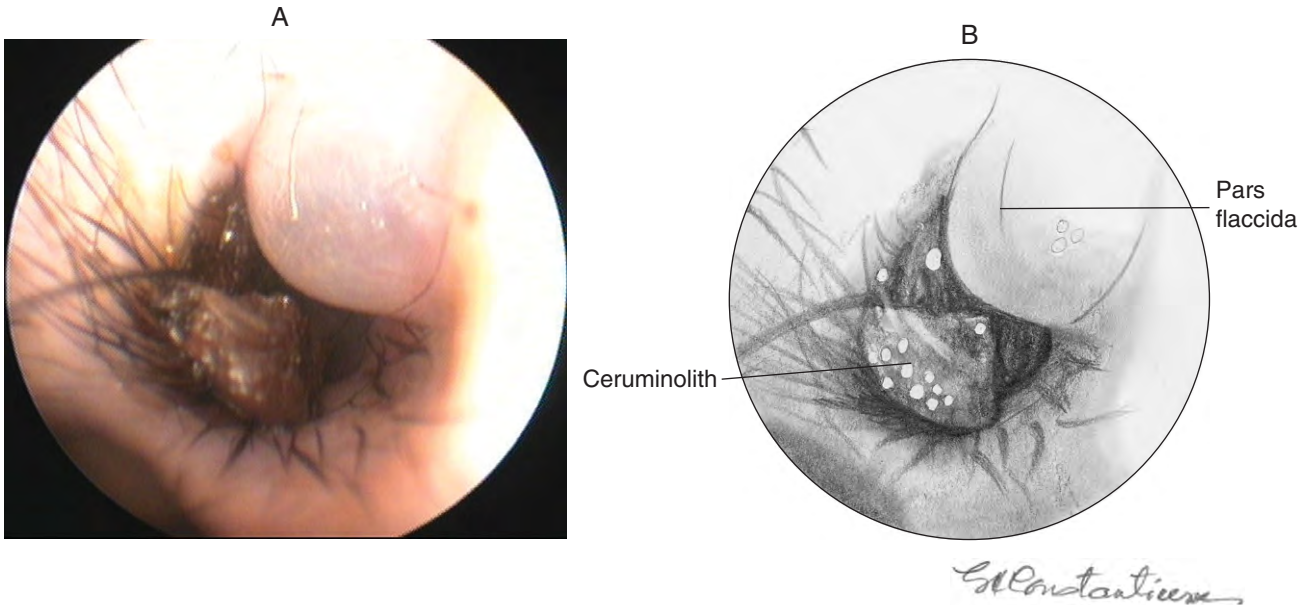



**Fig. 11-20**
Ceruminolith filling the deep portion of the horizontal ear canal adjacent to the tympanic membrane in a dog. The pars flaccida is dilated.

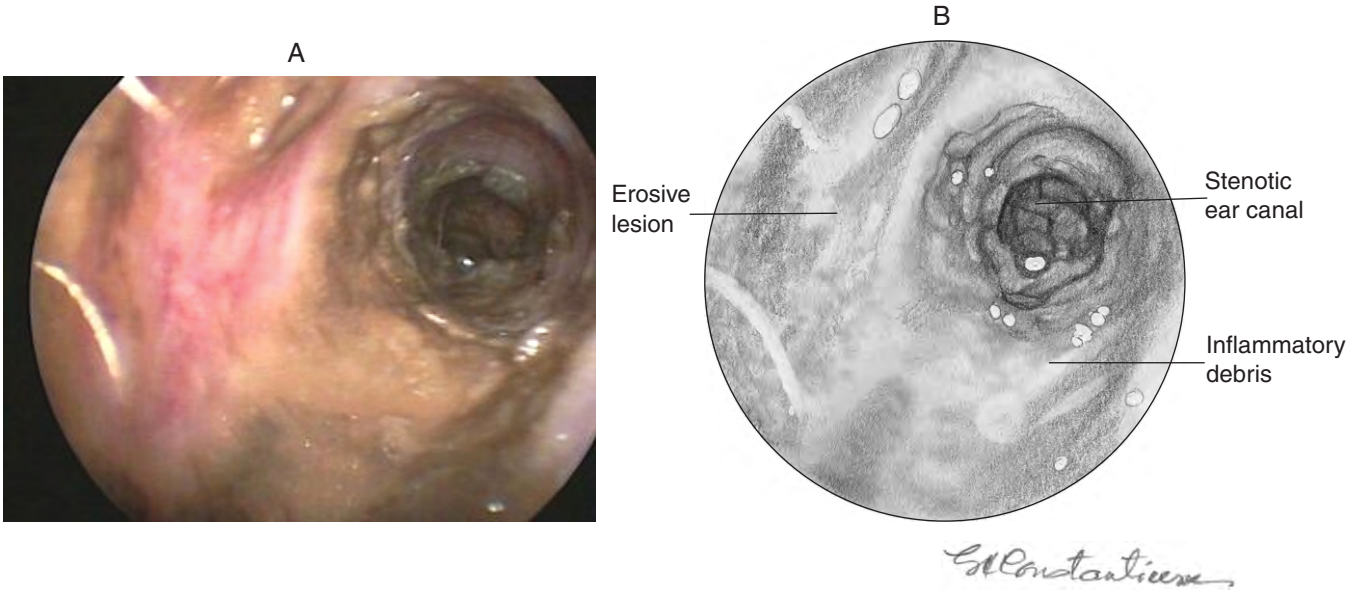



**Fig. 11-21**
Erosive otitis externa associated with reaction to topical miconazole solution. Large numbers of neutrophils and moderate numbers of *Malassezia* were present on cytologic examination.

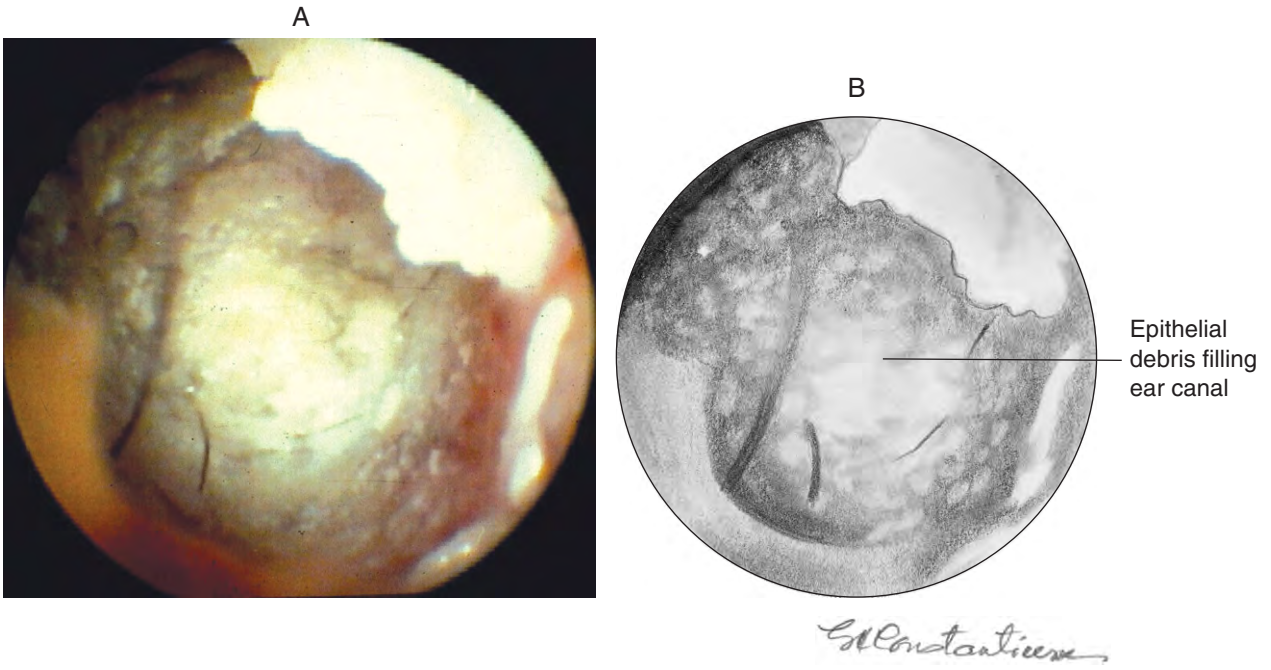



**Fig. 11-22**
Inflammation and accumulation of large amounts of opalescent epithelial debris filling a dog's horizontal ear canal that has become macerated because of too frequent use of topical therapeutic solutions.

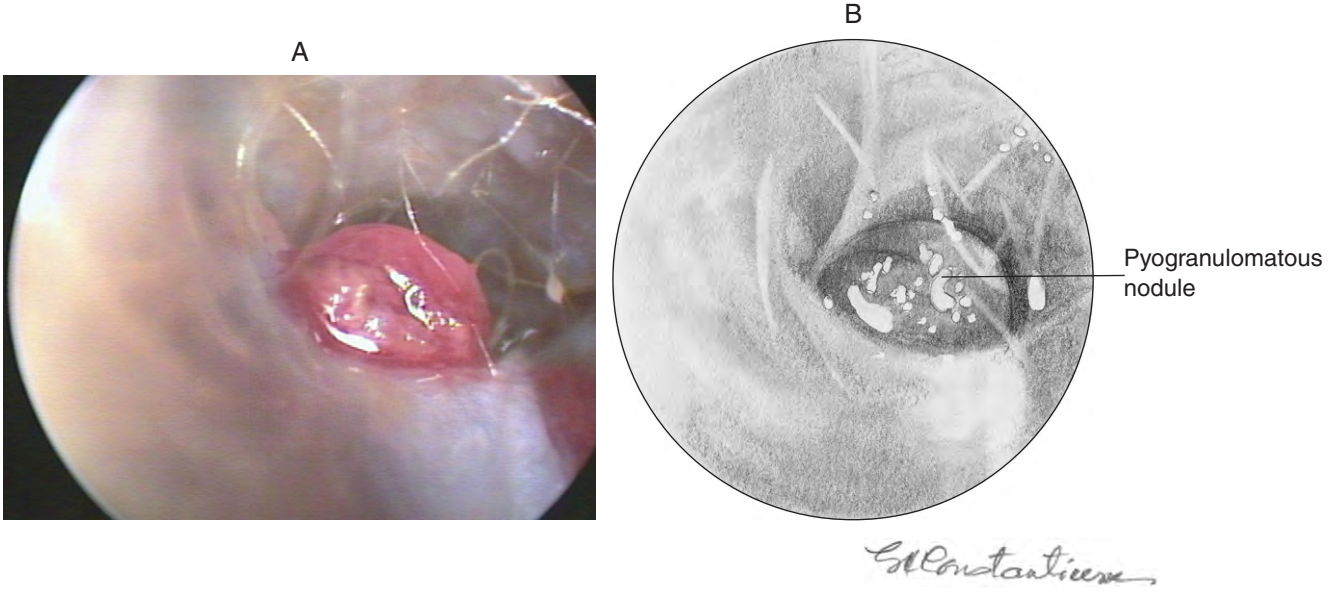



**Fig. 11-23**
A pyogranulomatous nodule growing from the wall of the horizontal ear canal in a Poodle with chronic otitis externa. This resolved following partial removal and treatment with a topical steroid/antibiotic/antifungal preparation.

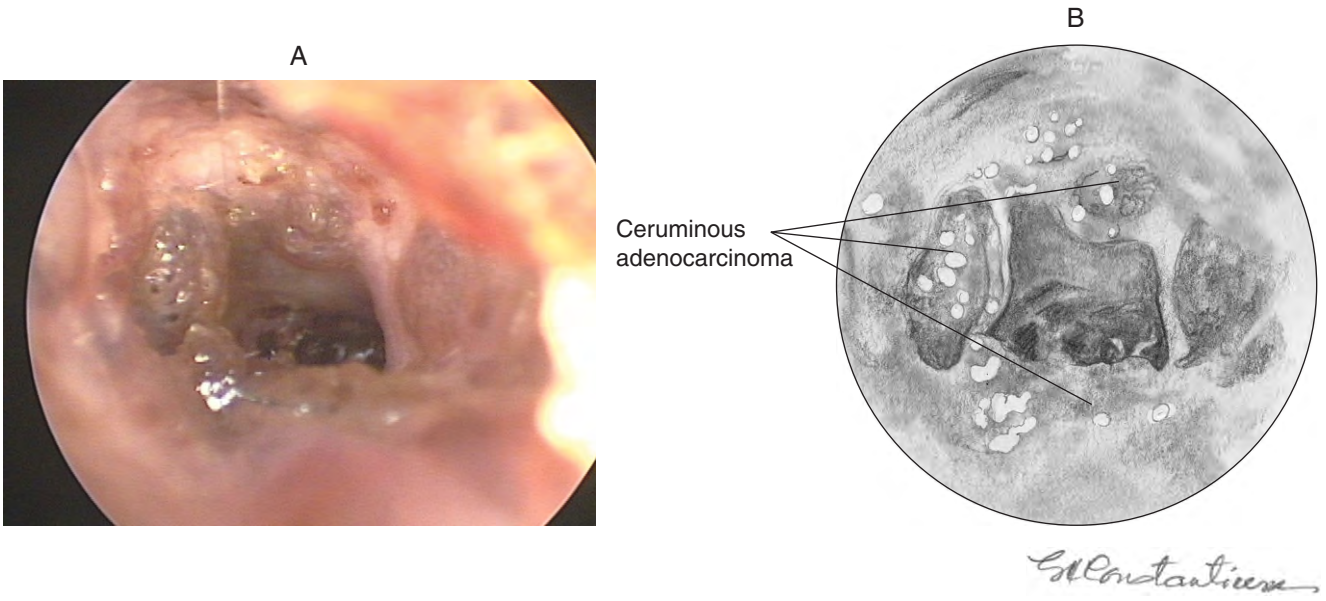



**Fig. 11-24**
A ceruminous adenocarcinoma involving the horizontal ear canal in a cat. The darker, bluish discoloration of the neoplasm is related to the accumulation of ceruminous secretions.

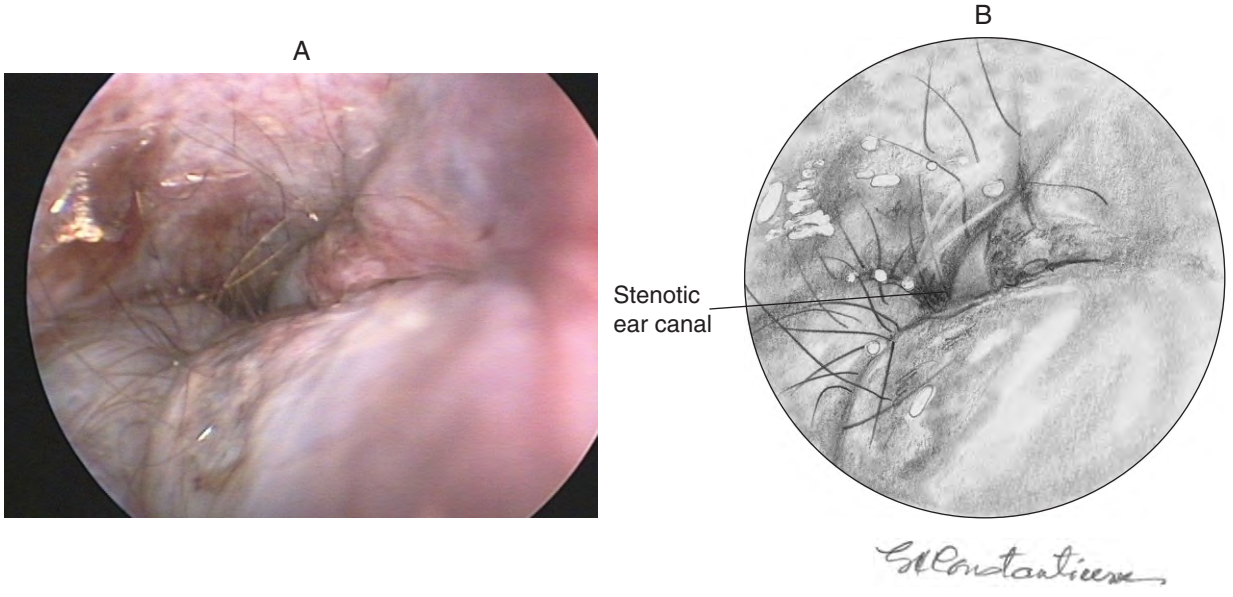



**Fig. 11-25**
A 360-degree stenosis of the horizontal ear canal due to inflammation and fibrosis in a mixed breed dog with chronic atopic otitis externa. Moderate numbers of both bacterial rods and cocci plus small numbers of *Malassezia* were seen on cytology.

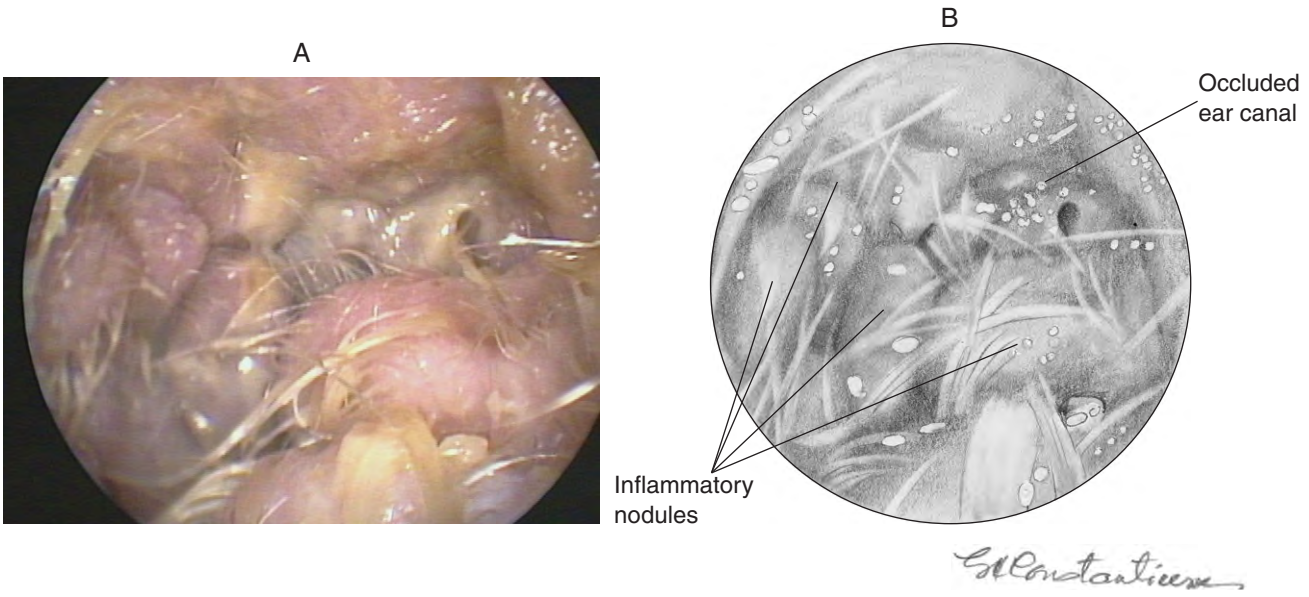



**Fig. 11-26**
Inflammatory and fibrotic proliferative nodules filling the horizontal ear canal of a Cocker Spaniel with chronic atopic otitis externa. Cytology revealed moderate numbers of a pleomorphic population of both rod- and cocci-shaped bacteria.

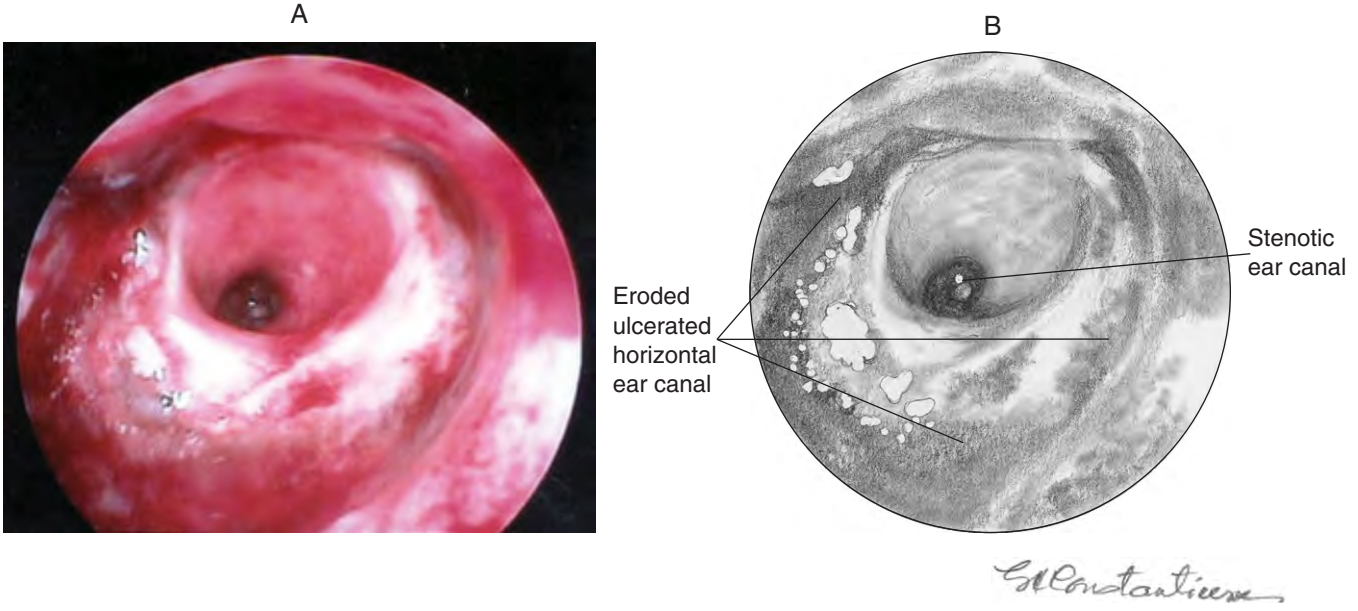



**Fig. 11-27**
Erosive and ulcerative otitis externa due to *Pseudomonas*. *(Courtesy Dr. James Noxon.)*

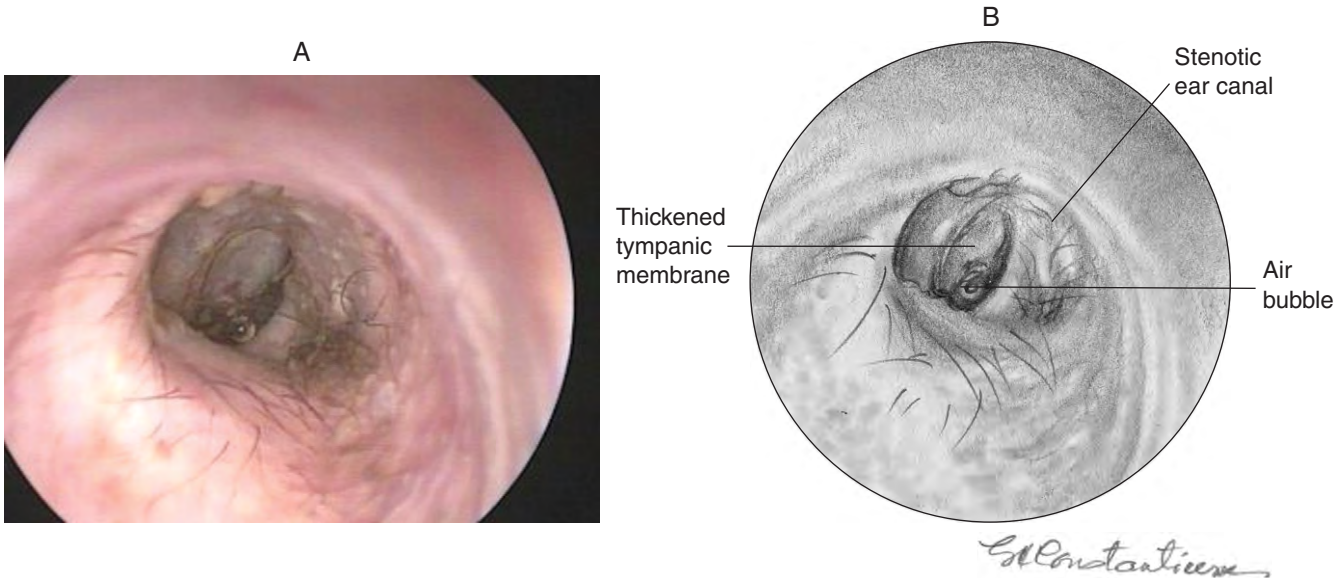



**Fig. 11-28**
A thickened opaque tympanic membrane caused by chronic irritation in a dog secondary to an accumulation of debris in the ear canal. Otitis media was not present. Fluid is being infused after the debris had been removed from the surface of the tympanic membrane.

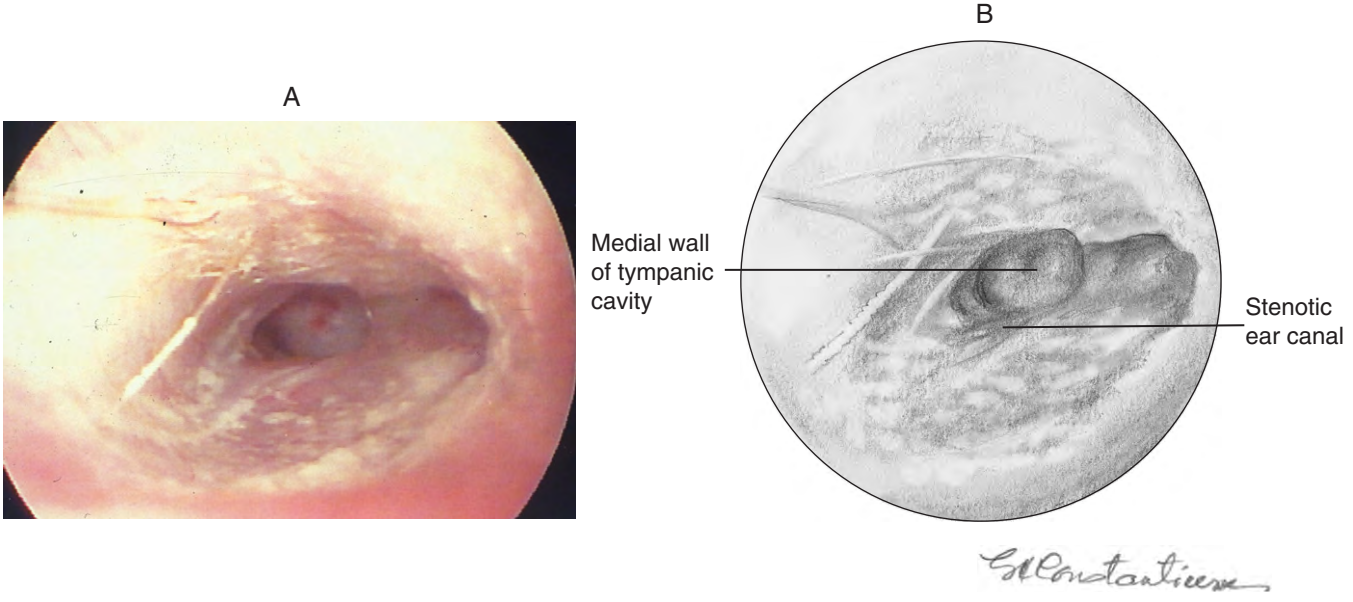



**Fig. 11-29**
Moderate stenosis of the horizontal ear canal and a perforated tympanic membrane in a Cocker Spaniel with chronic atopic otitis externa and secondary infection with bacteria and *Malassezia*. The white structure in the center is the bone on the medial aspect of the tympanic cavity.

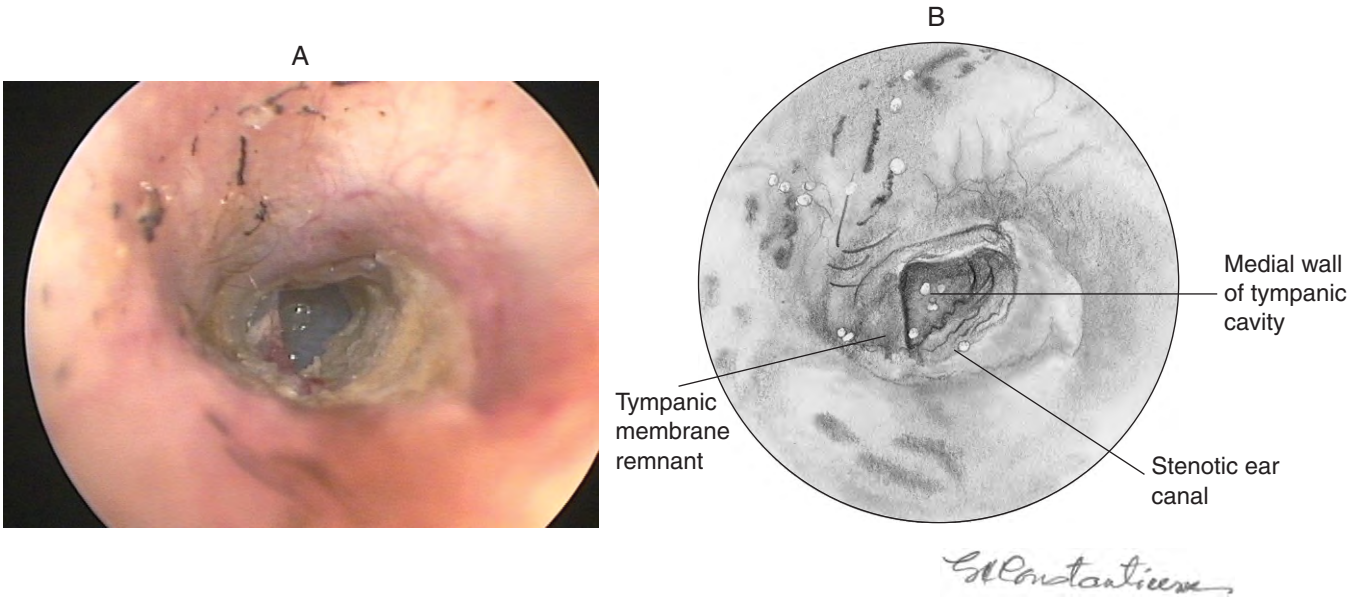



**Fig. 11-30**
A perforated tympanic membrane in a cat with chronic atopic otitis externa. Some of the tympanic membrane is still present, and glistening bone is seen on the medial aspect of the tympanic cavity. A secondary staphylococci infection was present.

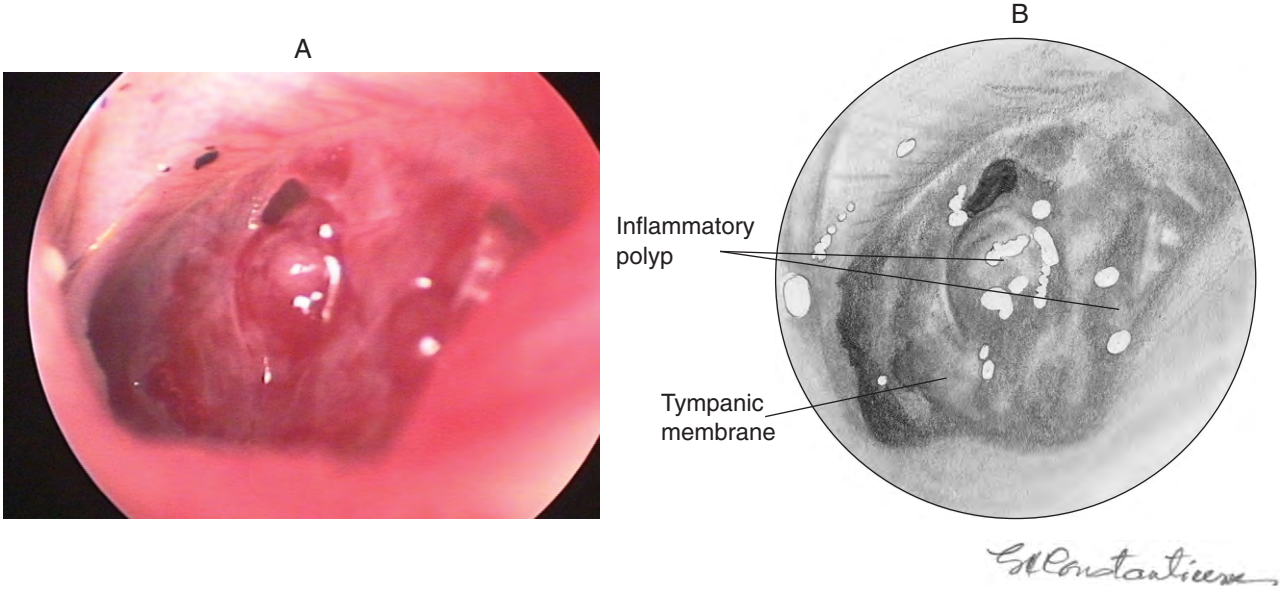



**Fig. 11-31**
A feline inflammatory polyp just beginning to exit the middle ear through the tympanic membrane.

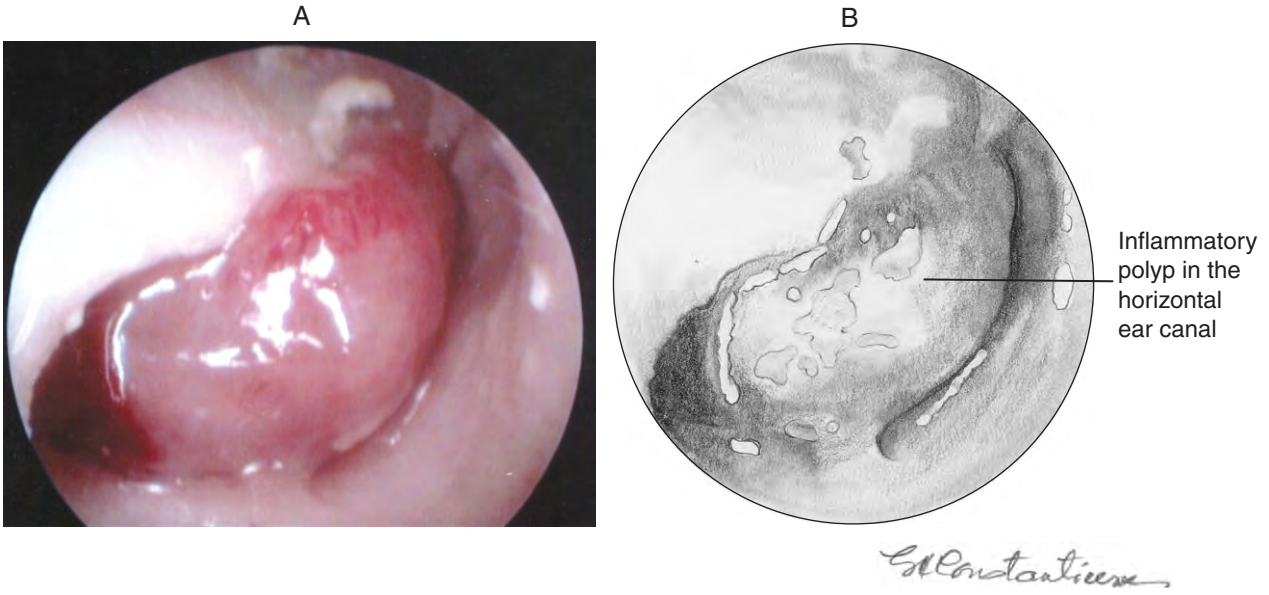



**Fig. 11-32**
A well-developed feline inflammatory polyp originating from the tympanic bulla and filling the horizontal ear canal.

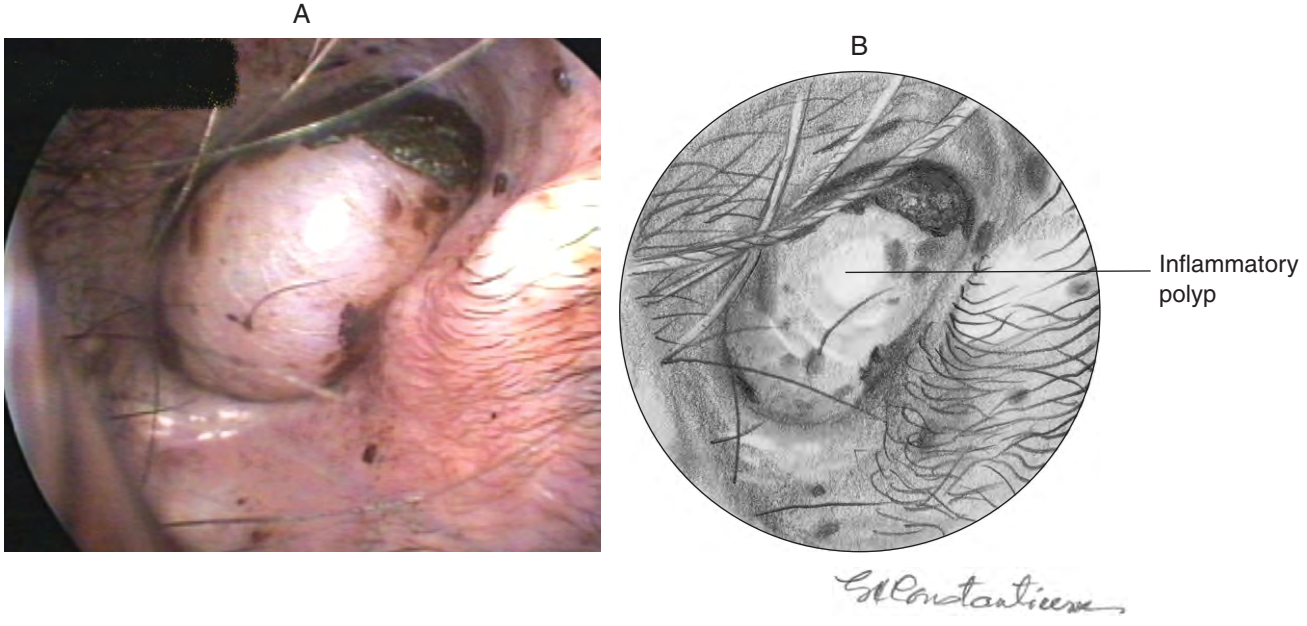



**Fig. 11-33**
Canine inflammatory polyp originating from the tympanic cavity.

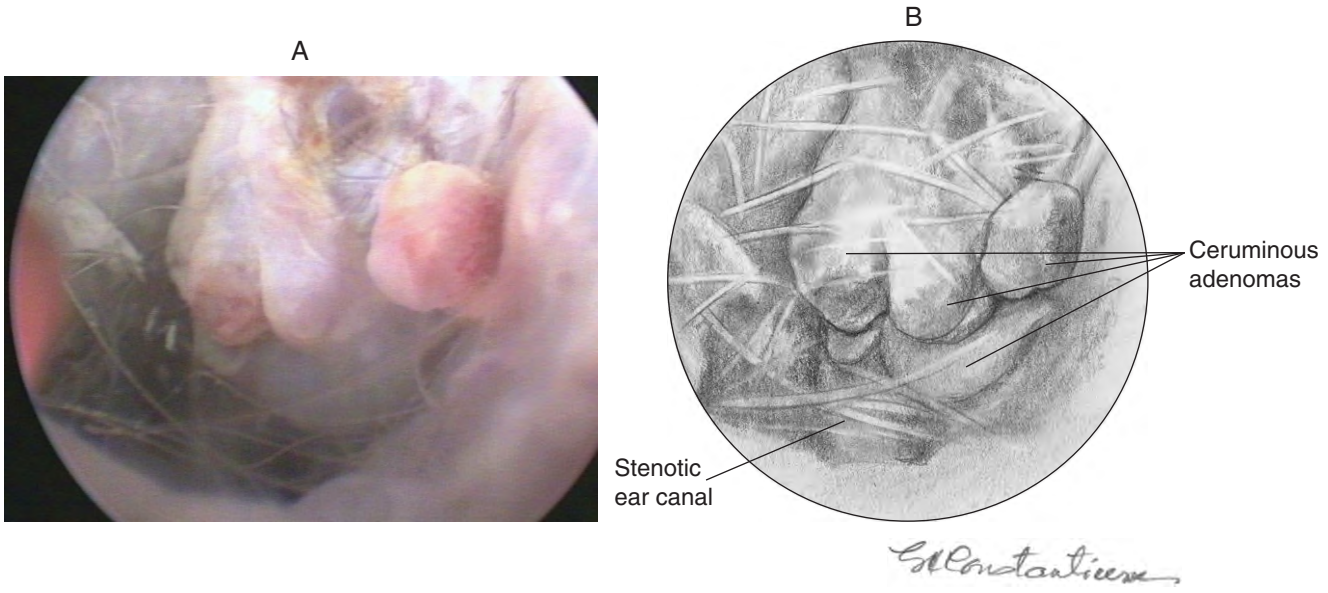



**Fig. 11-34**
Multiple ceruminous adenomas in a Miniature Poodle with chronic otitis externa. Saline was being infused when the photograph was taken.

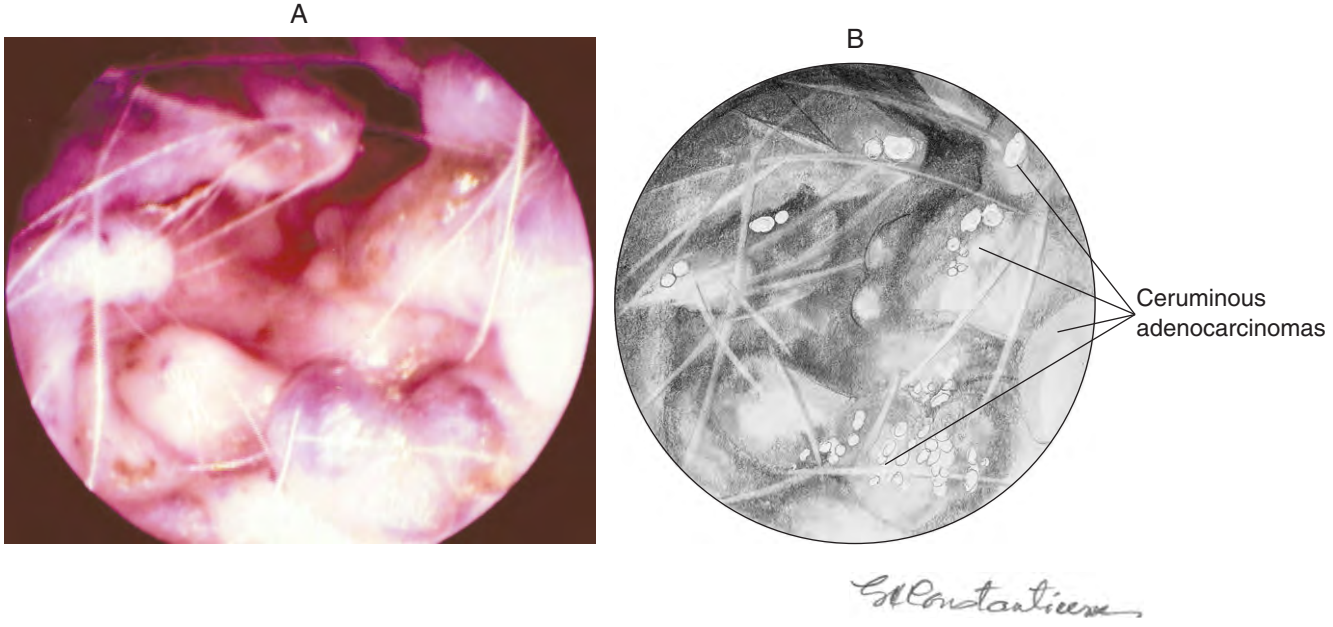



**Fig. 11-35**
Ceruminous adenocarcinoma in the horizontal ear canal of a dog. Note the bluish coloration of the ceruminous secretions. *(Courtesy Dr. James Noxon.)*

intralesion injections, mass biopsies or removals, and removal of deep or difficult foreign material are best done under general anesthesia. Patients are often sensitive to manipulation deep within the horizontal canal and general anesthesia is often necessary to prevent patient movement, which in turn minimizes the potential for damage to sensitive structures. Anesthesia also allows placement of an endotracheal tube to prevent aspiration of fluids that may pass through the middle ear and auditory canal into the posterior pharynx.

Before doing more extensive procedures in ears that are severely inflamed and stenotic, consideration is given to treating the ear or ears for 1 to 2 weeks to open up the canals and facilitate access to the deeper portion of the ear canal. This therapy usually involves use of both topical and oral glucocorticoids.

When deep ear cleaning is anticipated, consideration is also given to placing a ceruminolytic agent in the ears 15 to 60 minutes before the procedure to soften material. This is only done when it is not important to visualize changes as they would have appeared before placing fluid in the ear.

Positioning of the animal during procedures varies with the preference of the video-otoscopist. I prefer to work from the back of the head when the animal is in lateral recumbency. This allows for grasping of the pinna in one hand, along with the video-otoscope, leaving the other hand free to do manipulative procedures. This approach may result in the structures seen on the video monitor screen being upside down, depending on the orientation of the camera. Familiarity with the normal anatomy of the ear decreases any confusion when using this orientation.

Procedures are usually begun with a thorough examination of the ear. Lens fogging or obstruction of the visual field with debris is best dealt with by removing the telescope and wiping the lens with a cotton ball soaked in 70% isopropyl alcohol. An image may be obtained before ear cleaning is initiated to document "before and after" improvement. A sample of debris is aspirated from the depths of the ear canal for cytologic examination and possibly for culture and sensitivity testing. If the culture is not deemed necessary at the end of the procedure, based on cytologic findings and assessment of integrity of the tympanic membrane, the sample is discarded. If the tympanic membrane is perforated, samples are always taken from both the horizontal canal and the middle ear for cytologic examination and for culture and sensitivity testing. Organisms from the horizontal canal and middle ear may differ and sensitivity patterns of the same organism may also differ from one area to the other.[8] Samples obtained from the middle ear are always submitted for both aerobic and anaerobic cultures, even when they do not show cytologic evidence of organisms.

Administration of saline through the working channel of the video-otoscope facilitates expansion of the ear canal and further magnification of images, prevents fogging of the lens, and lessens debris accumulation around the tip of the otoscope. Gravity flow usually provides sufficient pressure. Removal of debris is often facilitated by continuous fluid flow.

Flushing and suctioning can be done through the working channel of the video-otoscope using a 16-gauge, 5.5-inch Teflon catheter (Abbot Hospital, Inc., North Chicago, Ill), a 4.5-inch, open-ended tomcat catheter, or a 5-French red rubber feeding tube. The channel is also used for passage of biopsy forceps, grasping forceps, or a specially modified ear curette. Debris can be grasped and removed, masses can be biopsied or removed, cysts can be drained or removed, foreign bodies can be removed, and in cats polyps can be removed. When using the Storz double-port adapter, fluids can be administered simultaneously while biopsy forceps, foreign body graspers, or an ear curette is used (see Fig. 11-14).

A flushing and suction apparatus can be made that allows for alternating flushing and suctioning action through one catheter in the operating port. A 16-gauge, 5.5-inch Teflon jugular catheter (Abbot Hospital, Inc., North Chicago, Ill) or a 5.5-inch, open-ended tomcat catheter is attached via an extension set to a three-way stopcock. A 60-ml syringe and the hose from a surgical suction apparatus are attached to the three-way stopcock (see Fig. 11-13). Adjusting the amount of suction is important to effectively remove debris without collapsing the ear canal or causing trauma to the ear. Controlling the amount of suction is critical to effective use of this apparatus. Excessive suction results in collapse of the canal and can cause perforation of the tympanic membrane. Too little suction is ineffective. Minimal amounts of suction are used when working deep within the canal adjacent to the tympanic membrane to decrease the chance of perforation of the tympanic membrane.

Using a combination of cleaning techniques facilitates removal of debris from the canals. Alligator forceps and ear curettes are used through a conventional operating otoscope head to remove larger debris. Flushing with a 12-ml syringe attached to an open-ended tomcat catheter followed by suctioning through a 14-gauge Teflon catheter (Abbot Hospital, Inc., North Chicago, Ill) attached to a suction hose and controlled suction apparatus can facilitate rapid debris removal.

One shortcoming of the video-otoscope is that the exit point of the operating channel is in a fixed position and any instrumentation coming out of this channel is therefore fixed in its range of motion. The telescope tip is manipulated to provide access to all areas of the ear canal. This can be cumbersome and time consuming.

### The "False" Middle Ear

The tympanic membrane can be forced medially into the tympanic cavity space, usually as a result of chronic, progressive pressure exerted by accumulated debris within the horizontal ear canal. The space created has been referred to as the "false" middle ear. Its depth of extension usually gives the impression of a very deep horizontal canal, especially when compared with a more normal, contralateral tympanic membrane. The tympanic membrane can be flattened against the bony prominence of the medial aspect of the tympanic cavity or it may extend to an even greater extent into the tympanic bulla. This deformed tympanic membrane can often be visualized better through the video-otoscope than with conventional otoscopy. Use of a longer, rigid scope, such as an arthroscope, may facilitate visualization to an even greater degree.

### Cleaning the Middle Ear

If the tympanic membrane is perforated, the bulla can be flushed and aspirated as outlined for the canals. Catheter tips are always directed through the ventral portion of the tympanic cavity opening, between about the 4- and 6-o'clock positions, just above the floor of the horizontal canal. This maximizes the potential of entering the bulla. It is best to avoid passage of catheters dorsally through the tympanic opening to minimize the potential of damage to sensitive structures.

It is common to have the catheter catch on the bony ridge that partially separates the tympanic cavity from the tympanic bulla in the dog. When this occurs, bulla cleaning is achieved through fluid turbulence created within the bulla space. To facilitate better entry into the tympanic bulla, a slight curve can be given to the tip of a 16-gauge Teflon catheter by placing an orthopedic wire through the catheter, bending the tip, then heating the catheter in boiling water. After cooling, a bend remains in the catheter after the wire is removed. The tip of the catheter straightens as it passes through the operating channel of the video-otoscope but retains some curve once it exits the scope.

### Intralesional Glucocorticoid Injections

Proliferative lesions within the horizontal and vertical ear canals can be injected with glucocorticoids to facilitate more rapid resolution of the lesions and to minimize the amount of systemic glucocorticoids that are necessary. Triamcinolone acetonide is used at a concentration of 1 to 2 mg/ml through a 6-inch, 22-gauge spinal needle. This needle passes through the operating port of the video-otoscope. The more dilute of the concentrations is used when relatively widespread application is necessary. If there is 360-degree stenosis of the canal, the video-otoscope is placed as deeply in the ear as possible and injections are given at the 12-, 4-, and 8-o'clock positions. Approximately 0.5 mg is administered per injection site. Injections are repeated at about 1-cm intervals while backing the video-otoscope out of the ear canal. The total dose of triamcinolone acetonide used per dog or cat is usually 6 mg. Proliferative nodules are injected individually, usually with about the same amount of triamcinolone and at about the same distances apart.

### Laser Therapy

Lasers can be used through the video-otoscope to vaporize masses within the ear canal.[9] A 180-mm × 0.8-mm $CO_2$ laser tip or 1000-micron quartz diode laser fiber passes through the 2-mm operating port of the video-otoscope. The laser tip is advanced to a point just outside the telescope tip so that it can be visualized, and the laser beam is directed at the lesion. The goal is to vaporize the mass without causing significant tissue charring. The use of a low wattage setting provides for very little smoke plume formation. The potential for damaging deeper structures such as the tympanic membrane can be minimized by filling part of the horizontal canal with saline or by using a small piece of moistened cotton to cover the tympanic membrane. The laser can also be used to perform myringotomies.

### Myringotomy

Myringotomy, incision of the tympanic membrane, is generally performed when there is suspicion of otitis media but the tympanic membrane is intact. In most of these cases, the tympanic membrane was previously perforated but has healed. Retrograde infections moving up the auditory canal (eustachian tube) can also cause active otitis media with an intact overlying tympanic membrane. Occasionally, a myringotomy may be performed to reduce the size of the pars flaccida to facilitate visualization of the rest of the tympanic area.

### Pars Flaccida "Puncture"

Dilation of the pars flaccid can, at times, be sufficient to prevent visualization of the tympanic membrane or to interfere with cleaning of the space between the pars flaccida and the pars tensa of the tympanic membrane. When this occurs, consideration is given to incising the air-filled pars flaccida. This is a modified myringotomy. The hole created in this flaccid structure typically seals quickly compared to incisions in the pars tensa. Because the procedure does allow for potential contamination of the middle ear, it is important that every effort be made to clean the ear canal as well as possible before the procedure. The procedure can be done through the video-otoscope with a 6-inch, 22-gauge spinal needle (Mila International, Inc., Florence, Ky), a 16-gauge Teflon jugular catheter, or an open-ended tomcat catheter whose tip

has been cut to a sharp point. The needle or catheter is passed through the wall of the dilated pars flaccida until it deflates. Using a small amount of negative pressure through the needle or catheter can facilitate deflation. If fluid exits through the opening, further examination for otitis media is indicated.

### Myringotomy through the Pars Tensa

Before performing myringotomy, the horizontal canal is thoroughly cleaned. The preferred site for performing a myringotomy is ventrally at the 6-o'clock position. I most commonly use a 22-gauge, 6-inch spinal needle attached to an intravenous transfer set for this purpose. The needle is passed through the operating channel of the video-otoscope, through the tympanic membrane, and into the middle ear. When the needle has entered the middle ear, an assistant creates negative pressure through the system to collect a sample for cytology and for culture and sensitivity. Alternatively, the needle is removed and a 16-gauge Teflon jugular catheter is passed into the bulla. If there is strong suggestion of debris within the middle ear based on radiographs, computed tomography, magnetic resonance imaging, or otoscopic findings but nothing is retrieved on initial aspiration, then a small amount of sterile saline can be infused into the bulla and then aspirated. If otitis media is encountered, the myringotomy is enlarged to facilitate more thorough flushing with a catheter placed into the middle ear and debridement of the middle ear with instrumentation. Medication (e.g., enrofloxacin) may be infused into the middle ear if necessary.

### Hemorrhage

If bleeding is encountered during deep ear procedures, the scope is removed, and a cotton-tipped swab is placed in the ear canal or pressure is applied to the canal until the bleeding stops. Continuous flow irrigation can also be used to clear the visual field. Most hemorrhaging stops within a couple of minutes.

### Visualization of the Tympanic Cavity and Bulla with the Arthroscope

It is possible to visualize into the tympanic cavity through the regular video-otoscope but the tympanic bulla cannot be reached. The 2.7-mm arthroscopic telescope (Fig. 11-36) works well for examination of the middle ear because of its small size and the 30-degree angle of the tip, which allows for visualization into the middle ear beyond the axis of the telescope (Figs. 11-37 and 11-38). Continuous infusion of saline through the arthroscope is necessary for adequate visualization. If fluid flow with this cannula is too slow, it can be increased by applying pressure to the fluid bag. Manipulative procedures are done around the cannula. This size scope allows ready access to the middle ear in most dogs larger than 35 or 40 pounds. It is also possible to access the bulla in smaller dogs and cats with this telescope, but this can be traumatic. Smaller arthroscopes can be used to facilitate examination in smaller dogs and in cats. The ear canal must be thoroughly cleaned before performing a myringotomy or placing the arthroscope into the middle ear through a previously perforated tympanic membrane.

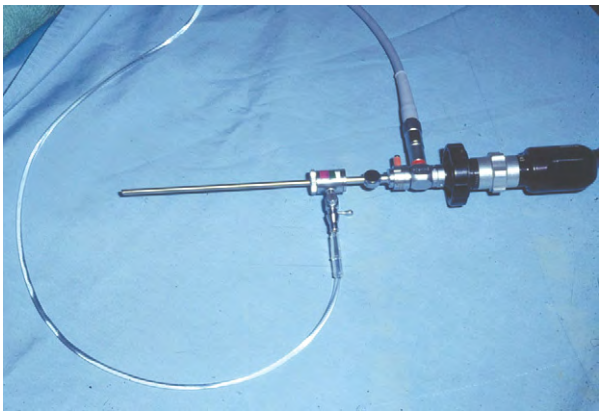


**Fig. 11-36**
The 2.7-mm arthroscope used for video-otoscopic examination of the tympanic cavity and tympanic bulla.

### Cleaning and Disinfecting the Video-Otoscope

Cleaning and disinfection alternatives vary. For use in the examination room, cleaning and disinfection is recommended between each patient. Chlorhexidine (2% solution, 3 oz per gallon) is routinely used for cleaning the outer aspect of the telescope and for flushing or brushing through the video-otoscope working channel. Afterward, the lens surface is wiped with 70% isopropyl alcohol to remove any residue or film. More aggressive cleaning can be achieved by first removing the light cable from the telescope and immersing the telescope in a neutral pH enzymatic cleaning solution (e.g., EZ-Zyme by Miltex, Bethpage, NY; or Metrizyme Enzymatic Cleaner by Metrex, Orange, Calif) for no longer than 45 minutes. Cleaning residual proteinaceous material can be done with a sponge or soft cloth. The operating channel is cleaned with a special brush designed for that purpose. The telescope is rinsed thoroughly in distilled water. Both the lens and the fiberoptic inlet post are wiped with 70% alcohol to remove any residue or film. The entire scope is dried with a lint-free soft cloth or compressed air. The video-otoscope may also be sterilized or disinfected using ethylene oxide (ETO), Sterrad (Advanced Sterilization Products, Irvine, Calif), or Steris 20 (Steris Corporation, Mentor, Ohio) or by soaking in a 2.5% glutaraldehyde solution (e.g., Cidex 14 day by Johnson & Johnson, Irvine, Calif).

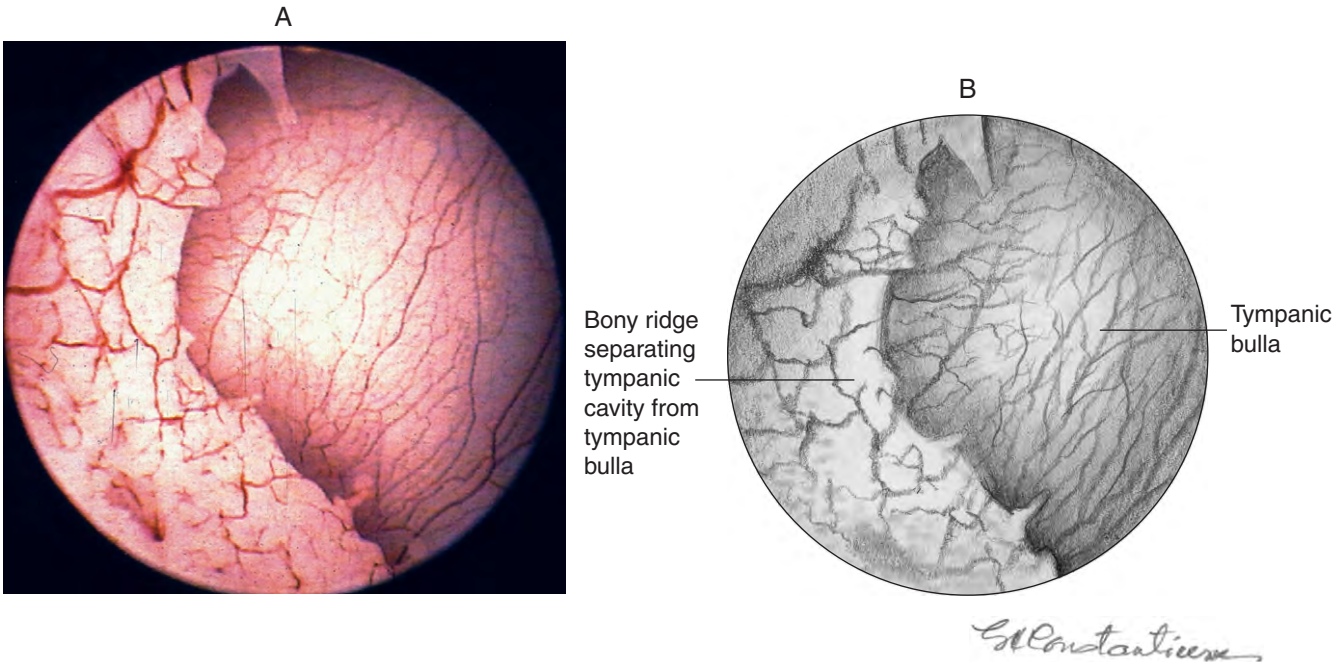



**Fig. 11-37**
Bony ridge separating the tympanic cavity from the tympanic bulla seen with the arthroscope positioned in the middle ear. The pointed and ball-shaped projections along the edge of the ridge are normal.

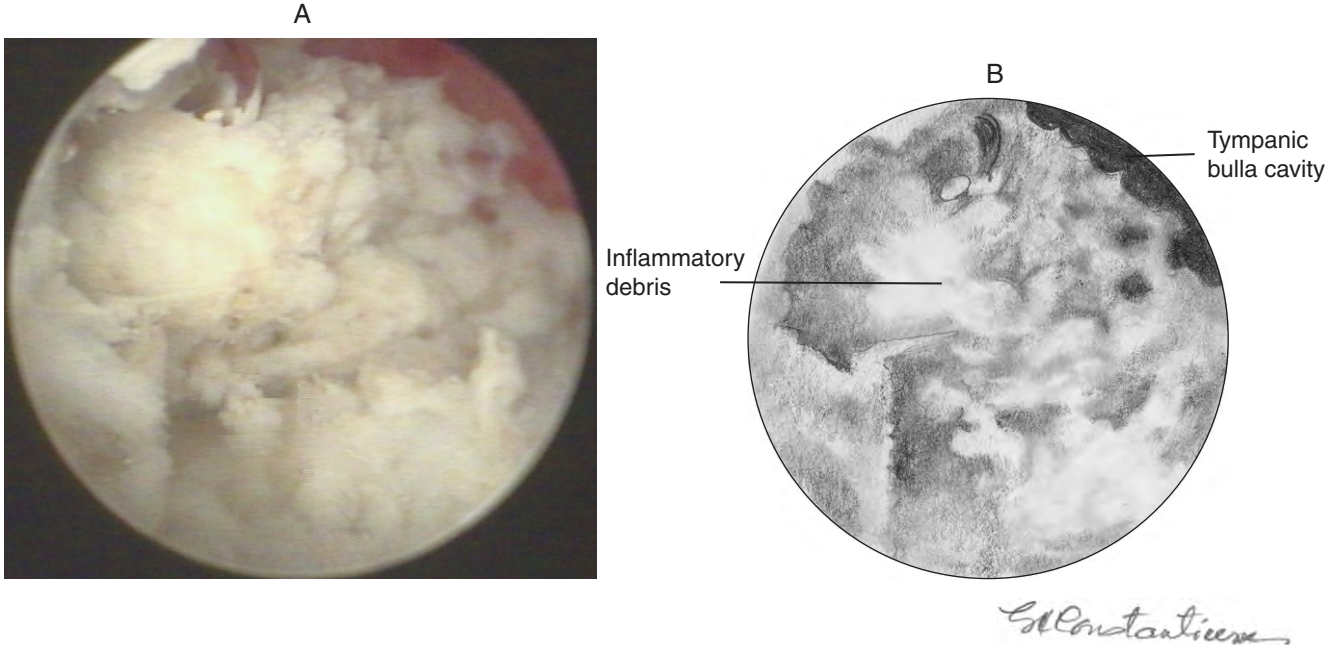



**Fig. 11-38**
Debris in the tympanic bulla of a German Shepherd seen with the 2.7-mm arthroscope.

The video-otoscope is not soaked in any solution, including distilled water, for more than 45 minutes. It is important to follow the manufacturers' cleaning and disinfection instructions for their specific equipment.

## REFERENCES


1. Broekaert D: The migratory capacity of the external auditory canal epithelium: a critical mini review, *Acta Otorhinolaryngol* 44:385-392, 1990.
2. Scott DW: Feline dermatology: a monograph. *J Am Anim Hosp Assoc* 16:426-433, 1980.
3. Huang HP: *Studies of the microenvironment and microflora of the canine external ear canal*, Glasgow, 1993, PhD thesis.
4. Stout-Graham M and others: Morphologic measurements of the ear canal of dogs, *Am J Vet Res* 51:990-994, 1990.
5. Fernando SDA: A histological and histochemical study of the glands of the external auditory canal of the dog, *Res Vet Sci* 7:116-119, 1966.
6. Steiss JE and others: Healing of experimentally perforated tympanic membranes demonstrated by electrodiagnostic testing and histopathology, *J Am Anim Hosp Assoc* 28: 307-310, 1982.
7. Matsuda A and others: The aerobic bacterial flora of the middle and externa ears in normal dogs, *J Small Anim Pract* 25:269-274, 1984.
8. Cole LK and others: Microbial flora and antimicrobial susceptibility patterns of isolated pathogens from the horizontal ear canal and middle ear in dogs with otitis media, *J Am Vet Med Assoc* 212:534-538, 1998.
9. Gotthelf LN: Laser ear surgery. 17th Proceedings of the AVD/ACVD, 137-138, 2002.

# 12 Vaginoscopy and Endoscopic Transcervical Insemination in the Bitch

Marion S. Wilson

Vaginoscopy using a rigid endoscope allows routine clinical examination of the dog's vagina, transcervical insemination (TCI), and assessment of the estrous cycle. Vaginoscopy offers exciting prospects for the clinician in the field of canine reproduction. Technology to freeze and inseminate frozen semen has been available for more than 30 years, but it is only relatively recently that there has been an increase in its use as dog breeders realize the potential frozen semen has for their breeding programs. This increased use results from improved conception rates due to a better understanding of the critical factors involved, such as the requirement for intrauterine deposition of semen. Two methods of achieving intrauterine semen deposition are surgical and transcervical. Traditionally the surgical technique has been the method of choice of many clinicians, because it is easy to perform with no major learning period. The surgical technique does have some drawbacks: There are risks associated with the use of general anesthesia, surgery does incur surgical trauma, and only a single insemination is possible. Many owners and veterinarians prefer a nonsurgical option and are now adopting the endoscopic transcervical technique. This technique is not limited to intrauterine frozen semen deposition.

## RELEVANT ANATOMY

For TCI to be successful, it is essential to be familiar with the anatomy of the caudal reproductive tract of the bitch before performing vaginoscopic examination and TCI. The caudal part of the bitch's reproductive tract can be divided into three distinct areas: the vestibule, the body of the vagina, and the paracervix.

### Vestibule

The caudal portion of the vagina is the *vestibule,* which extends from the vulvar labia to the cingulum at the vestibulovaginal junction. Anatomic structures of importance in the vestibule include the clitoris, clitoral fossa, urethral tubercle, urethral orifice, and cingulum. The clitoris within the clitoral fossa is located immediately within the ventral commissure of the vulvar lips. The urethral tubercle is located on the ventral wall of the vestibule just caudal to the vestibulovaginal junction and contains the urethral orifice. When performing vaginoscopy, care is taken to ensure the endoscope is not introduced into the clitoral fossa or into the urethra instead of the vagina. The cingulum is found just cranial to the urethral tubercle as an annular, narrow, bandlike constriction, which acts as a functional sphincter at the vestibulovaginal junction (Fig. 12-1).

### Body of the Vagina

The *body of the vagina* is a tubular structure extending from the cingulum to the cervix. The vagina is lined with

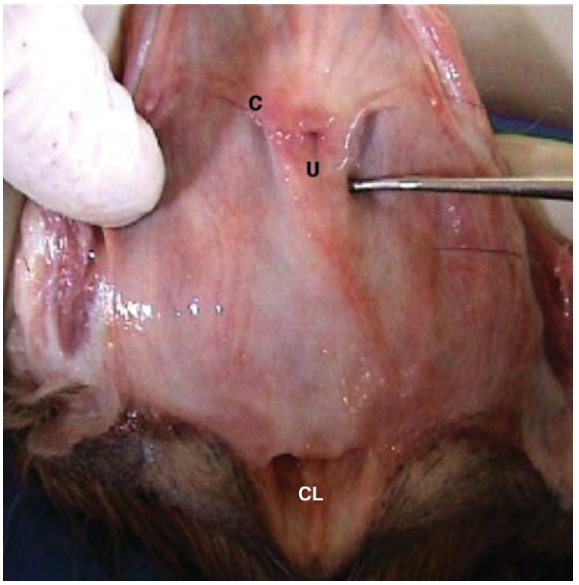



**Fig. 12–1**
Vestibule. View of the ventral surface illustrating the position of the clitoris within the clitoral fossa (*CL*), urethral tubercle and urethral orifice (*U*), and cingulum (*C*).



**Fig. 12-2**
Body of the vagina. This anestrus tract illustrates the longitudinal mucous membrane folds.

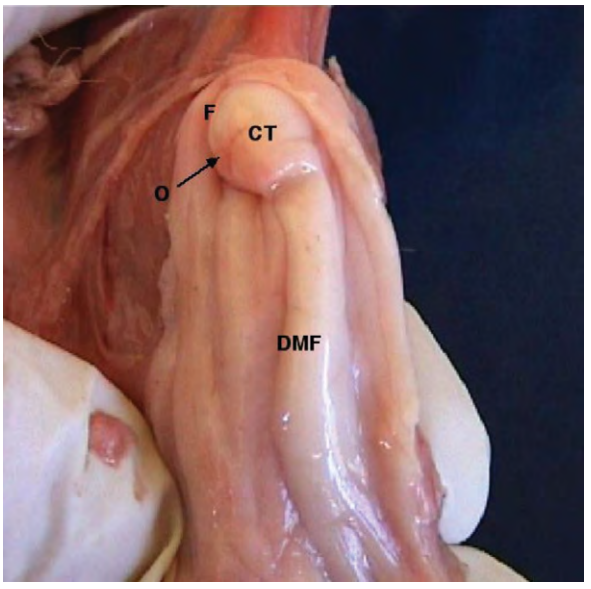



**Fig. 12-3**
Paracervix. The dorsal median fold (*DMF*) extends cranially to the cervical tubercle (*CT*). The almost ventral location of the external cervical os is apparent (*O*). The fornix (*F*) is the space cranioventral to the cervical tubercle.

mucosa that has longitudinal folds that vary significantly in size, shape, and appearance depending on the stage of the reproductive cycle (Fig. 12-2).

### Paracervix

The cranial portion of the vagina presents the most significant features with respect to endoscopic examination (Fig. 12-3). The dorsal median fold (DMF) is a well-developed fixed ridge that dominates the *paracervix*. The DMF is important because it significantly reduces the vaginal lumen in the approach to the cervix, limiting the diameter of instrumentation that can be passed through this area. The transition to the paracervical area is obvious as the DMF reduces the vaginal lumen to a crescent shape. The DMF extends cranially to the cervical tubercle, which is the vaginal portion of the cervix and is tubular in shape in most bitches. The cervix lies diagonally across the uterovaginal junction, so the cervical canal is directed craniodorsally from the vagina to uterus. This means that the external orifice is directed toward the vaginal floor. The vagina is limited cranially by the fornix, which is a slit-like space cranioventral to the cervical tubercle. The cervical canal is patent throughout the reproductive cycle of the bitch, but catheterization can be performed more readily at some stages of the cycle than others.

## ENDOSCOPIC TRANSCERVICAL INSEMINATION

The ability to reach the cervix with a rigid endoscope allows transcervical catheterization and intrauterine insemination of frozen semen.

### Equipment

The specifications for equipment to perform TCI are particularly exacting due to the wide range of patient sizes, the long vagina, and the narrow paracervical area. The equipment used is a rigid cystourethroscope (Storz Extended Length 30-degree Cysto-urethroscope: Telescope 325B, 3.5 mm Sheath 027KL Bridge 027NL, Goleta, Calif), which consists of a telescope with a 30-degree oblique viewing angle, a sheath, a bridge, and an external light source. The working length of the assembled endoscope is 29 cm and the sheath has a diameter of 22 French (Fig. 12-4). A video camera can be attached to the endoscope but is not essential. For TCI, an 8-French urinary catheter is appropriate in most bitches for cervical catheterization. A 6-French catheter is sometimes required in small or maiden bitches.

During estrus when exhibiting standing behavior, bitches readily tolerate vaginoscopic examination in the standing position without any need for sedation. The bitch is restrained in a standing position on a specially designed platform on a hydraulic table. The platform provides a tie point to the dog's collar, and a canvas band around the abdomen restricts sideways movement and discourages any attempts to sit. The use of a hydraulic table and chair ensures the optimum position of the bitch relative to the operator during the procedure (Fig. 12-5).




**Fig. 12-4**
Endoscopic equipment for transcervical insemination consists of a 30-degree extended length cystourethroscope **(A)**, sheath and bridge **(B)**, obturator **(C)**, light source and cable **(D)**, and camera **(E)**.

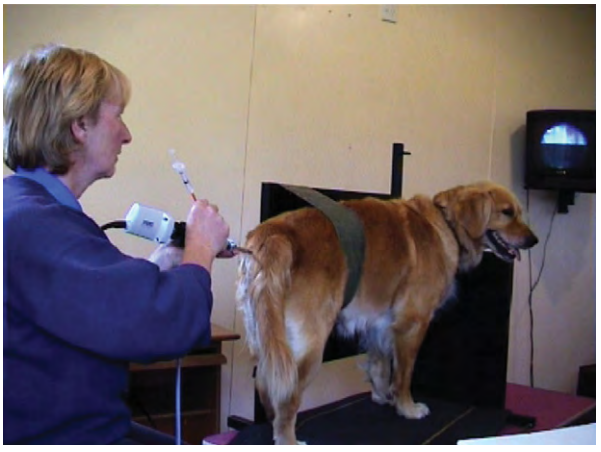


**Fig. 12-5**
Endoscopic transcervical insemination. The bitch is restrained on a specially designed platform. The abdominal band limits sideways movement and attempts to sit.

## Technique

Lubrication of the endoscope sheath is required to ensure easy passage of the scope through the vaginal folds. The quantity of lubricant is minimized.

The endoscope is introduced through the dorsal commissure of the vulvar labia to avoid the clitoral fossa and clitoris just inside the ventral commissure. The angle of introduction is important to take into account the craniodorsal slope of the vestibule and ensure smooth passage up and over the pelvic brim. The urethral orifice on the floor of the vestibule is avoided to keep from passing the tip of the endoscope into the urethra, which bitches generally resent. Once past the cingulum and into the folds of the vagina, the scope is advanced under gentle pressure, observing and following the direction of the vaginal lumen. During proestrus and early estrus, the rounded vaginal folds and excess fluid can make advancing the scope more difficult, because the folds tend to fill the lumen. The insemination catheter can be used to keep folds off the tip of the scope. During estrus, dehydration and shrinkage of the folds results in a more spacious vaginal lumen (Fig. 12-6). It is important to keep the tip of the scope in the lumen as much as possible, because it makes advancing the scope much easier. Most bitches resent the tip being pushed along the dorsal wall. The direction of the vaginal lumen can vary significantly between bitches from horizontal to sharply angled up or down.

It is important to identify landmarks as the scope is advanced through the body of the vagina and to be able to pass the endoscope into the paracervical region with its distinct narrow crescent lumen and DMF (Fig. 12-7). The scope can be passed either down the side of the DMF or under it, depending on the amount of available space. The vaginal portion of the cervix appears as a distinct tubercle below the DMF. The cervical os is frequently not immediately apparent because of its ventral location. The scope is manipulated under the tubercle until the cervix can be visualized (Fig. 12-8). The external cervical os is typically located in the center of a rosette of furrows in most bitches, although in maiden bitches and in some mature bitches it is less obvious. The presence of fluid issuing from the os can aid in identifying its position.

The catheter is introduced into the cervical os by manipulation of the endoscope and catheter. Once the tip of the catheter is in the os, it is steadily advanced using a twisting movement to aid its passage through the cervical canal. For semen deposition, the catheter is passed in as far as it will go without force before the semen is inseminated. The semen is inseminated slowly and the catheter is visualized at all times to ensure there is no excessive backflow or leakage of semen (Fig. 12-9). If leakage occurs, the catheter is repositioned slightly within the uterus, either further in or withdrawing slightly, and insemination recommenced. A small amount of air is introduced into the catheter to ensure all the semen is inseminated.

Bitches in estrus and exhibiting standing behavior show excellent tolerance to the technique. Sedation has not been necessary. Air insufflation and irrigation are commonly used in association with diagnostic endoscopic techniques, but for TCI, air insufflation is not necessary, because any folds obscuring vision can be readily deflected using the tip of the insemination catheter. Care must be taken to not compromise semen viability in any way, so irrigation is considered inadvisable.

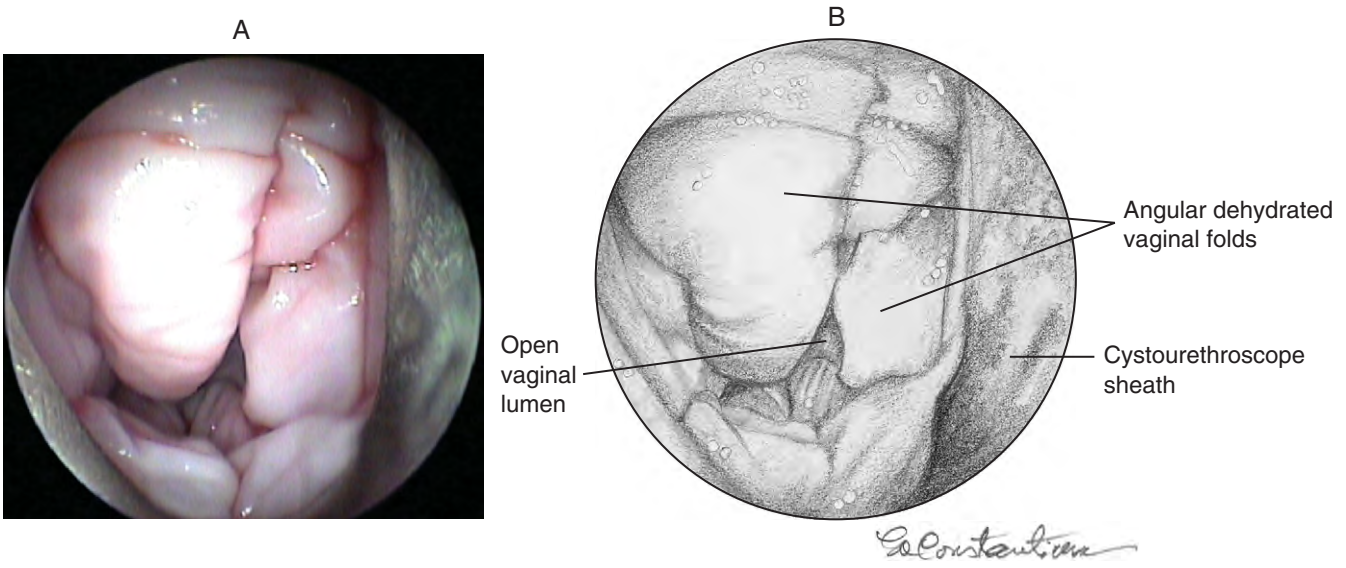



**Fig. 12-6**
In late estrus, shrinkage of the vaginal folds provides an obvious route through the body of the vagina.

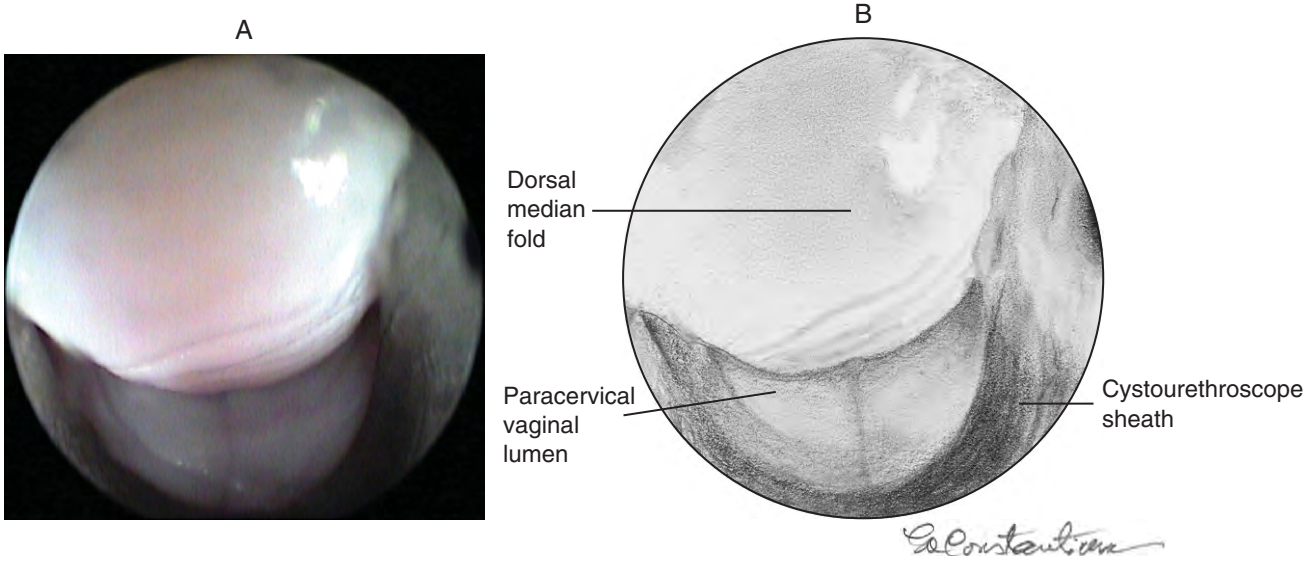



**Fig. 12-7**
The distinct appearance of the dorsal median fold and narrow crescentic vaginal lumen clearly identify the paracervical area.

## The Learning Curve

The theory of TCI is simple, but clinicians can expect to encounter some problems and difficulties when learning the procedure. It is essential that the correct equipment be used to reach the cervix. Even though breeds range widely in size and shape, TCI is possible in most bitches with the correct equipment. In a few bitches the paracervix is too tight for the procedure. Learning is facilitated by practicing on bitches that are of medium size, have had at least one litter, and are well into estrus. Many learning problems relate to lack of familiarity with the anatomy of the region. It is vital for operators to be able to identify the anatomy in which they are working and to know what the cervical os looks like, where it is usually located, and how to search for it in a systematic way. Once the cervical os can be located, catheterization should be possible as long as pressure is applied at the correct angle to take into account the angle of the cervical canal. Sometimes progress is limited by the diameter of the canal and a smaller gauge catheter is necessary. Vaginal discharges

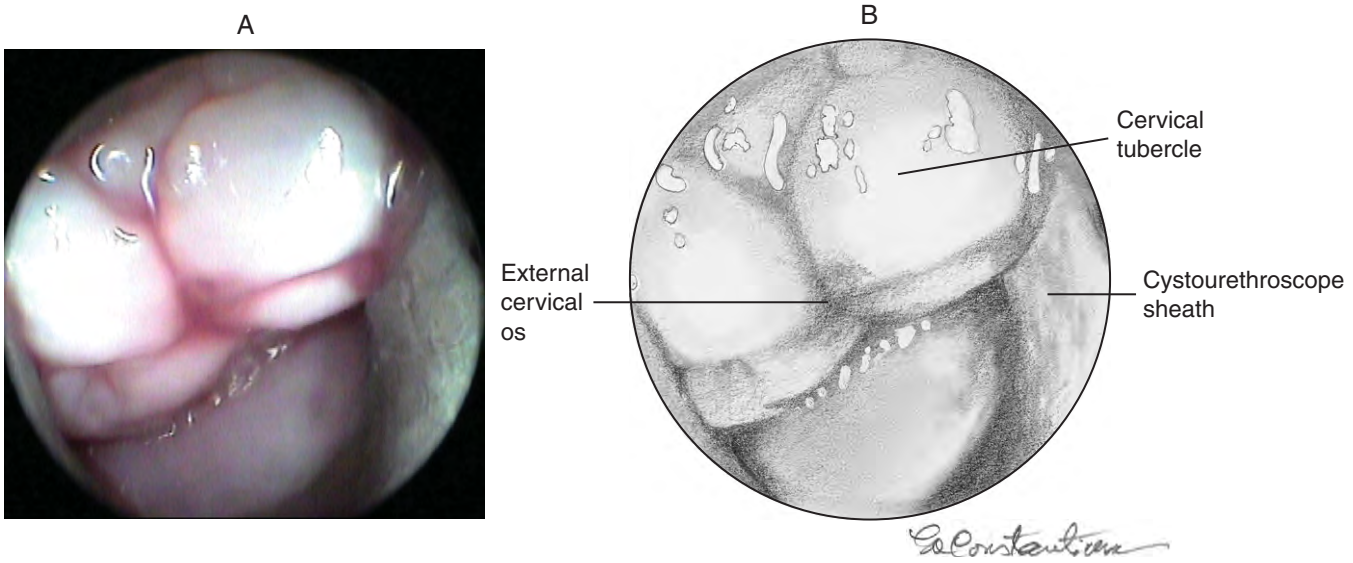



**Fig. 12-8**
The position of the cervical os within the rosette of furrows on the cervical tubercle can be identified by fluid issuing from it.

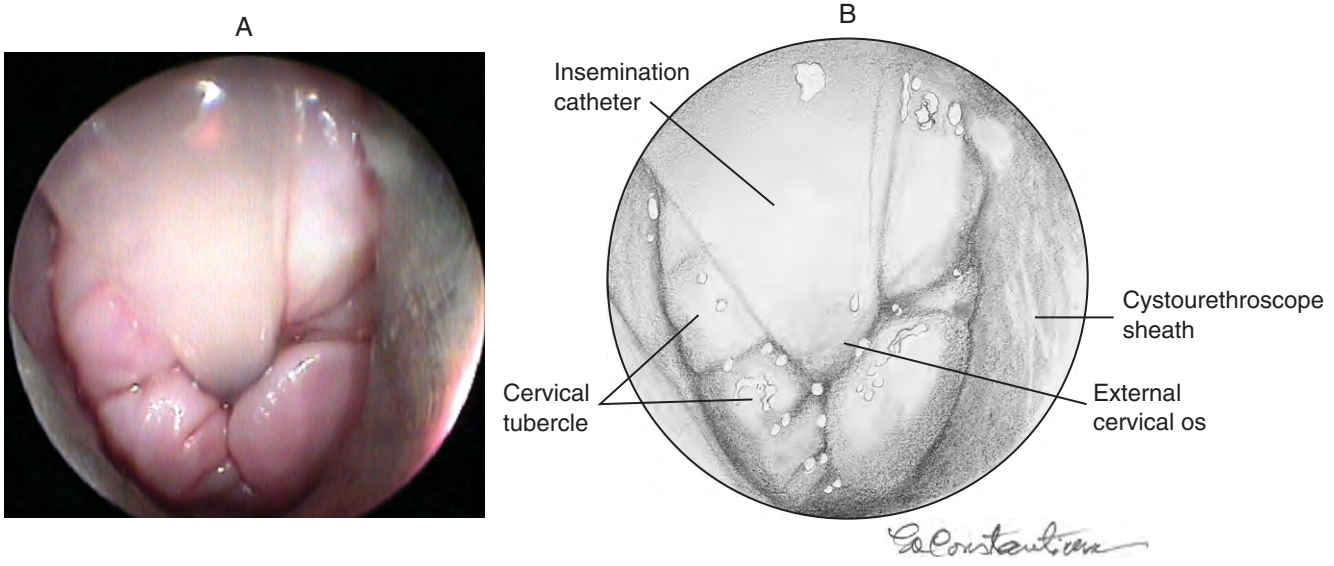



**Fig. 12-9**
The catheter containing semen can be seen within the cervical os. The insemination is observed to ensure that catheter position is maintained during semen injection and that no backflow occurs.

can result in poor visibility, causing significant problems, particularly during the learning phase. Visibility may clear with time or with repositioning of the telescope, or it may be necessary to withdraw the telescope from the sheath and rinse its tip. Occasionally it is possible to draw off the discharge through the catheter.

## Intrauterine Deposition

Visualization of the cervix eliminates any doubt that the catheter is positioned correctly in the uterus and continued viewing of the insemination process ensures that the semen is deposited in the uterus. Use of a video camera allows the client to observe the intrauterine deposition of the semen along with the veterinarian.

## Safety

The risk of trauma or infection resulting from this procedure is an important consideration. It is unlikely that the plastic urinary catheter could perforate the vaginal or uterine wall during estrus unless a pathologic condition

already exists. However, the paracervical area can be traumatized by the endoscope if inappropriate force is used. If the bitch exhibits obvious discomfort while the endoscope is being advanced, the procedure should be stopped. Introduction of infection into the uterine environment during TCI has been a concern but is unlikely. The vagina is not a sterile environment during proestrus and estrus, and bacteria are routinely isolated from the uterus and vagina without apparently causing any problems. This is possibly due to a greater resistance to infection at these phases of the estrous cycle. Therefore it is reasonable to assume that advancing a catheter from the vagina into the uterus at this time will not cause any problems. However, care must be taken to ensure that no new infections are introduced as a result of inadequately cleaned equipment or from the environment through poor technique.

### Frozen Semen Insemination

Endoscopic TCI provides intrauterine deposition of semen but is only successful when all the other factors important in frozen semen technology are taken into account. These include timing of insemination, semen quality, and bitch fertility. The ability to do repeat inseminations has been reported to increase conception rates and litter size. With semen of lower quality, repeat inseminations allow more semen to be deposited over a longer period. Repeat inseminations are also useful when optimum insemination time is difficult to define.

### Fresh or Chilled Semen Insemination

The endoscope is not reserved for use for frozen semen insemination. TCI was developed for intrauterine deposition of frozen semen, but it can be used equally well for fresh semen and chilled semen inseminations. Repeat inseminations can be done when appropriate with no apparent stress to the bitch. TCI is particularly advantageous when fresh semen quality is poor. Using TCI for fresh and chilled inseminations not only results in excellent conception rates and litter sizes but also provides the operator with the opportunity to develop experience and expertise with the technique.

## OTHER TRANSCERVICAL INSEMINATION APPLICATIONS

The TCI technique has been used to study the intrauterine environment with respect to microbiology and cytology throughout the reproductive cycle of the bitch, rendering valuable research information. When examinations are performed during anestrus and diestrus, the vaginal walls are thinner and more susceptible to trauma, so extreme care must be taken in these situations. Bitches do not tolerate the endoscope well when not in standing heat, so sedation is usually required. This also means they will not react to inappropriate manipulation of the endoscope, further emphasizing the need for extreme care. Air insufflation or fluid irrigation is helpful during anestrus and diestrus, because the vaginal wall tends to cling to the scope. The uterus is likely to be more susceptible to infection during diestrus, when under the influence of high progesterone levels, requiring particular attention to aseptic technique.

With the ability to catheterize the cervix, new diagnostic procedures and therapies may become possible.

## VAGINOSCOPY: ESTROUS CYCLE

The vaginal mucosa is a target for reproductive hormones, and changing levels of reproductive hormones alter the appearance of the mucosa in ways that can be appreciated by endoscopic examination. This provides a useful method for identifying the stages of the cycle.

### Equipment

It is not necessary to advance the scope into the paracervix for monitoring the estrous cycle, so a wide range of endoscopes can be used. For examination to determine progress through estrus, the bitch can usually be restrained as for TCI without the need for sedation.

### Technique

Changes in the appearance of the mucosa are more advanced as the scope is moved cranially in the vagina, so it is desirable to always examine bitches at the same distance into the vagina to make valid comparisons. The assessment is made as the scope is passed into the body of the vagina.

### Proestrus

As a result of estrogen stimulation, the mucous membrane folds increase in number, become markedly edematous, and fill the lumen of the vagina. The folds are rounded, even in outline, and have a shiny, moist appearance (Fig. 12-10). A clear, bright-red fluid is seen among the folds in the vagina and flooding through the external os of the cervix. The dorsal median fold of the vagina is prominent and fills the paracervical lumen, leaving a narrow crescentic channel for access to the cervix. In the later stages of proestrus, as estrogen levels begin to decrease before ovulation, dehydration of the mucosa begins. There is progressive loss of edema, and the mucosa develops a wrinkled surface (Fig. 12-11).

### Estrus

In early estrus, the shrinking stage results in mucosal folds that no longer fill the vaginal lumen and the mucosa becomes increasingly pale (Fig. 12-12). Continuing

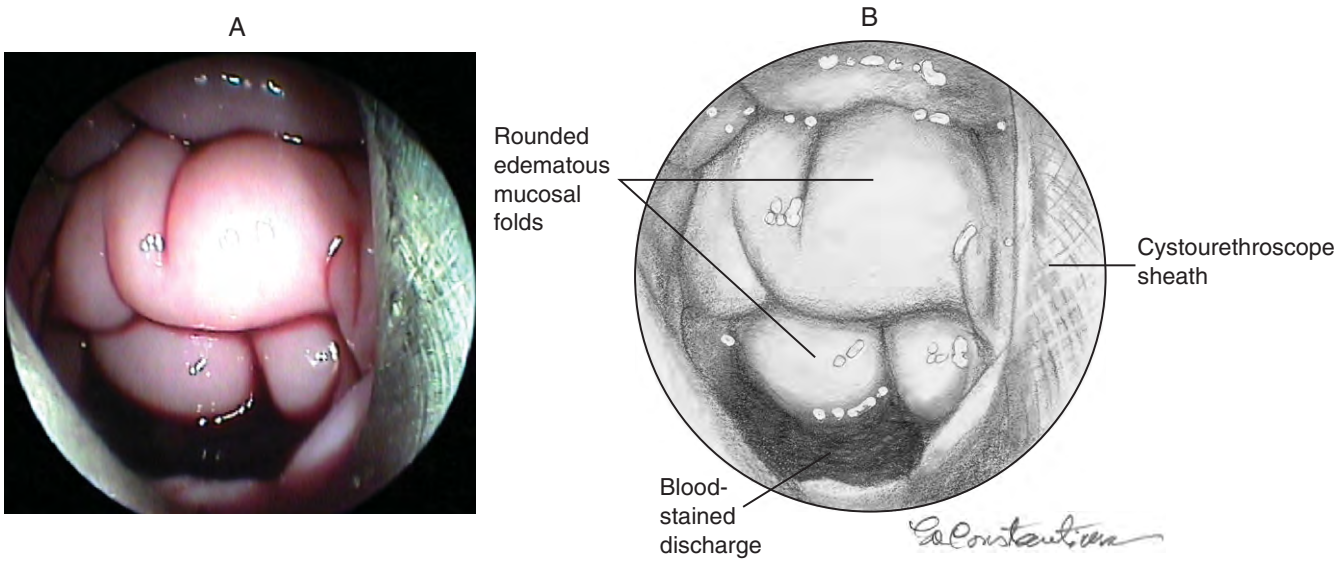



**Fig. 12-10**
Early proestrus. The mucosa is rounded, shiny, and moist, with the folds filling the lumen. Large quantities of blood-stained discharge are evident.

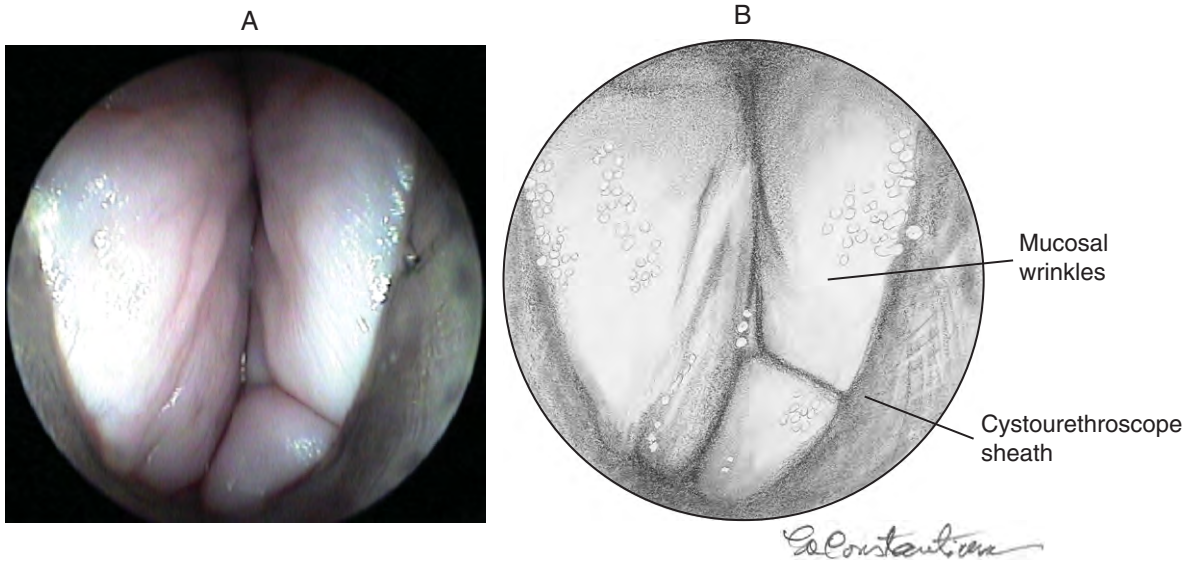



**Fig. 12-11**
Late proestrus. The wrinkled surface of the mucosa indicates the beginning of dehydration as estrogen levels begin to decrease.

dehydration of the mucosa causes the profile of the folds to become sharp and peaked, with the dorsal median fold appearing increasingly shrunken and distorted. By late estrus all the folds are extremely shrunken and angular, with the vaginal lumen appearing wide (Fig. 12-13).

## Diestrus

Diestrus is signaled by a "rounding out" of the angular folds (Fig. 12-14). The mucosa shows areas of patchy hyperemia, and the discharge becomes thicker. The mucosal folds once again acquire a round profile, but they remain low and indistinct, leaving a wide vaginal lumen, unlike the proestrous picture.

## Anestrus

During anestrus, examination reveals low mucous membrane folds, which are simple and rounded in outline. The mucosa has a scant mucous coating and is a diffuse

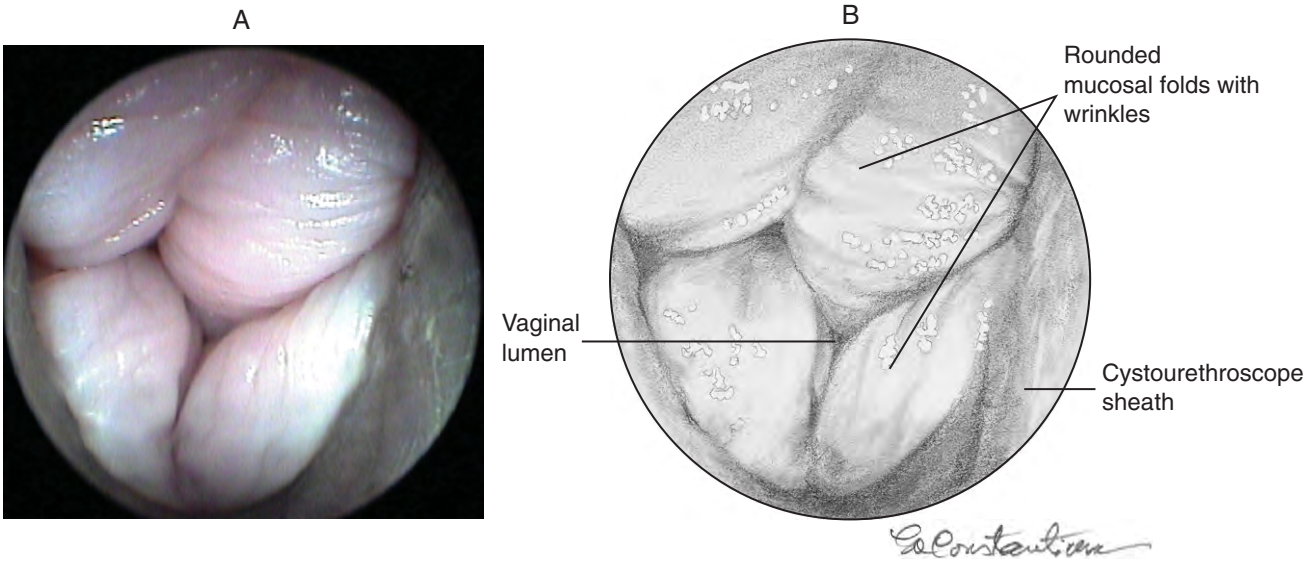



**Fig. 12-12**
Early estrus. The mucosal folds no longer fill the vaginal lumen, but at this stage, although the surface is wrinkled, the profile of the fold remains rounded.

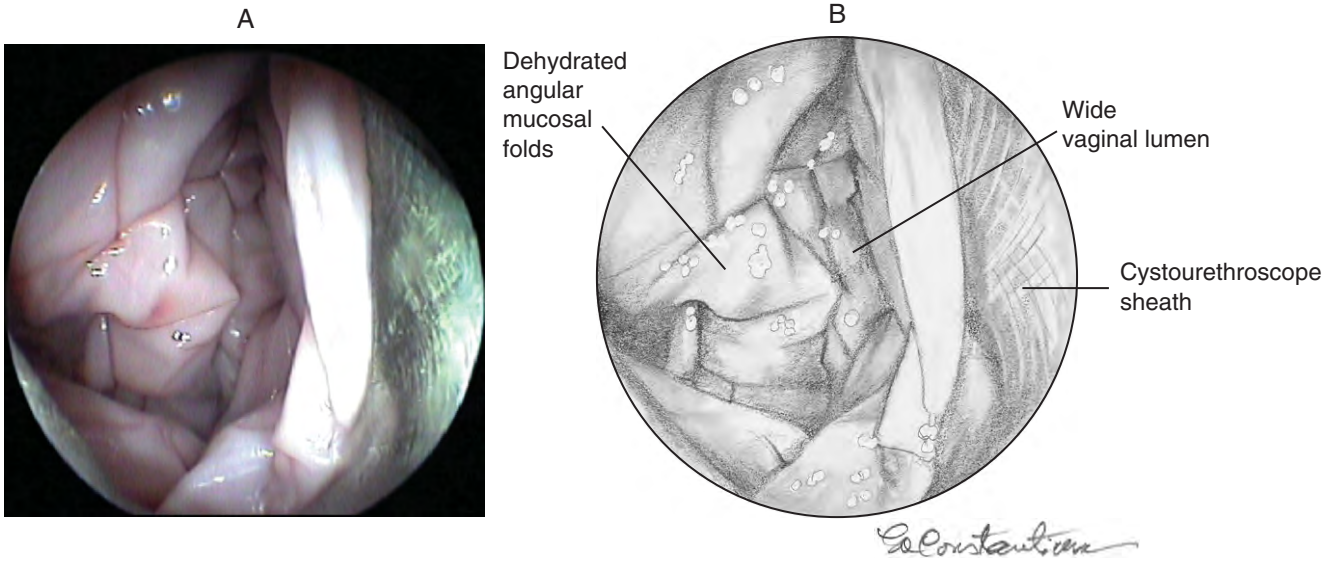



**Fig. 12-13**
Late estrus. Continued dehydration causes the profile of the folds to become angular and the vaginal lumen wide.

pink-red color. At this stage the mucosa is thin and extremely susceptible to trauma (Fig. 12-15).

The endoscopic appearance of the vagina can be divided into four clearly defined stages: edematous, shrinkage without angulation, shrinkage with angulation, and rounding out. Progress through the estrous cycle can be readily appreciated using these phases. Correlation between these stages and other events in the cycle has been established. The initial phase of shrinkage without angulation occurs from around the time of the preovulatory luteinizing hormone (LH) surge until ovulation. Development of angulation is associated with the period of ovulation and oocyte maturation. The rounding-out phase corresponds to the shift in cell type seen in vaginal smears, indicating the onset of diestrus.

Even though the degree of shrinkage and angulation varies among bitches, the timing relative to other events appears to be reasonably consistent, making vaginoscopic

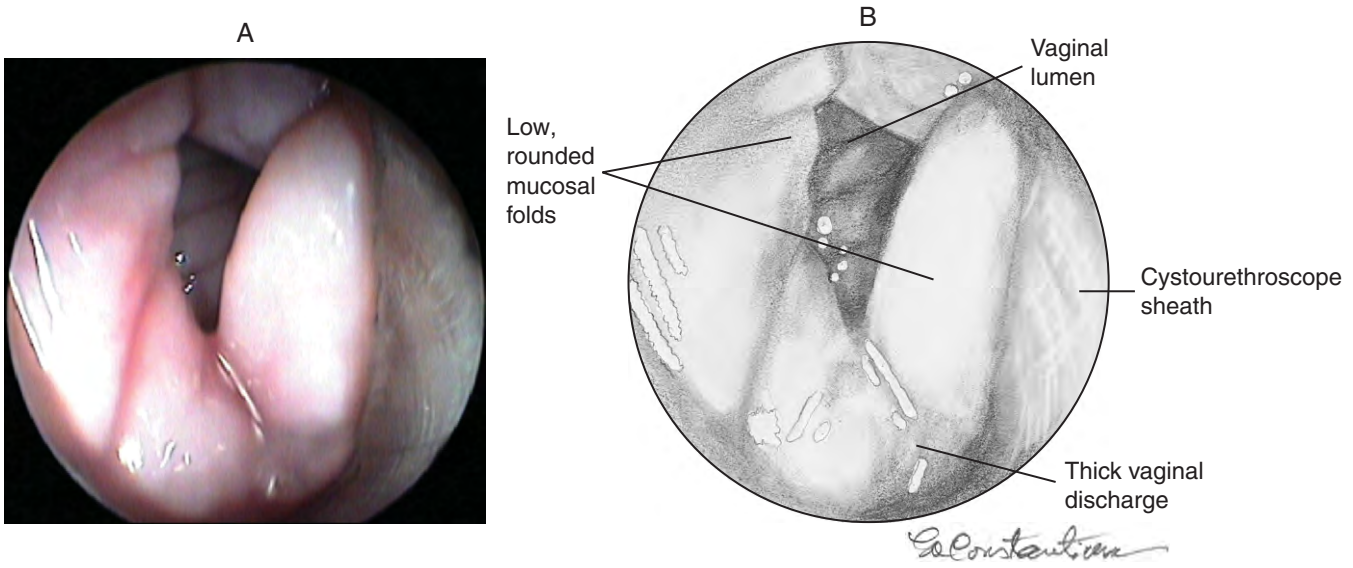



**Fig. 12-14**
Diestrus. The vaginal folds become hyperemic and flatten with progress to diestrus. The vaginal discharge becomes distinctly thick.

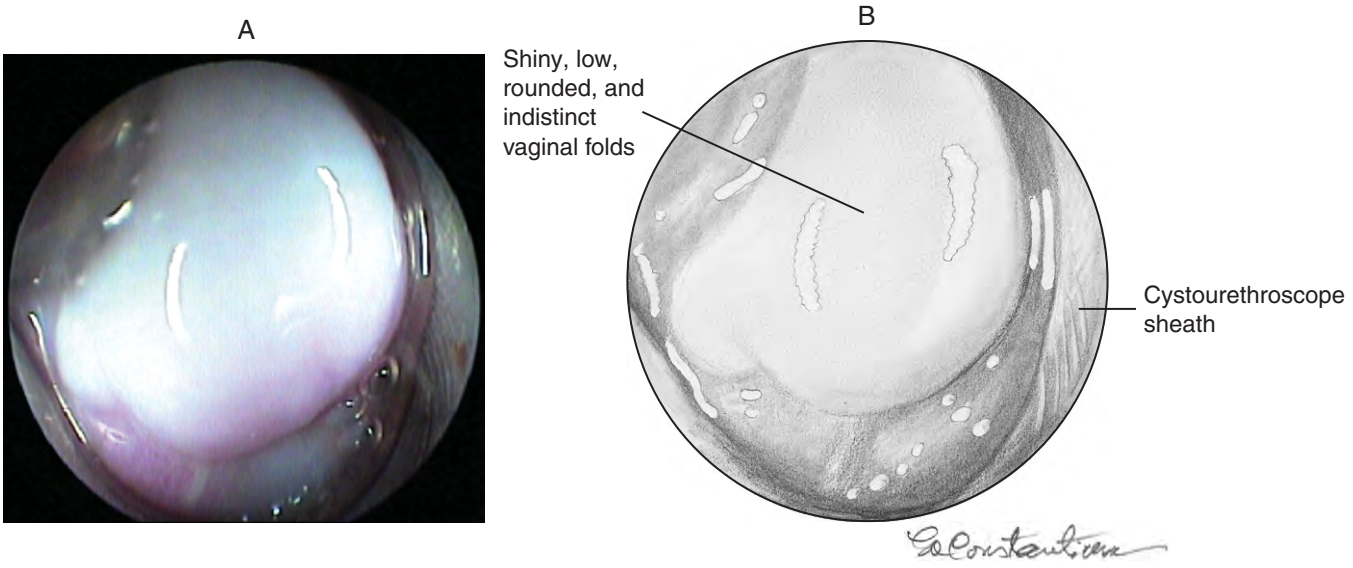



**Fig. 12-15**
Anestrus. The folds are shiny, moist, and featureless and cling to the scope, making air insufflation helpful for examination at this stage of the cycle.

examination a valuable technique in breeding management. The angulated period is the time recommended as optimum for natural mating and artificial insemination with fresh semen. Vaginoscopic changes reflect changes in estrogen levels and do not actually identify ovulation, so progesterone assays are required to confirm ovulation. When using frozen semen or in bitches with fertility problems, optimum timing of insemination is critical and is determined using a combination of vaginoscopy, vaginal cytology, progesterone assay, and LH assay (if available).

## VAGINOSCOPY: GENERAL

In addition to the specific applications described, vaginoscopy can be useful as a routine diagnostic technique. The most appropriate equipment depends on the

presenting problem and the probable location of the cause. The TCI endoscope provides the best possible access to the full length of the vagina, but other scopes can be used for more caudal examinations.

### Fertility Problems

Vaginoscopy allows the clinician to examine the vagina and evaluate any abnormalities found as possible causes of infertility. Bitches may be presented because natural matings are not possible or because the bitch has failed to conceive. Common problems encountered include congenital malformation of the tract in maiden bitches, strictures that vary in type and severity, scar tissue developed after difficult whelpings, and vaginal masses. The cingulum is normally narrowed, but pathologic annular strictures are relatively common and prevent natural matings. There are rarely any problems passing an endoscope in these situations as long as care is taken to identify the restricted lumen. Bitches with cingulum strictures usually whelp without assistance. Vaginal bands may prevent artificial insemination and may require surgical correction. The tendency for these abnormalities to run in families should not be overlooked in any breeding program.

### Vulvar Discharges

Bitches are frequently presented with vulvar discharges that could originate from the uterus, vagina, bladder, or vestibule. Vaginoscopic examination allows the clinician to determine the site of the discharge, identify lesions, take appropriate samples, and, in some cases, correct problems.

### Whelping

Vaginoscopy can be useful before, during, and after whelping, supplying valuable information regarding the state of the vaginal wall, cervix, and whelps.

## SUGGESTED READING

Jeffcoate IA, Lindsay FEF: Ovulation detection and timing of insemination based on hormone concentrations, vaginal cytology and the endoscopic appearance of the vagina in domestic bitches, *J Reprod Fertil (Suppl)* 39:277-287, 1989.

Lindsay FEF: The normal endoscopic appearance of the caudal reproductive tract of the cyclic and non-cyclic bitch: post uterine endoscopy, *J Small Anim Pract* 24:1-15, 1983.

Watts JR, Wright PJ: Investigating uterine disease in the bitch: uterine cannulation for cytology, microbiology and hysteroscopy, *J Small Anim Pract* 36:201-206, 1995.

Watts JR, Wright PJ, Whithear KC: Uterine, cervical and vaginal microflora of the normal bitch throughout the reproductive cycle, *J Small Anim Pract* 37:54-60, 1996.

Wilson MS: Transcervical insemination techniques in the bitch, *Vet Clin North Am Small Anim Pract* 31:291-304, 2001.

# 13 Otheroscopies

*Timothy C. McCarthy*

There are a number of endoscopic procedures that, although minor in case numbers, are of significant importance in their application on a patient by patient basis. These include transabdominal nephroscopy and ureteroscopy (TANU), vaginoscopy (see Chapter 12), prepucoscopy, fistuloscopy and laceroscopy, oculoscopy, oncoscopy, and analsacoscopy. These procedures are performed with the rigid instrumentation that is used for the major endoscopies, and additional equipment is not needed.

## TRANSABDOMINAL NEPHROSCOPY AND URETEROSCOPY

Renal and ureteral calculi in small dogs and cats are difficult to remove surgically, and the complications associated with surgery have established conservative treatment as the procedure of choice for their management. Visualization and access to renal and ureteral calculi is greatly enhanced by using a small-diameter rigid endoscope. After it was discovered that the open fillet nephrotomy technique for renal calculi removal essentially destroyed the kidney, leaving a small ball of dysfunctional scar tissue, renal calculi have been left untouched unless they are symptomatic. Using TANU, these calculi can be removed with minimally invasive technique, minimal renal trauma, and subsequent minimal loss of functional renal tissue.

To perform TANU, the abdomen is opened with a standard full-length ventral midline abdominal incision. Balfour retractors are placed, and appropriate exposure to the kidney and involved portion of the ureter is established with abdominal organ retraction and packing with moistened surgical gauze sponges or laparotomy sponges. If indicated, the kidney can be freed from its abdominal wall attachments and packing placed dorsal to the kidney to elevate it to facilitate access and to stabilize the kidney.

Three different calculi conditions are encountered: renal and ureteral calculi, renal calculi without ureteral calculi, and ureteral calculi without renal calculi. Each is approached differently, and each approach is affected by how far the ureteral calculi have migrated down the ureter. The easiest cases are those with a ureteral calculus that has produced significant ureteral dilation and the calculus is still close to the kidney, within the proximal 2 to 3 cm of the ureter. With this configuration, a ureterotomy is performed proximal to the calculus on the ventral aspect of the ureter or on the ventromedial aspect of the ureter on the convex surface where the ureter coming from the renal pelvis in a lateral to medial course makes the bend to its cranial to caudal course toward the bladder. This incision location allows access to both the distal ureter and the renal pelvis. A small rigid telescope (1.9-mm arthroscope, 2.4-mm arthroscope, or 2.7-mm multipurpose rigid telescope) with an arthroscopy cannula or a cystoscopy cannula is placed into the ureter and directed toward the calculus to be removed. Using continuous gravity flow irrigation with saline or Ringer's solution, for distention and to maintain a clear visual field, the calculi are visualized (Fig. 13-1) and removed (Fig. 13-2). Rigid endoscopic graspers are passed beside the arthroscopy cannula, or flexible instruments are used through the operating channel of a cystoscopy cannula. Irrigation flow is also used to dislodge smaller calculi and fragments of larger calculi to "float" them out of the ureterotomy incision or through a second cannula (Fig. 13-3). When all calculi have been removed (Fig. 13-4), the ureter is examined (Fig. 13-5) and irrigated distally to ensure patency into the bladder. For cases with only ureteral calculi, the procedure is completed and the ureterotomy is closed. In cases with ureteral and renal calculi, when all calculi in one direction have been removed, the instrumentation is repositioned in the other direction and the remaining calculi are removed. Ureterotomy closure is achieved with a double continuous pattern (baseball stitch) of 6-0 to 8-0 monofilament suture material using an operating microscope.

For cases with only renal calculi, a stab incision is made on the ventral surface of the kidney into the renal

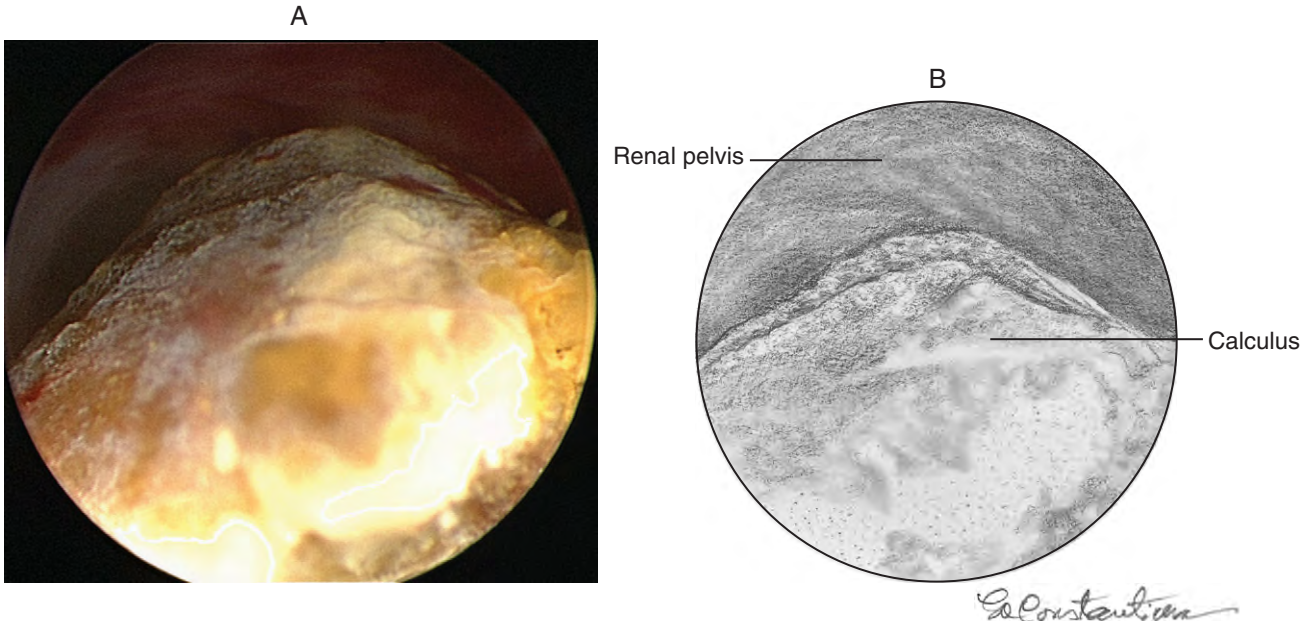



**Fig. 13-1**
Calculus visible in the renal pelvis of a cat.

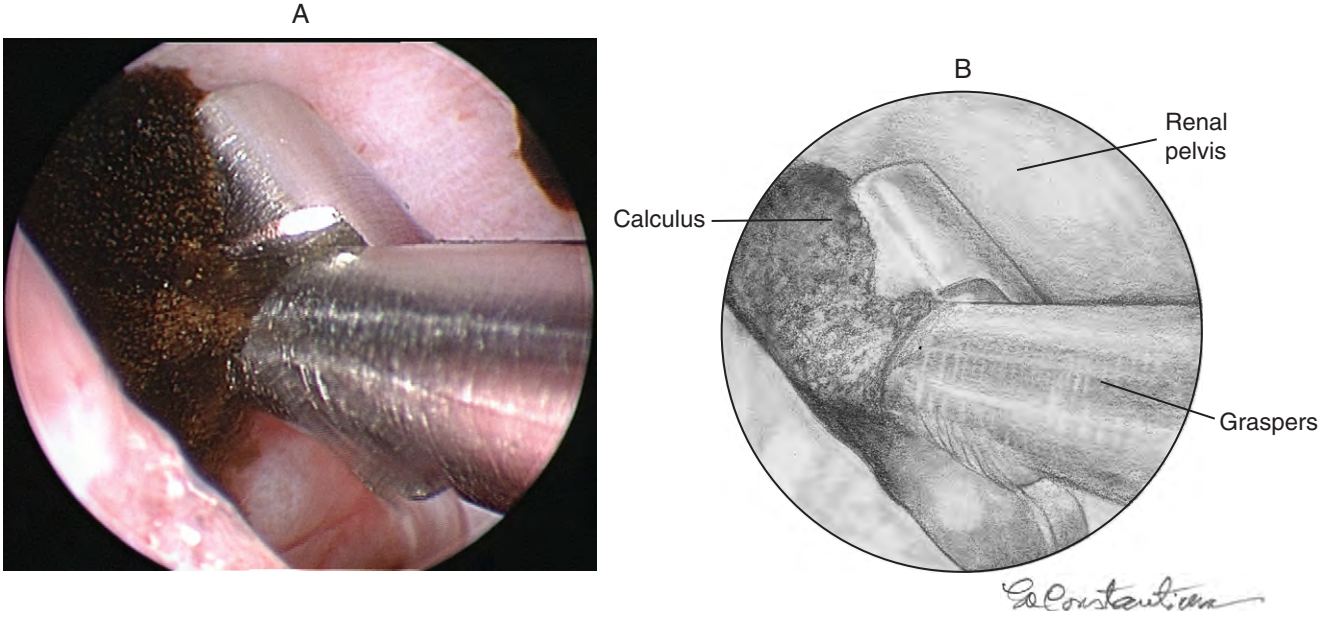



**Fig. 13-2**
Grasping a renal calculus with 2-mm diameter arthroscopic graspers.

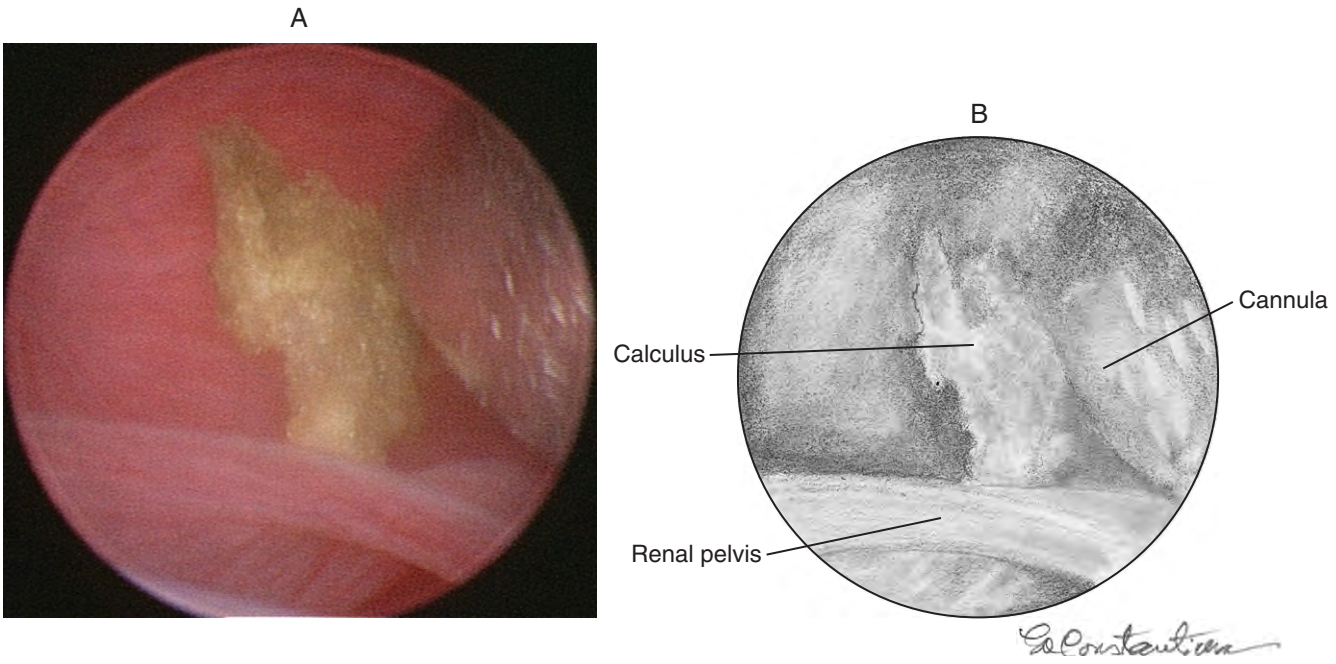



**Fig. 13-3**
Floating a small calculus out through a 2-mm diameter arthroscopy instrument cannula.

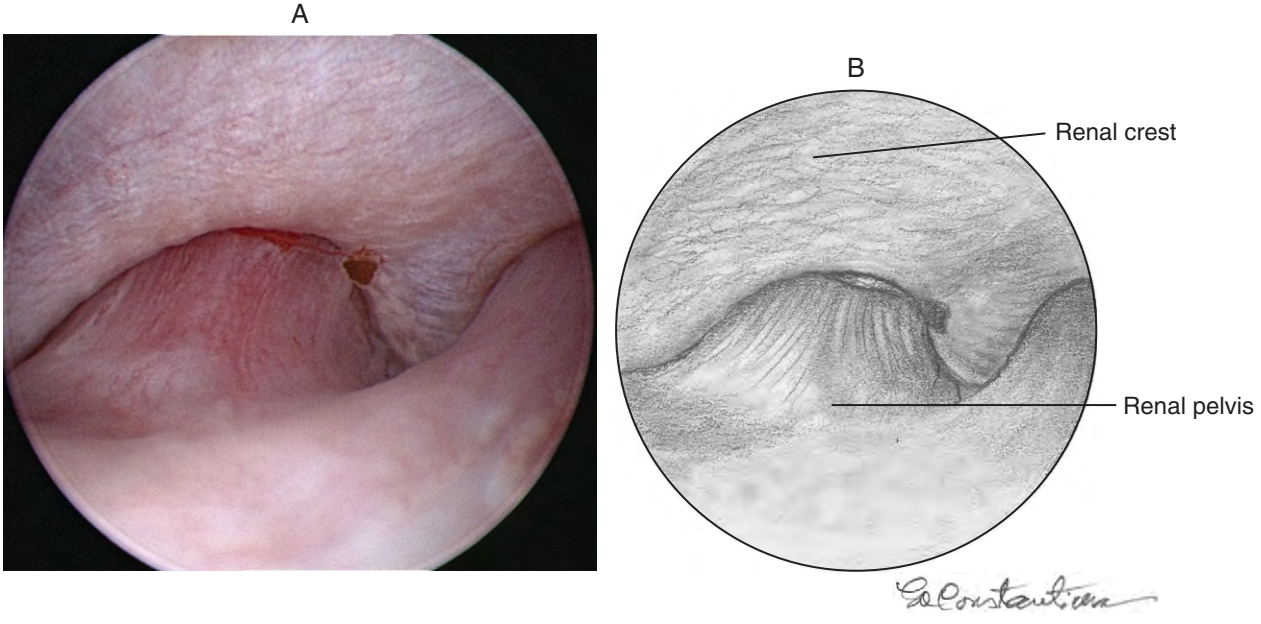



**Fig. 13-4**
Renal pelvis after removal of all calculi.

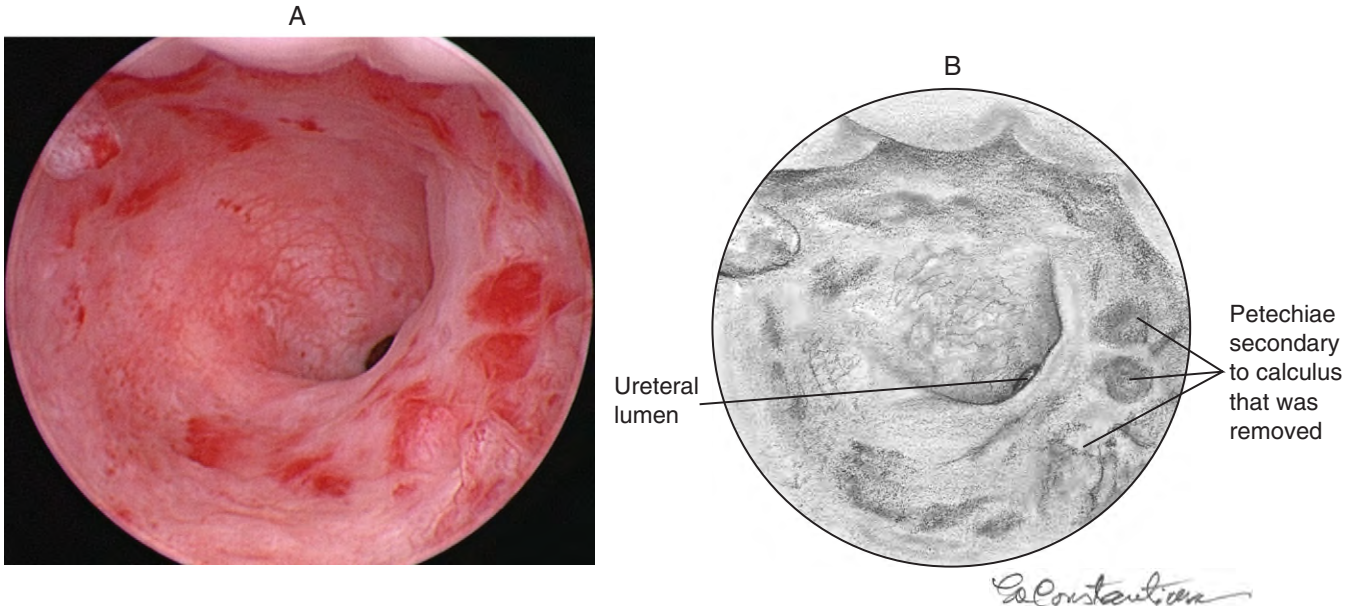



**Fig. 13-5**
Ureter after removal of all ureteral calculi.

pelvis for telescope placement, or the origin of the ureter is exposed and the endoscope placed into the renal pelvis through an incision at the junction of the renal pelvis and ureter if the patient is large enough for this to be possible. The renal calculi are removed with the same instrumentation and technique as used for ureteral calculi. All recesses of the renal pelvis are explored with the endoscope to remove all visible calculi (see Fig. 13-4). Magnification of the telescopes greatly enhances locating and removing small calculi and fragments of larger calculi that are crushed during removal. The nephrotomy incision is closed with 4-0 to 6-0 monofilament suture material with a double continuous pattern.

Success of this technique is critically dependent on removal of all ureteral calculi and patency of the ureter distal to the ureterotomy incision. If there is residual obstruction of the ureter, urine will leak from the ureterotomy closure. An operating microscope is essential for accurate, urine-tight ureterotomy closure. Excretory urography is routinely performed 24 to 48 hours after the procedure to confirm ureteral patency and ureterotomy closure integrity.

TANU is the most difficult, tedious, picky, time-consuming, frustrating endoscopic procedure currently being performed in small animal practice. It is not recommended for the beginning endoscopist. This is also a technique that cannot be performed under time pressure. Successful removal of renal and ureteral calculi is the reward for performing this difficult technique.

## VAGINOSCOPY

Vaginoscopy uses the same technique and instrumentation as for transurethral cystoscopy in the female dog and cat. Use of a rigid endoscope with fluid or gas for vaginal distention provides superior visualization when compared with speculum or test tube examination techniques. Vaginoscopy also provides better visualization with far less trauma than surgical exposure. Indications for vaginoscopy include urinary incontinence, stranguria, vaginal masses, trauma, persistent vaginal bleeding or discharge, evaluation of stages of the estrus cycle, and transcervical insemination. The 2.7-mm multipurpose rigid telescope, the 1.9-mm diameter cystoscope, the 4-mm cystoscope, or an arthroscope with the appropriate cystoscopy or arthroscopy cannulae can be used effectively for vaginoscopy. Endoscope selection depends on patient size and instrumentation available.

Sedation or general anesthesia is used, depending on the indication for vaginoscopy, patient disposition, and preference of the operator. The endoscope is directed into the vaginal vestibule, the vulva is occluded around the telescope, liquid or gas flow is initiated to distend the vagina, and examination is performed by passing the endoscope along the vagina rather than into the urethra. Saline or lactated Ringer's solution has been most commonly used for vaginoscopy with a standard liter bottle or bag and an intravenous administration set connected to the infusion port on the telescope cannula. Biopsy

specimens are obtained or foreign bodies removed with rigid forceps passed alongside the telescope or with flexible forceps passed through the operating channel of a cystoscopy cannula.

Normal structures seen with vaginoscopy include the clitoris (Fig. 13-6), clitoral fossa (Fig. 13-7), urethral orifice in the vaginal vestibule (Figs. 13-8 and 13-9), crypts of McCarthy (Fig. 13-10), vaginal mucosa and mucosal ridges (Figs. 13-11 and 13-12), dorsal median fold (Fig. 13-13), and opening of the cervix (Fig. 13-14). Ectopic ureters (see Chapter 4), vaginal tumors (Figs. 13-15 and 13-16), foreign bodies (Figs. 13-17 and 13-18), and persistent vaginal webs (Fig. 13-19) and bands (Fig. 13-20) are diagnosed with vaginoscopy. Vaginal webs and bands can be divided under endoscopic visualization (Figs. 13-21 and 13-22) without need for an episiotomy. The stages of the estrus cycle can be monitored effectively with vaginoscopy.[1,2] Foreign bodies can be removed effectively. Tumors can be biopsied and in some cases removed.

## PREPUCOSCOPY

The cavity of the prepuce can be examined effectively using any of the small-diameter rigid telescopes with an arthroscopy or cystoscopy cannula and liquid or air for distention. Sedation or general anesthesia is used as indicated. The telescope is placed into the prepuce, the prepuce is distended with liquid or gas, and examination is conducted (Figs. 13-23 and 13-24). Preputial tumors have been evaluated and biopsied (Fig. 13-25), traumatic lesions assessed, and foreign bodies removed with this technique.

## FISTULOSCOPY AND LACEROSCOPY

Endoscopy has been used effectively for evaluating and treating bite wounds, deep lacerations, or chronic draining fistulae and for removing Penrose drain fragments. Any of the small rigid telescopes can be used for this application with either a cystoscopy cannula or an arthroscopy cannula. Continuous irrigation with saline or Ringer's solution is used to create a visual space and to remove exudate, blood, and debris. Depending on the procedure being performed, sedation or general anesthesia is required, although drain fragments have been removed in the awake patient with minimal physical restraint.

Chronic draining fistulae can sometimes be examined with an arthroscope as long as the diameter of the tract is large enough and its course is straight enough to allow passage of the endoscope. Foreign bodies can be located and removed with this technique, thus avoiding surgery (Figs. 13-26 and 13-27).

Endoscopy has been used to evaluate multiple bite wounds, thus eliminating the need for surgical exploration and avoiding additional tissue devitalization associated with surgical incisions. The telescope is passed through existing skin wounds into the deep tissue planes, culminating in a very effective examination (Figs. 13-28 and 13-29). Thorough assessment and wound cleaning has been achieved by irrigation through the endoscope with minimally invasive debridement by passage of instrumentation through the same wound as the telescope or through other communicating wounds. Drains can be accurately placed with this technique by passing instruments into one skin penetration and out another under endoscopic guidance and then pulling a drain through the cavity to be drained. The need for open surgery can either be completely eliminated or the number of incisions greatly reduced.

Pharyngeal puncture wounds caused by sticks can be evaluated and managed effectively with endoscopy. The openings of the wounds can be located (Fig. 13-30), the extent of the puncture assessed (Fig. 13-31), and the wound irrigated to remove debris. Foreign material can be found (Fig. 13-32) and removed with foreign body graspers (Fig. 13-33). Drains can be placed using endoscopic guidance and the pharyngeal wound closed with sutures or with minimally invasive surgery staple applicators (Fig. 13-34) under endoscopic guidance.

Another convenient application of this technique is finding and removing pieces of drains that have been left in a surgical site when the patient has chewed off exposed portions of drains. The telescope is passed through the skin incision created for the drain, with the patient awake, and the drain remnant is located (Fig. 13-35) and removed. This eliminates time-consuming and potentially hazardous blind probing or the time, risk, and expense of anesthesia for reopening a surgical wound to retrieve the drain fragment.

## OCULOSCOPY

Examination of the cornea and anterior chamber of the eye is enhanced with application of a rigid endoscopic telescope. The eye is not penetrated with the telescope but magnification and lighting provided with an endoscope allow improved visualization of the cornea (Fig. 13-36), pupil and iris (Fig. 13-37), and structures of the limbus (Fig. 13-38). Corneal ulcers (Fig. 13-39), corneal foreign bodies, corneal lacerations, the iris, and structures of the limbus can be effectively evaluated.

## ONCOSCOPY

Cavitated tumors can be evaluated and biopsied with endoscopy (Fig. 13-40). Percutaneous penetration of the skin and overlying structures is performed using a small-diameter rigid telescope and a cannula with a sharp trocar.

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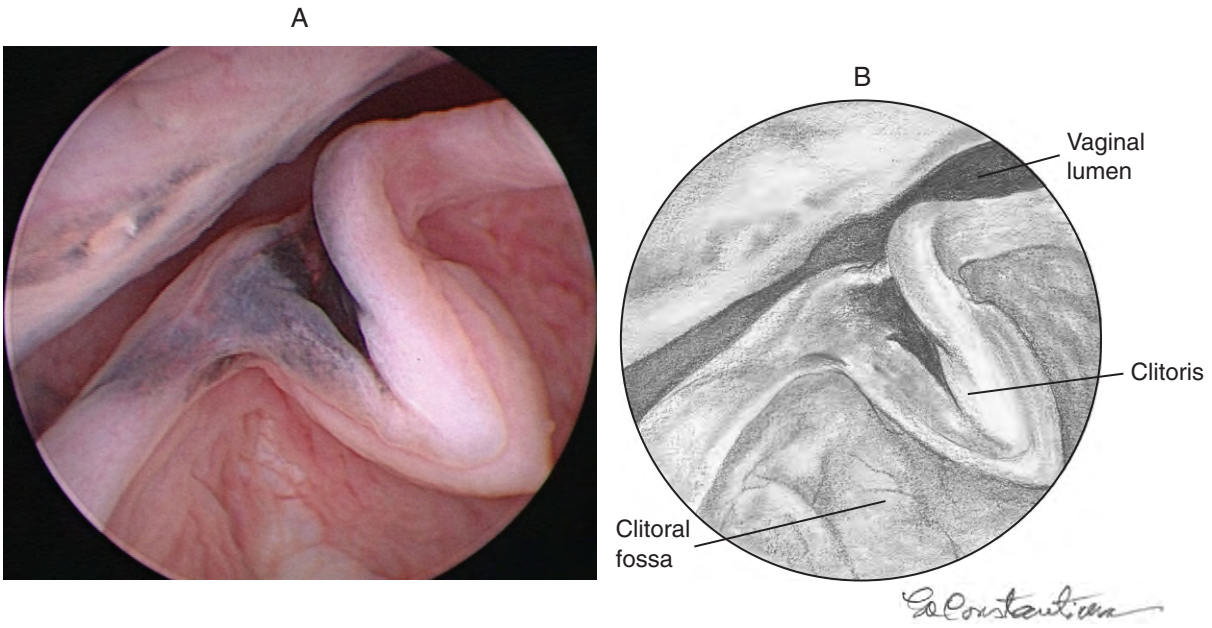



**Fig. 13-6**
Normal clitoris.

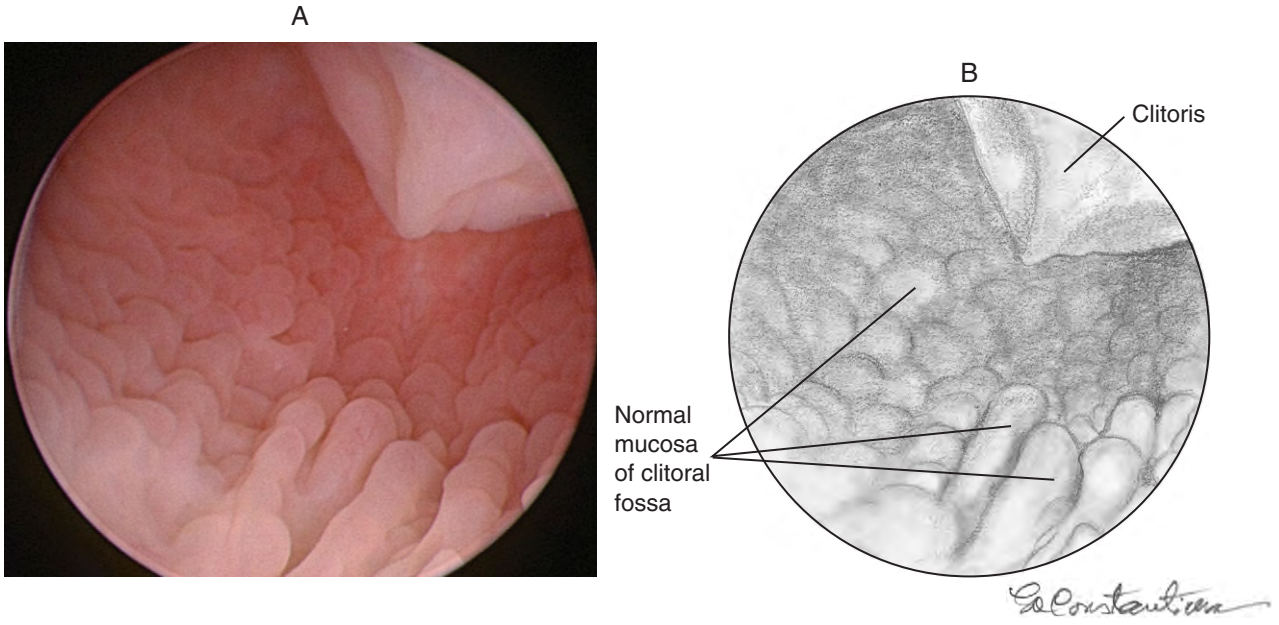



**Fig. 13-7**
Normal clitoral fossa.

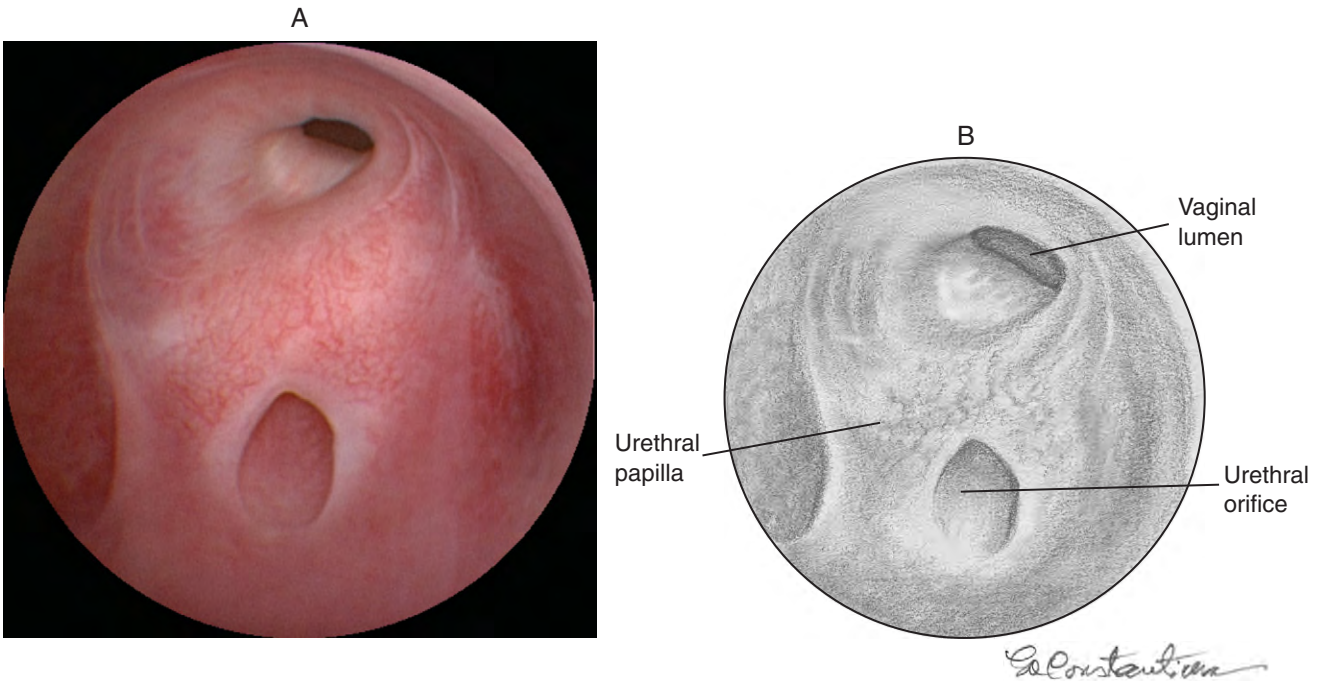



**Fig. 13-8**
Normal vaginal vestibule and urethral orifice in a spayed female dog.

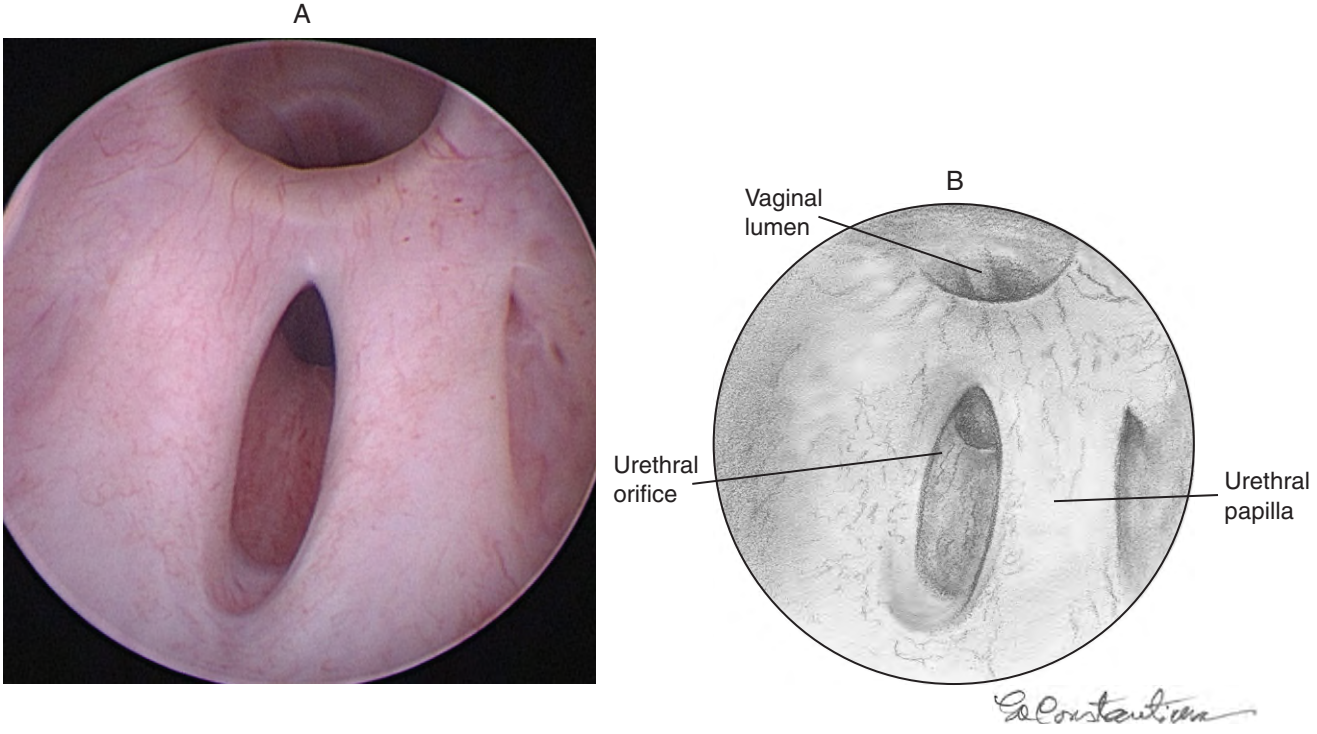



**Fig. 13-9**
Normal vaginal vestibule and urethral orifice in a spayed female cat.

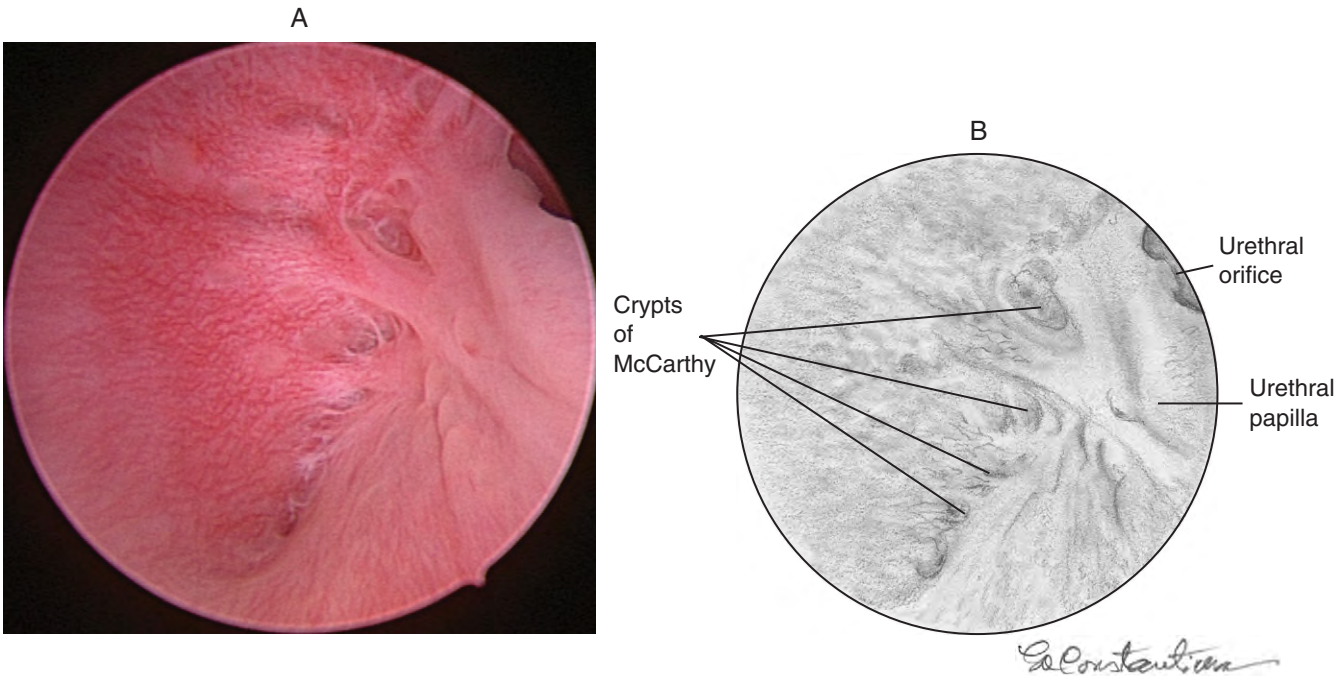



**Fig. 13-10**
Crypts of McCarthy in a normal spayed female dog.

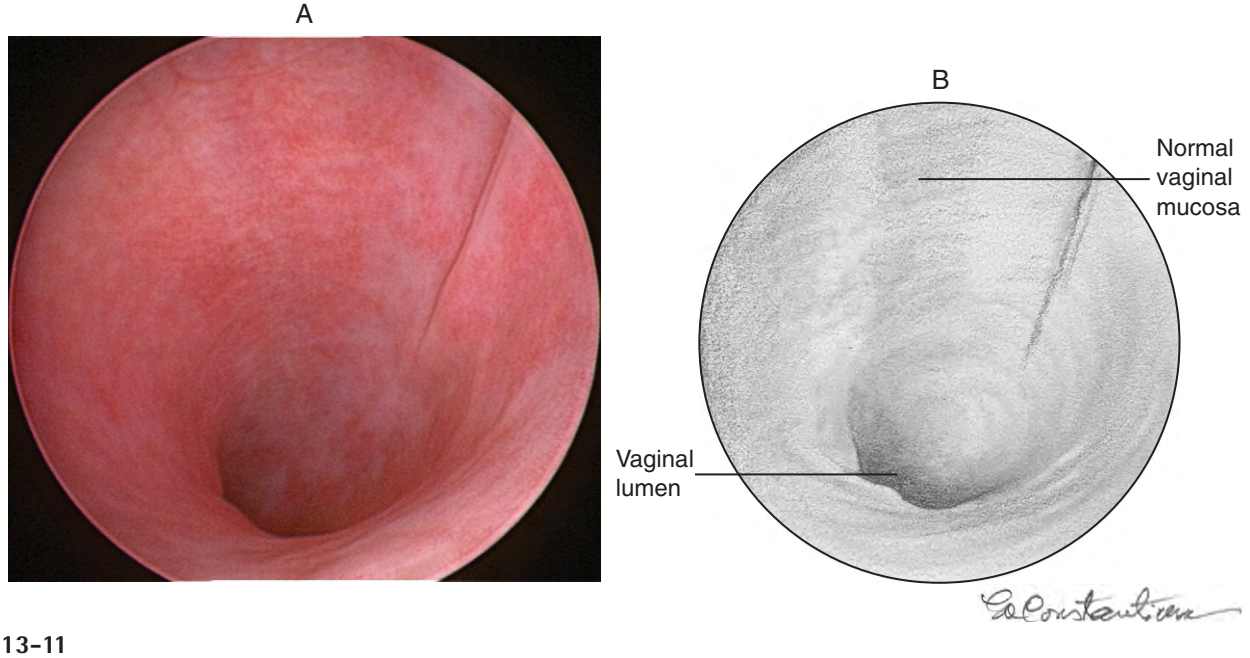



**Fig. 13-11**
Normal vaginal mucosa in a spayed female dog. Note the smooth mucosa with no mucosal ridges.

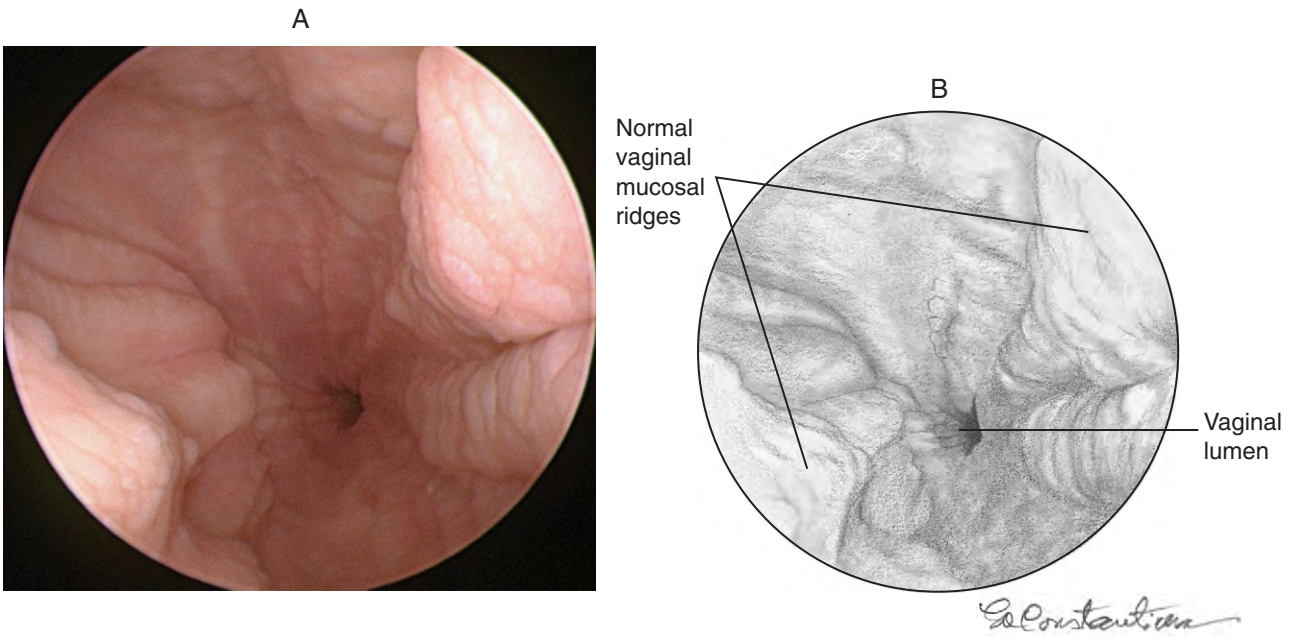



**Fig. 13-12**
Normal vaginal mucosa under hormonal influence in a spayed female dog with an active ovarian remnant. Note the prominent mucosal ridges typical of intact female dogs.

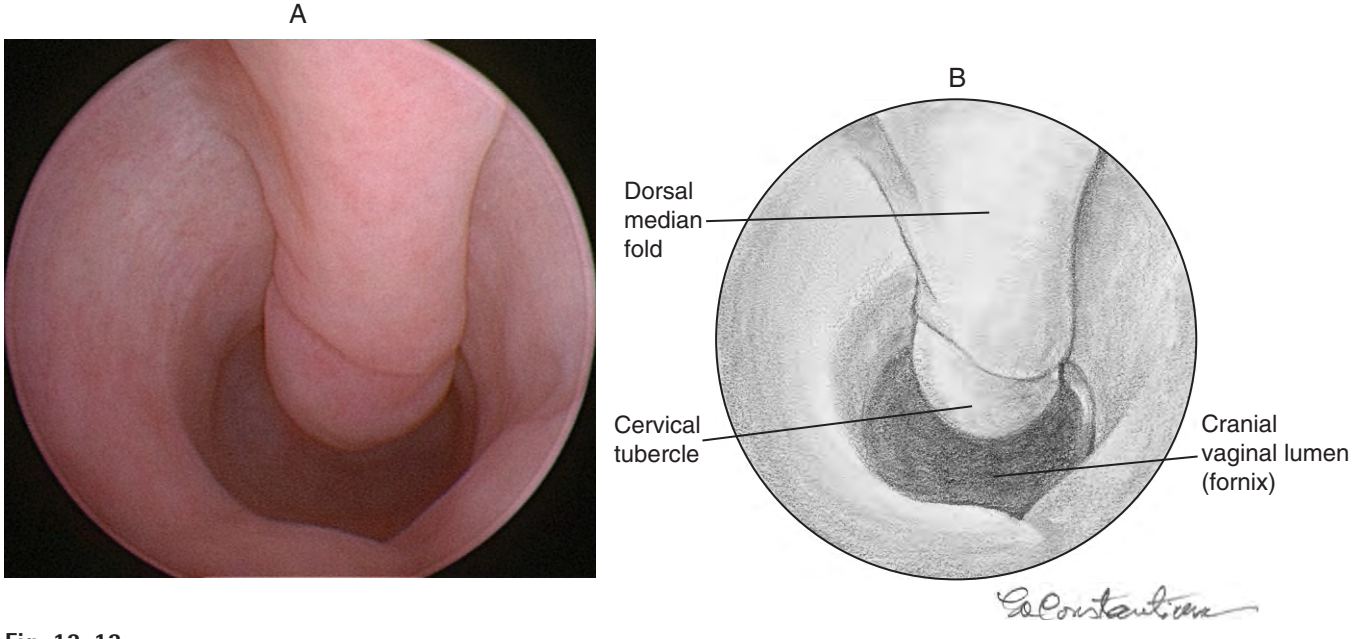



**Fig. 13-13**
Normal dorsal medial fold seen in the cranial vagina of a spayed female dog.

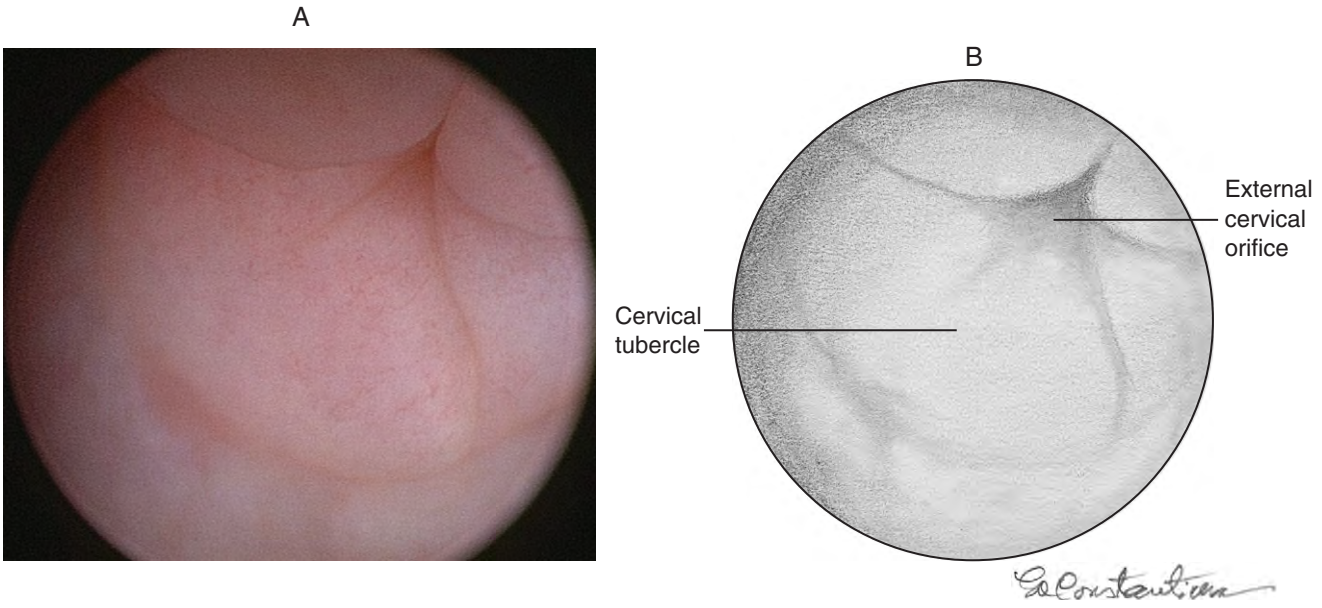



**Fig. 13-14**
Close-up view of the cervical opening in a spayed female dog.

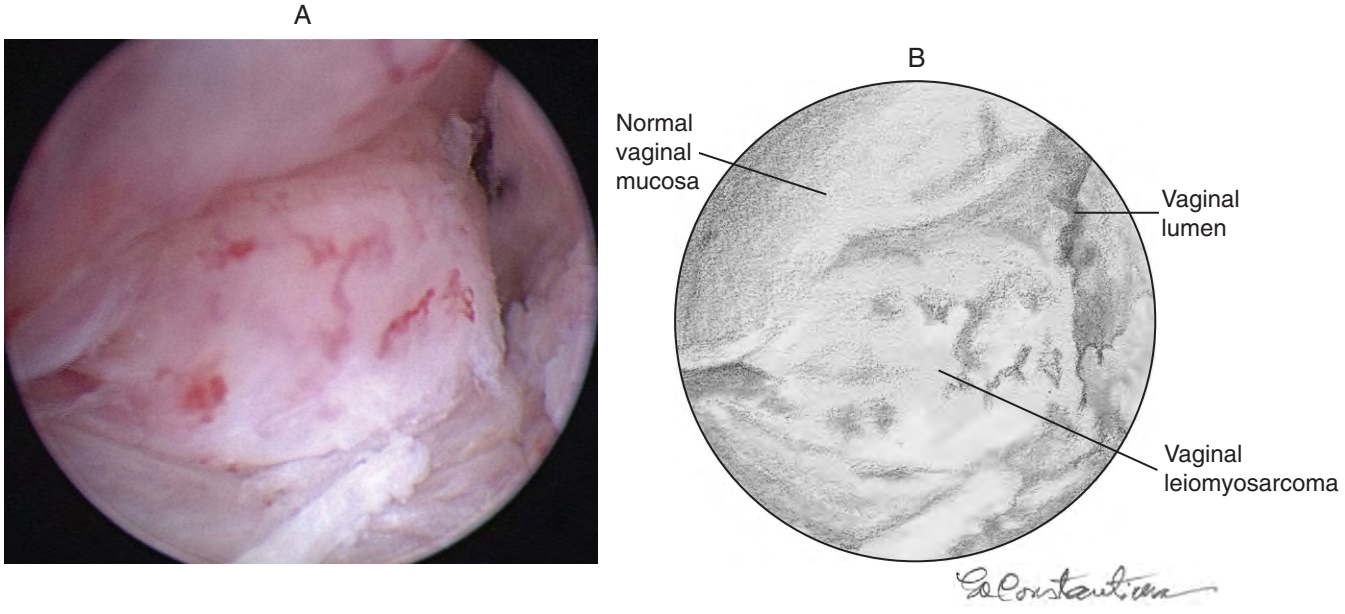



**Fig. 13-15**
Leiomyosarcoma of the vagina in a female cat.

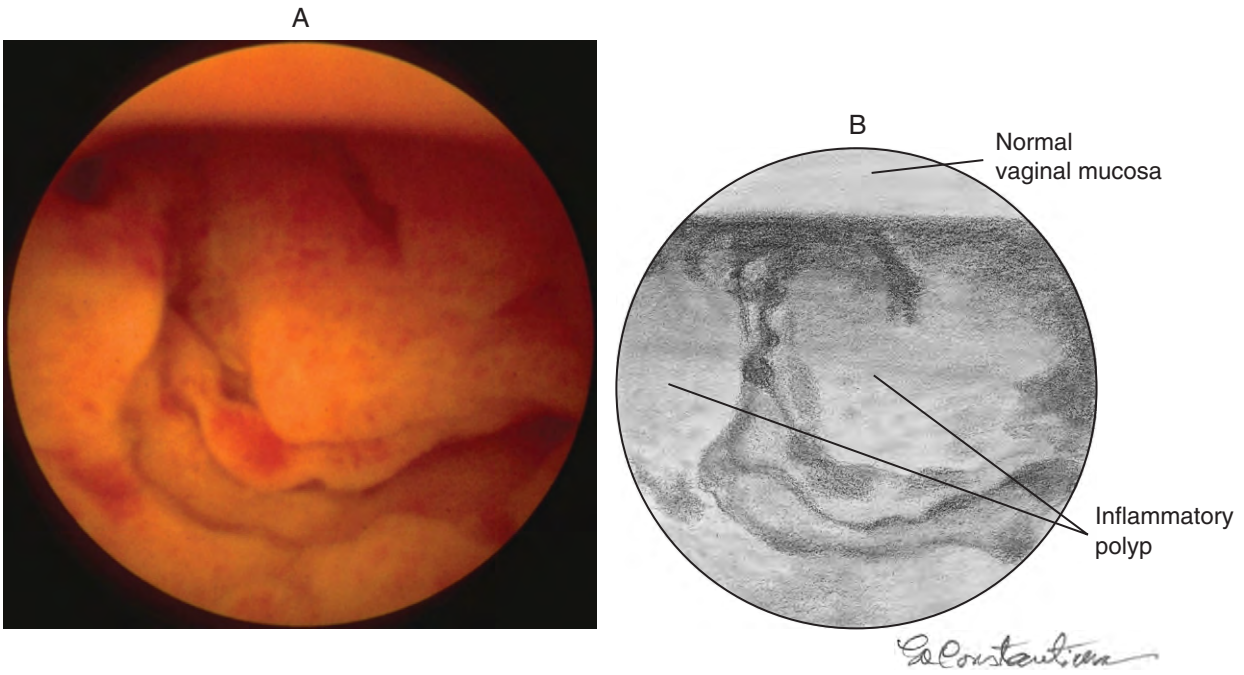



**Fig. 13-16**
A large inflammatory polyp in the vagina of a female dog.

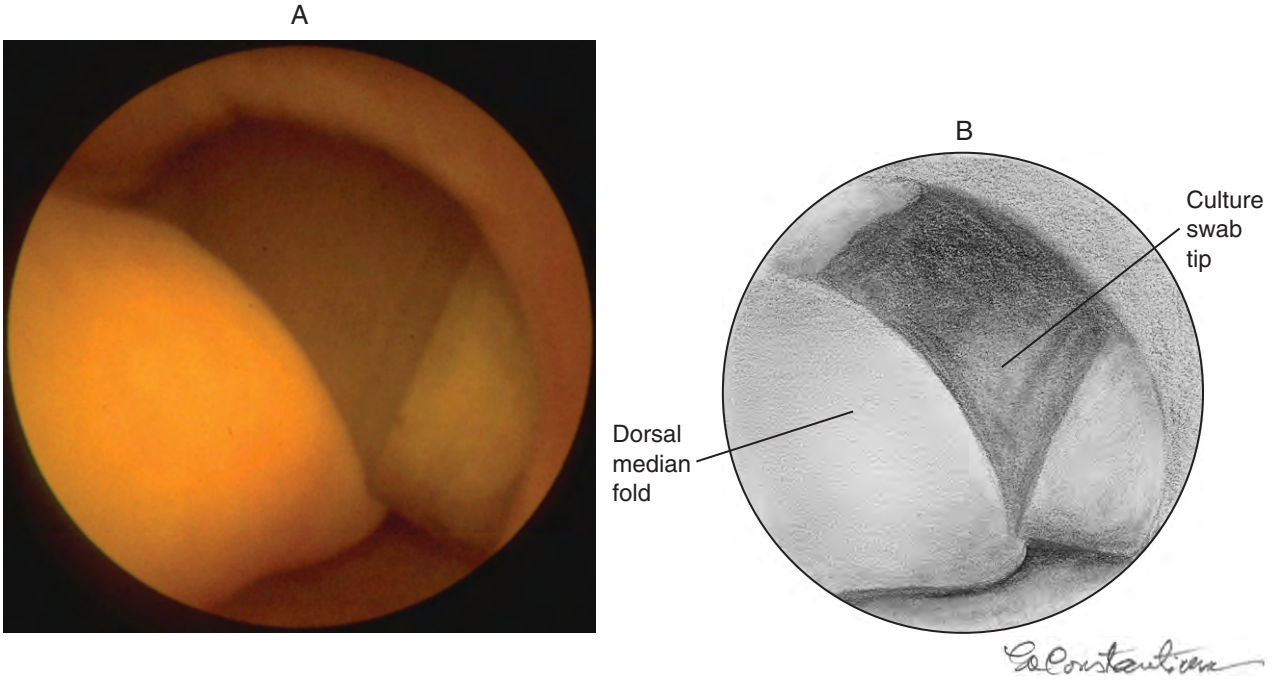



**Fig. 13-17**
The tip of a culture swab that was lost in the vagina of a dog while attempting to obtain a culture sample. The swab tip was lodged in the paracervical area at the cranial end of the vagina and was removed with endoscopic graspers.

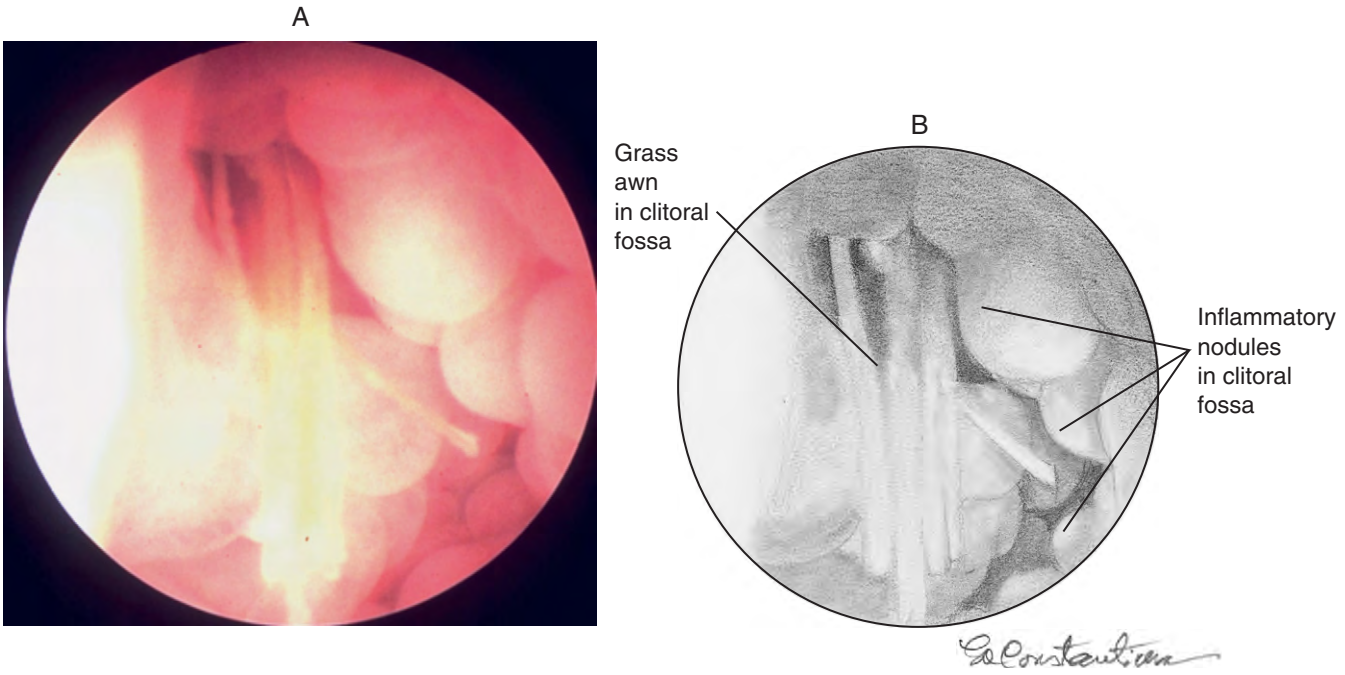



**Fig. 13–18**
A grass awn lodged in the clitoral fossa of a spayed female dog.

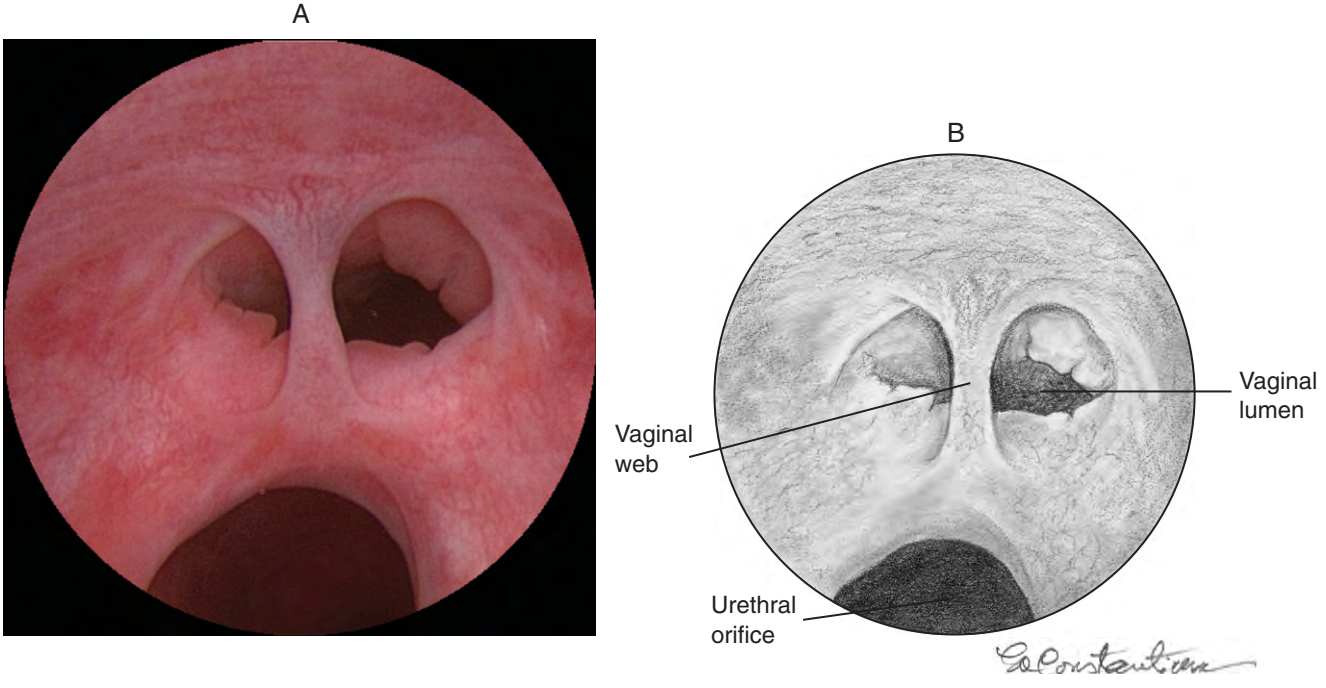



**Fig. 13–19**
Vaginal web in a spayed female dog.

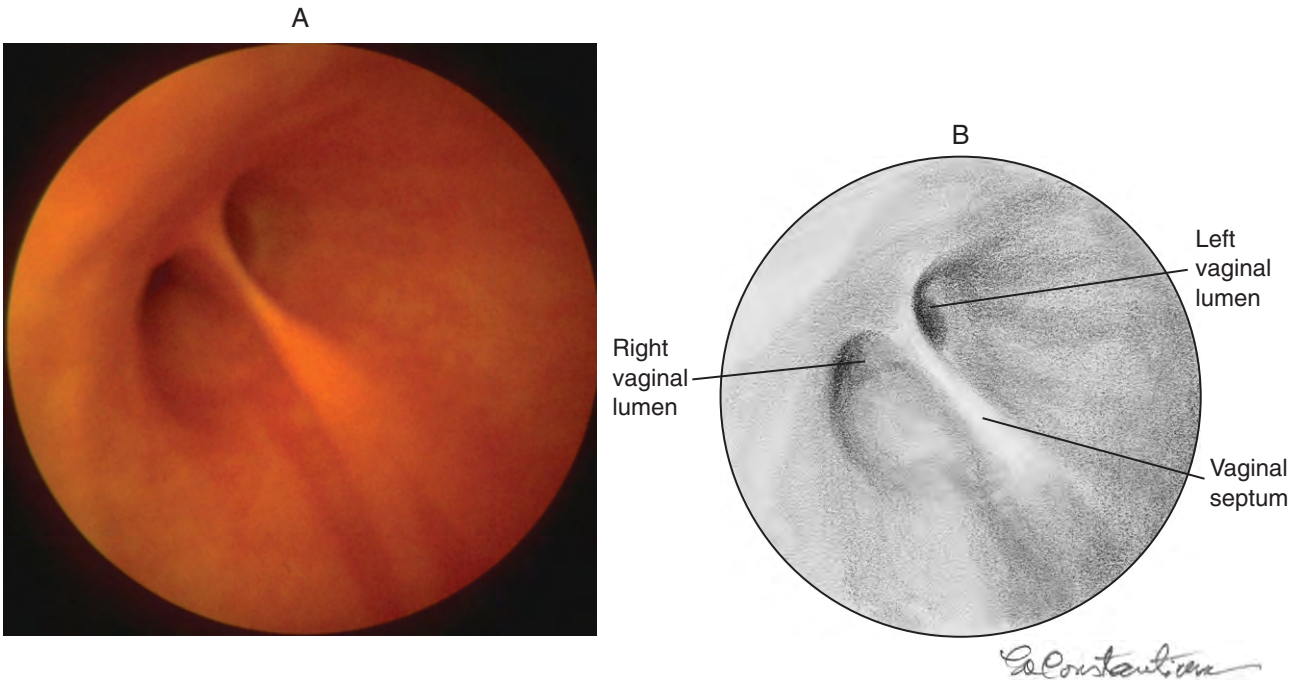



**Fig. 13-20**
Vaginal septum in the cranial vagina of a female dog.

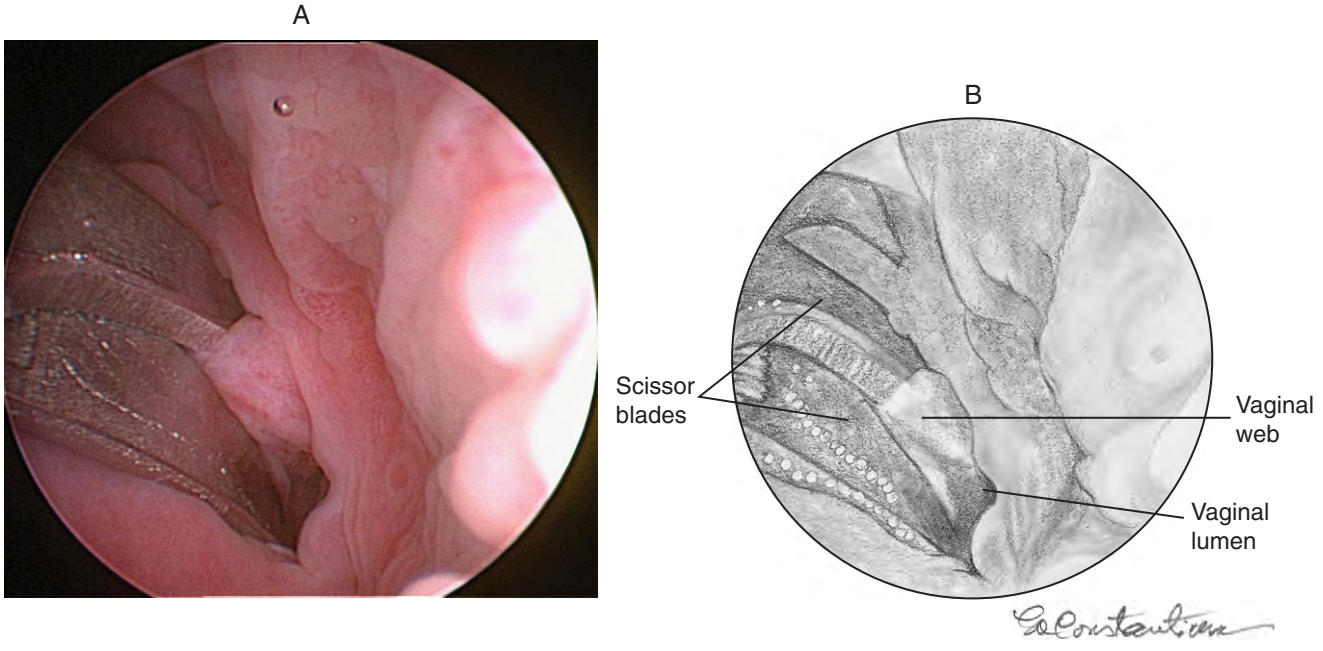



**Fig. 13-21**
Cutting a vaginal web under endoscopic guidance using Metzenbaum scissors.

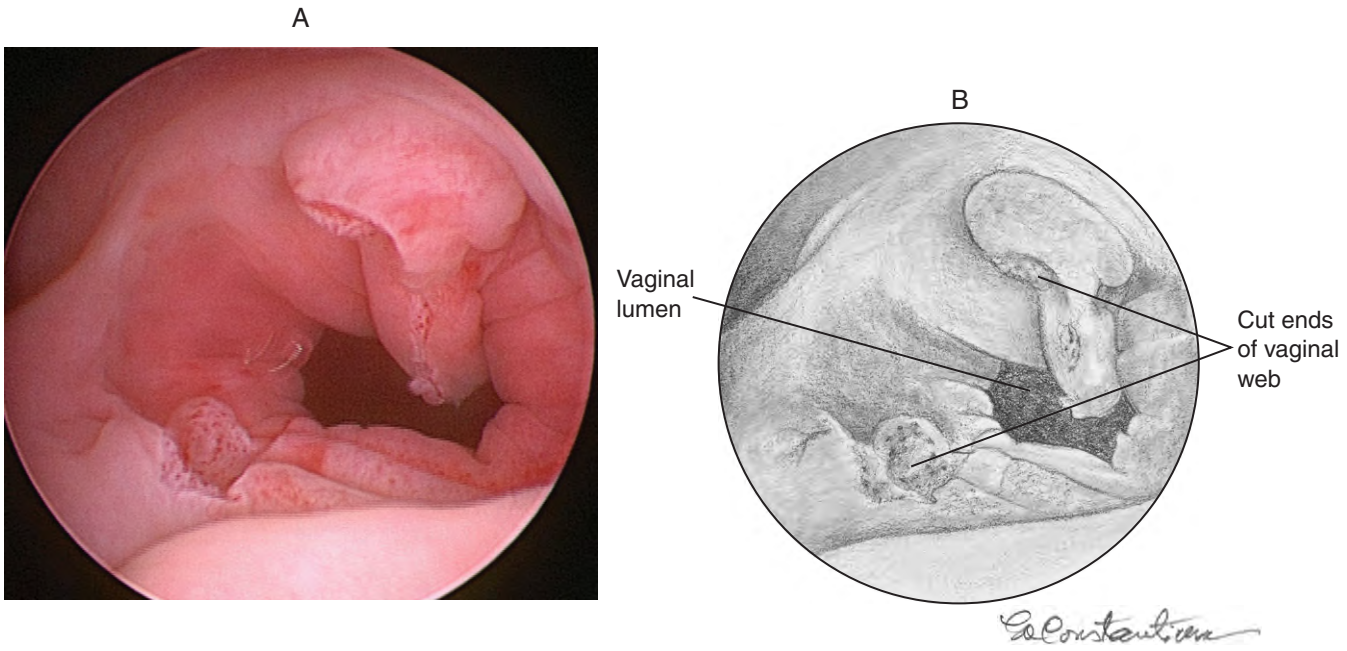



**Fig. 13-22**
Vaginal web from Fig. 13-21 after being cut.

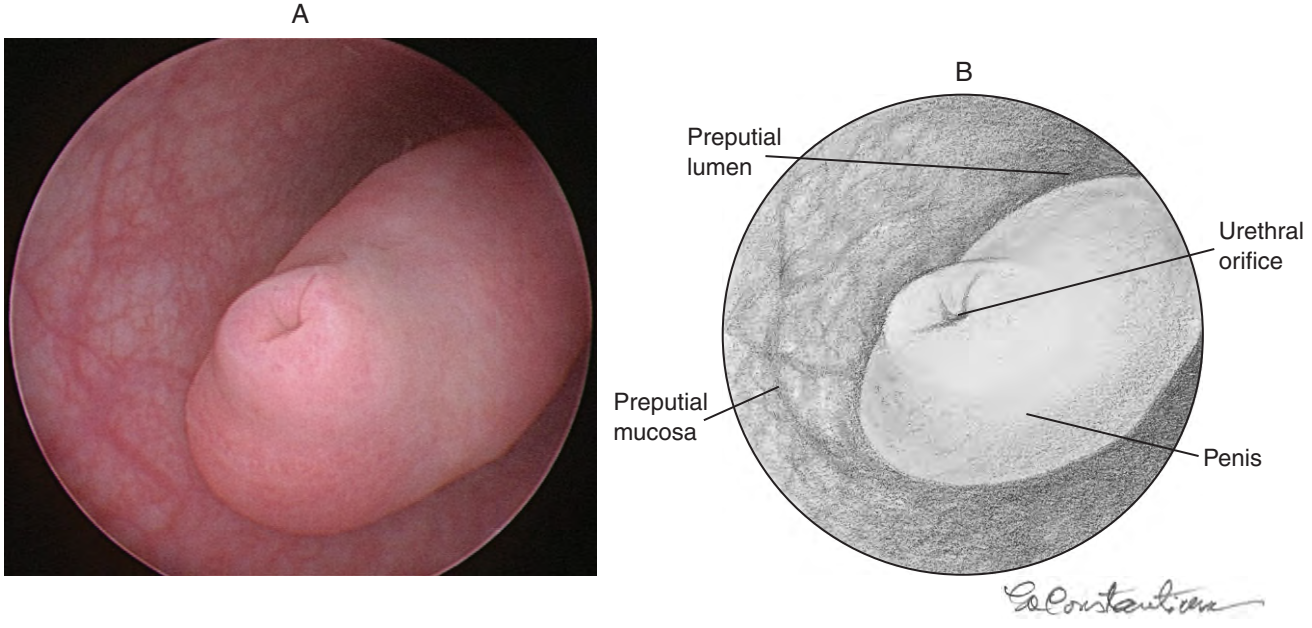



**Fig. 13-23**
Normal preputial cavity showing the tip of the penis and urethral orifice.

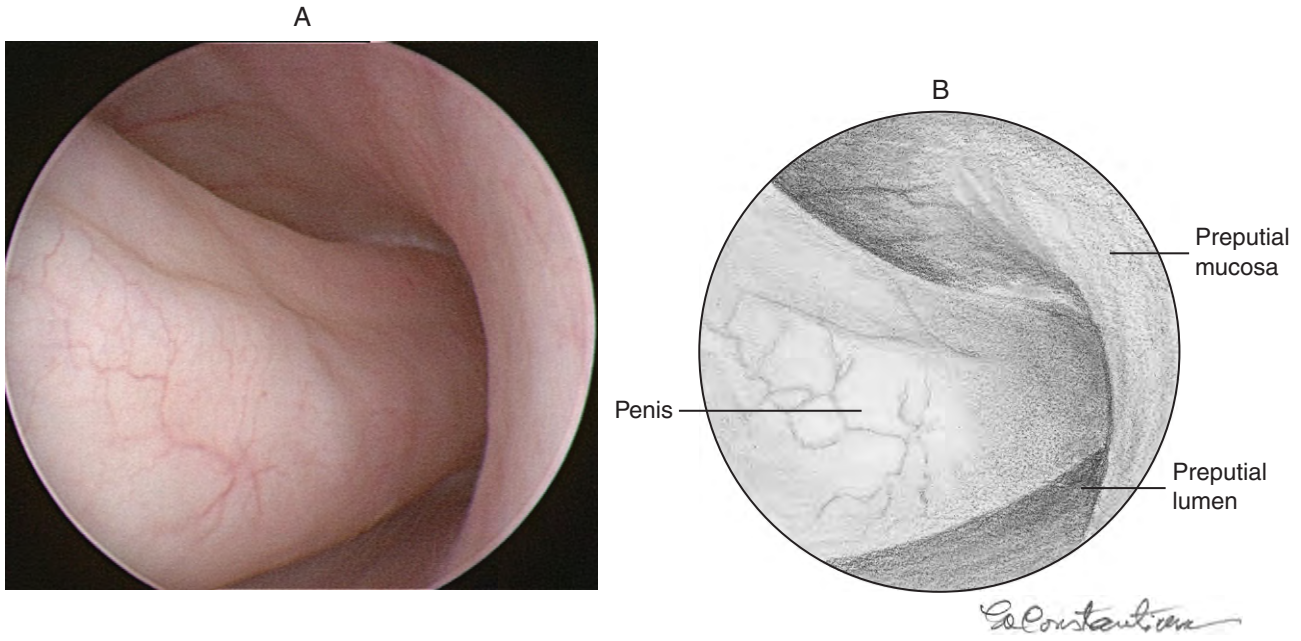



**Fig. 13-24**
Normal preputial cavity showing the caudal end of the penis.

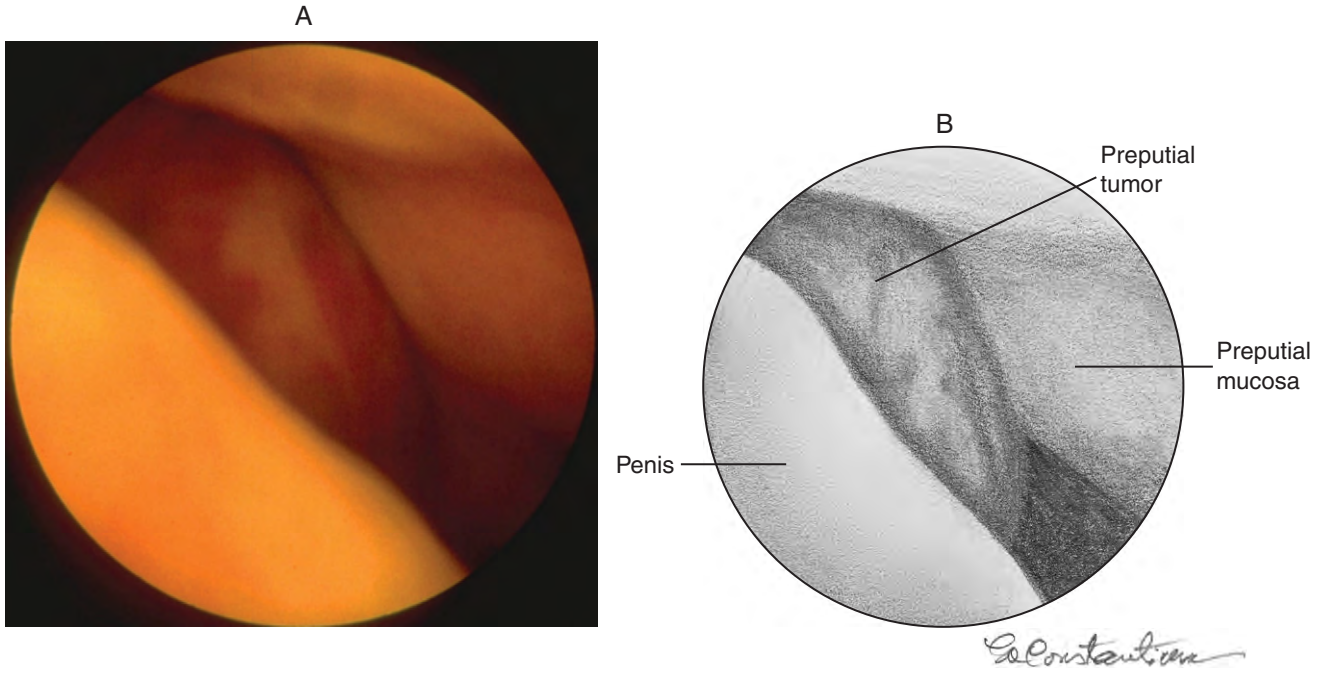



**Fig. 13-25**
Tumor mass in the caudal recess of the prepuce.

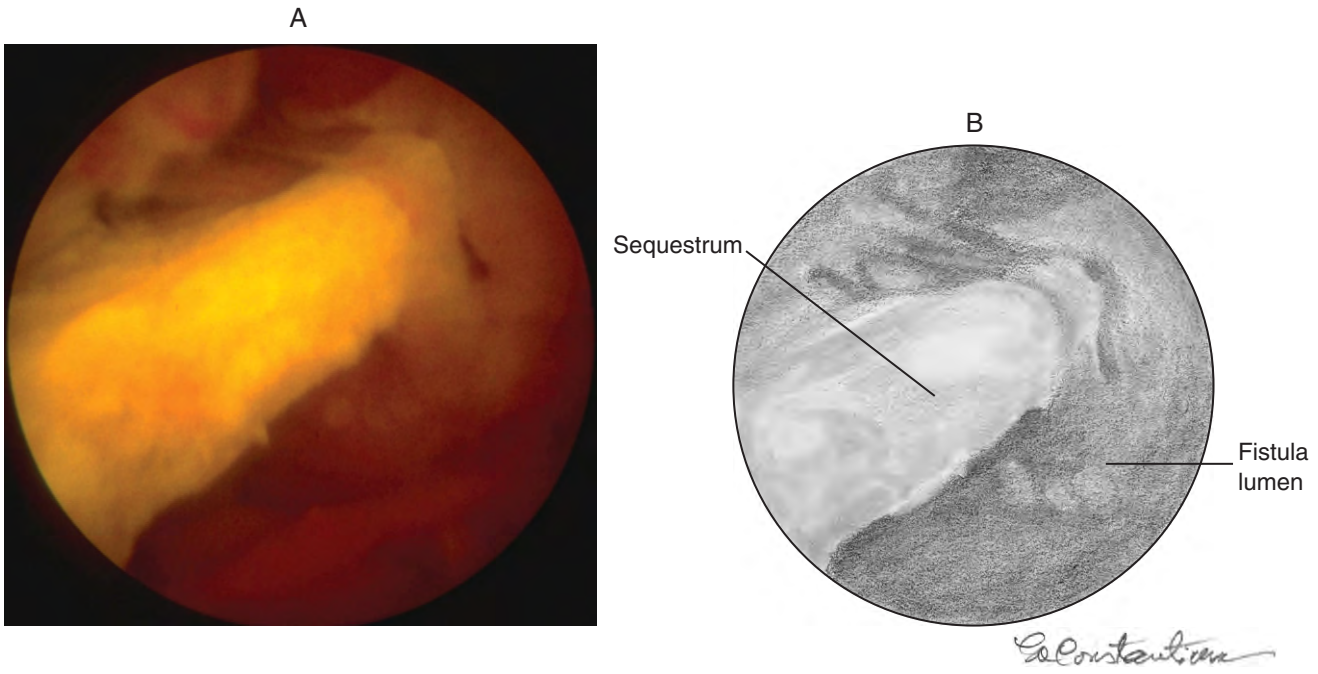



**Fig. 13-26**
Bone sequestrum causing a chronic fistula in the oral cavity of a dog.

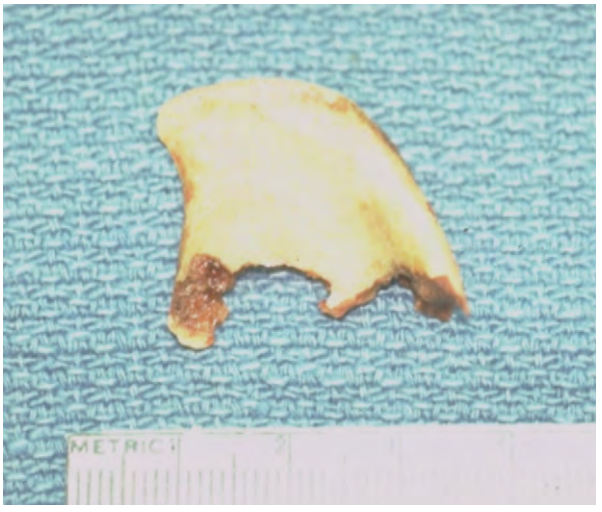


**Fig. 13-27**
Bone sequestrum from the case in Fig. 13-26, after removal.

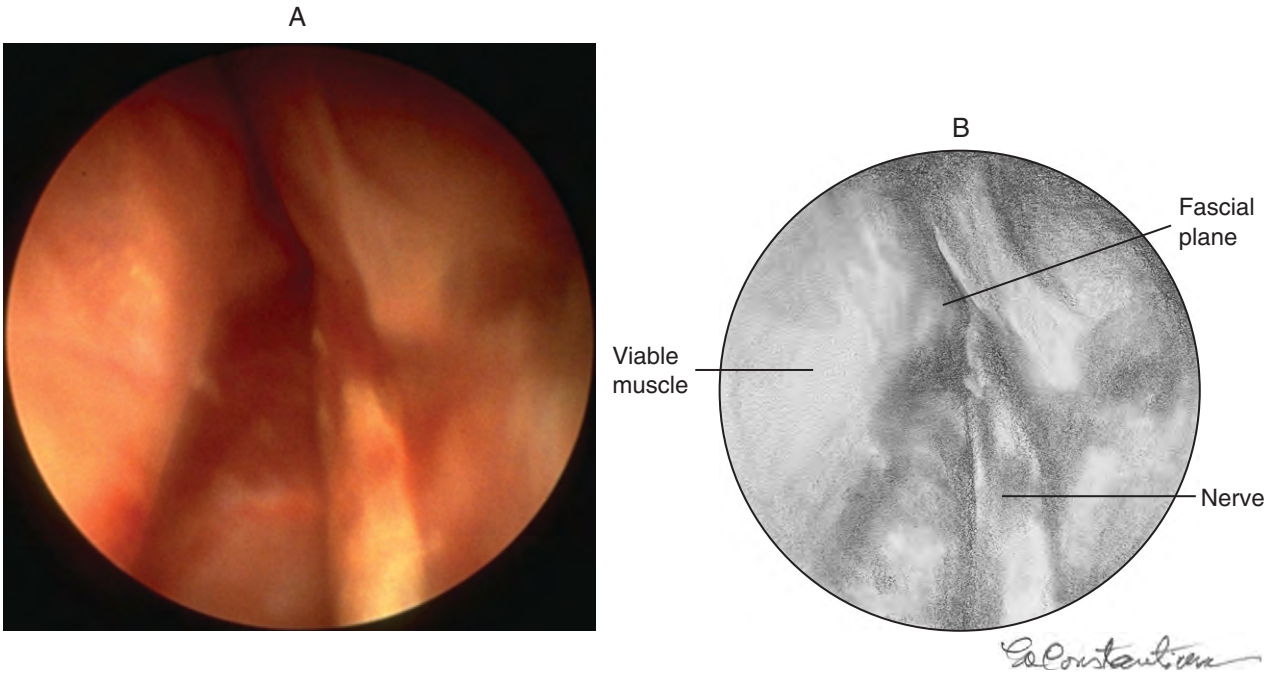



**Fig. 13-28**
Deep portion of a bite wound in a dog showing viable tissue and an intact nerve.

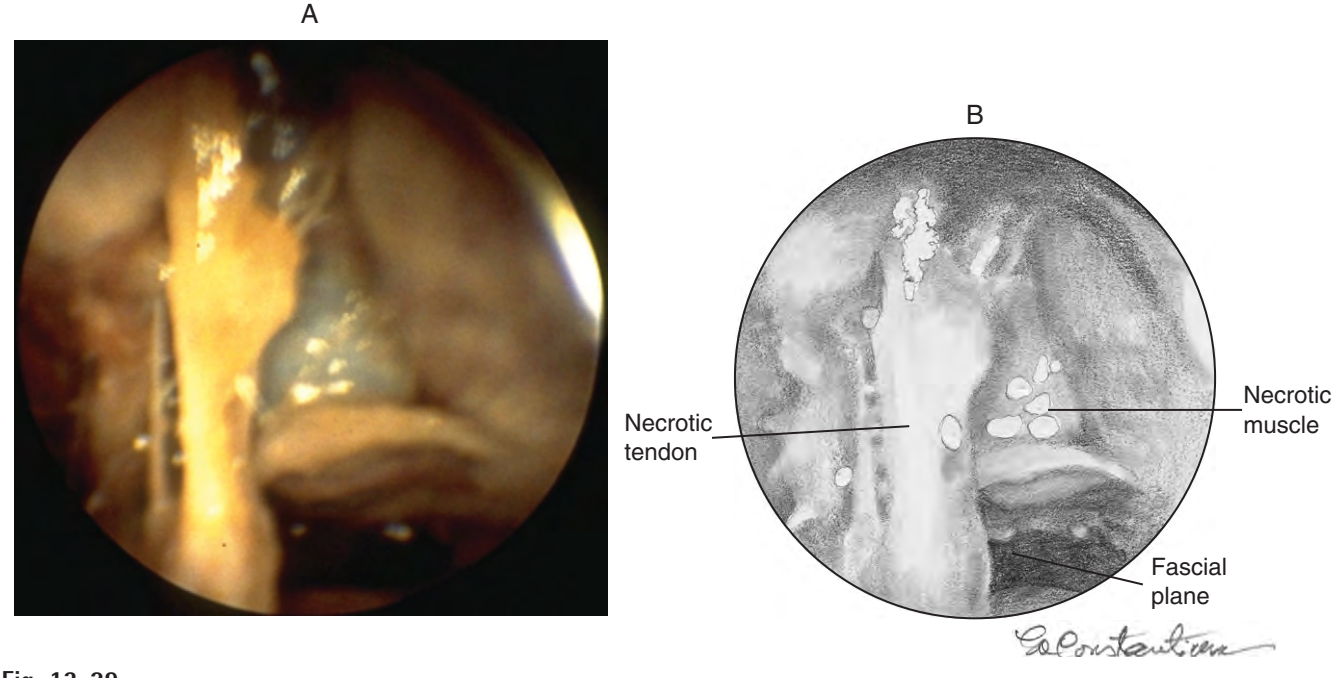



**Fig. 13-29**
Necrotic tissue in another bite wound in the same case as in Fig. 13-28.

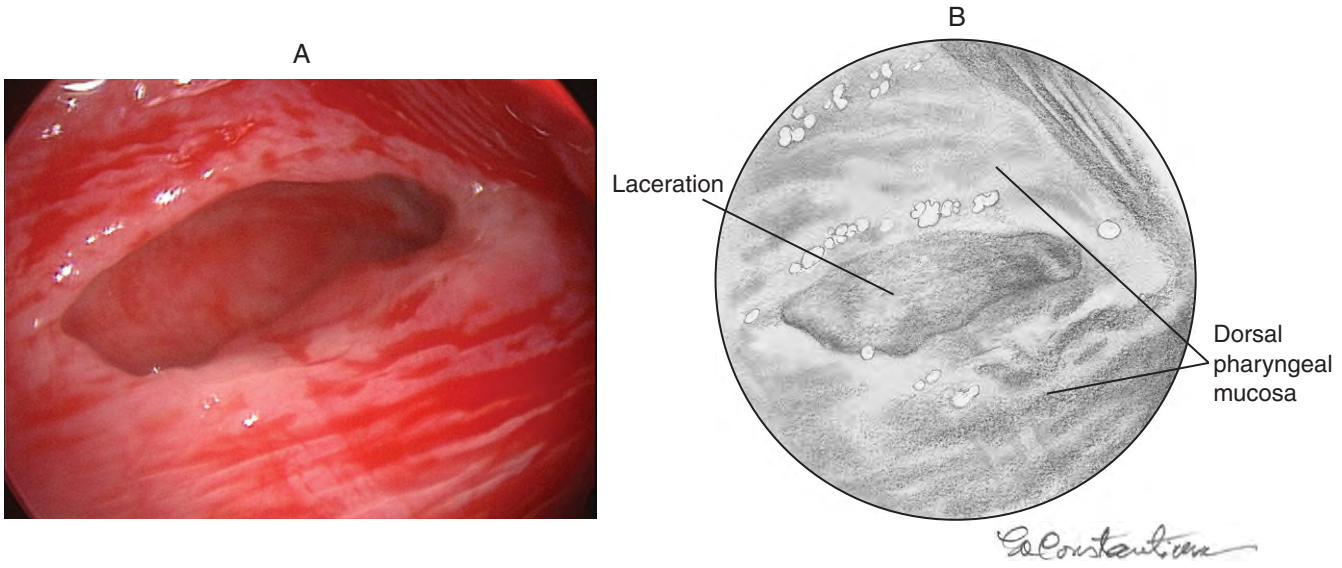



**Fig. 13-30**
Pharyngeal laceration in a dog caused by impaling a stick into the back of the dog's mouth.

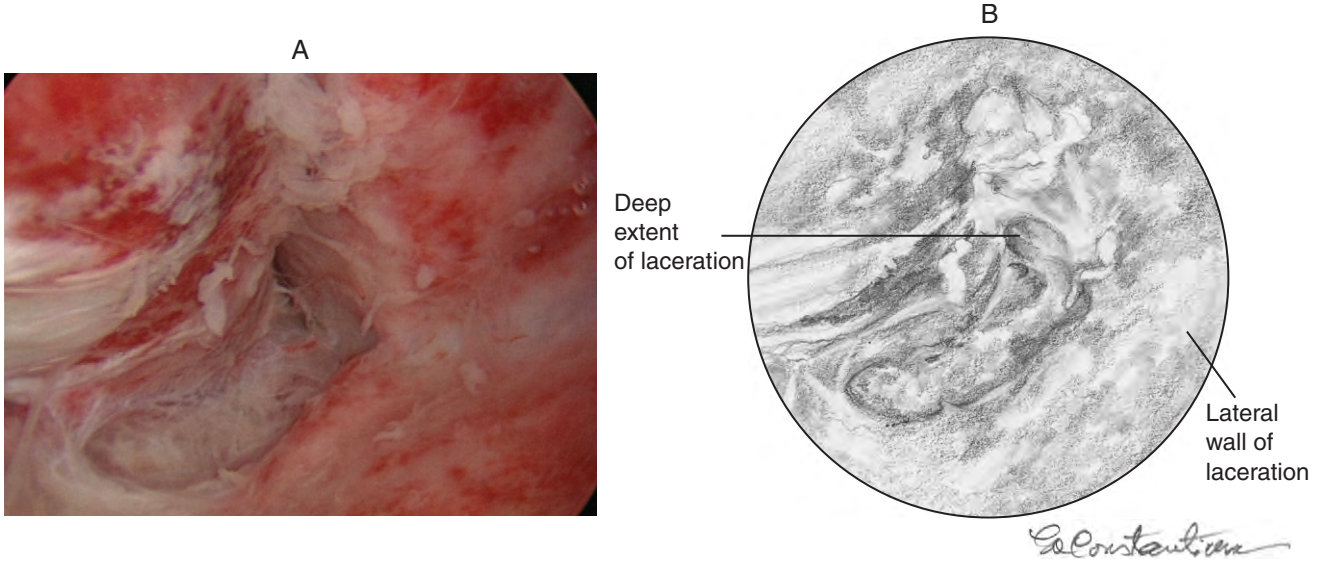



**Fig. 13-31**
Deep extent of a pharyngeal laceration in a dog caused by a stick.

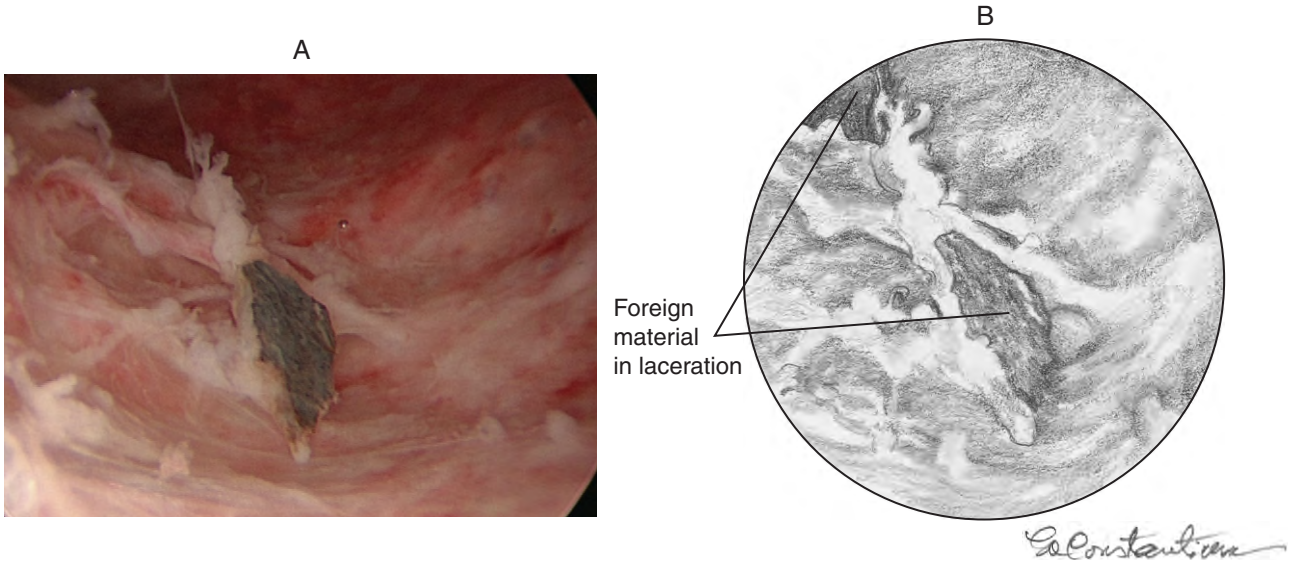



**Fig. 13-32**
Foreign material in the pharyngeal laceration shown in Fig. 13-31.

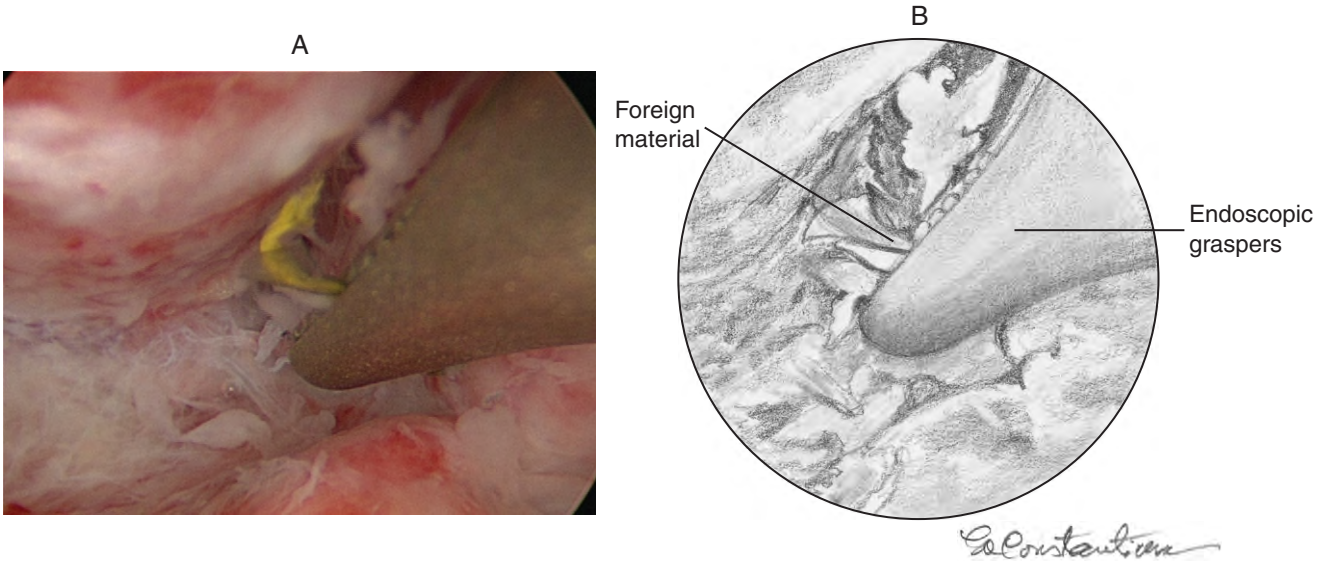



**Fig. 13-33**
Removing the foreign material shown in Fig. 13-32.

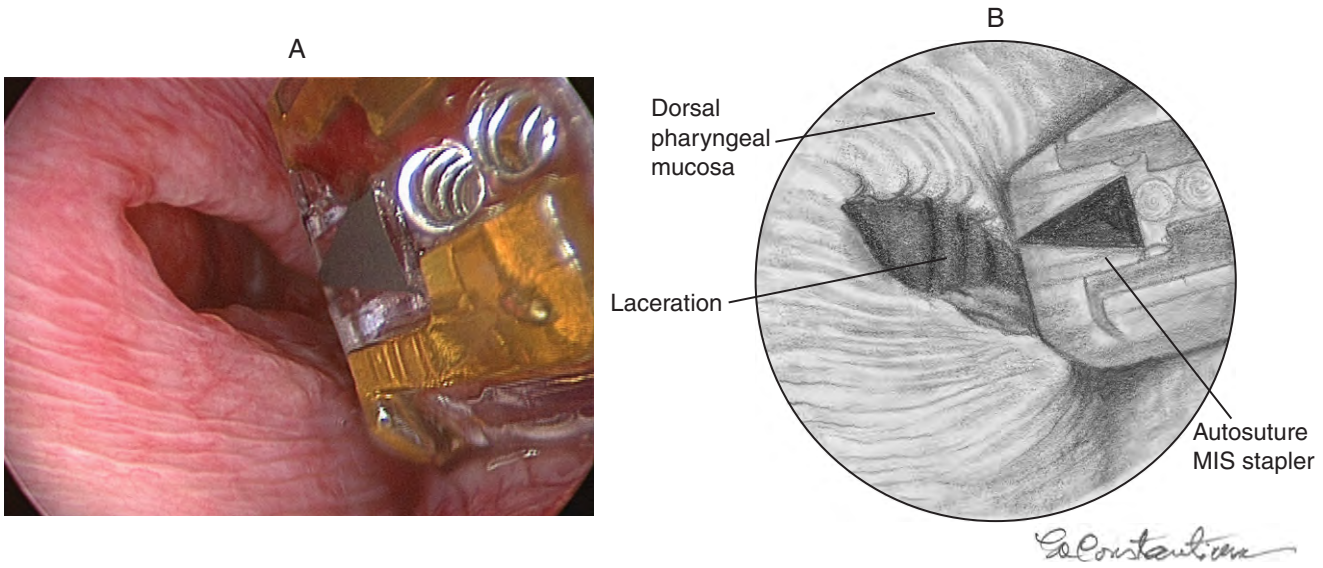



**Fig. 13-34**
Closing the pharyngeal mucosal wound seen in Fig. 13-30 with a minimally invasive surgery stapler under endoscopic guidance.

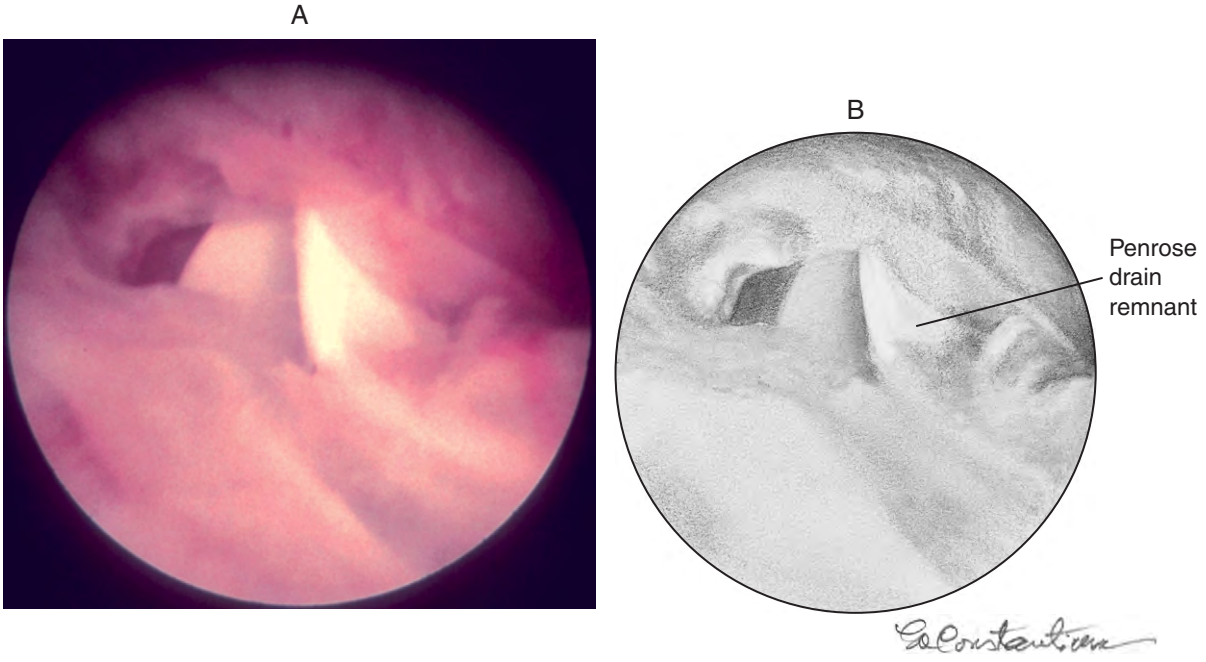



**Fig. 13-35**
Penrose drain remnant visualized and removed with endoscopy.

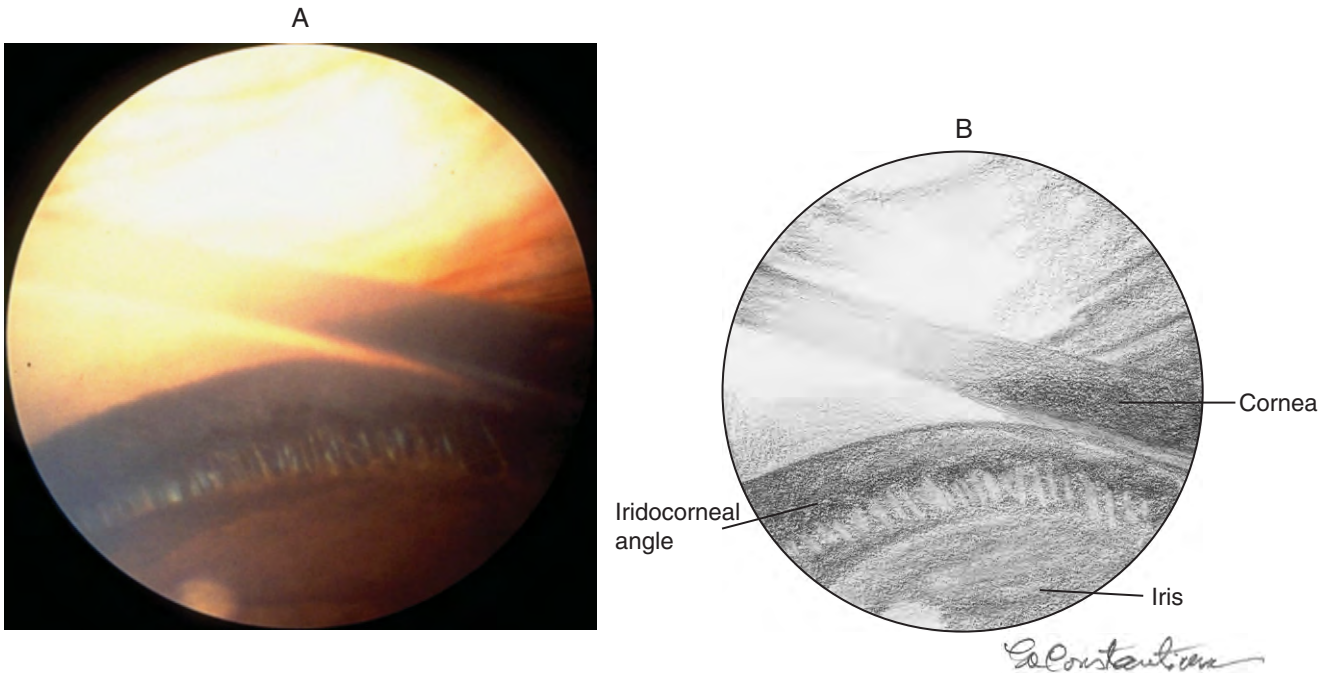



**Fig. 13-36**
Tangential view of the eye showing a cross section of the cornea.

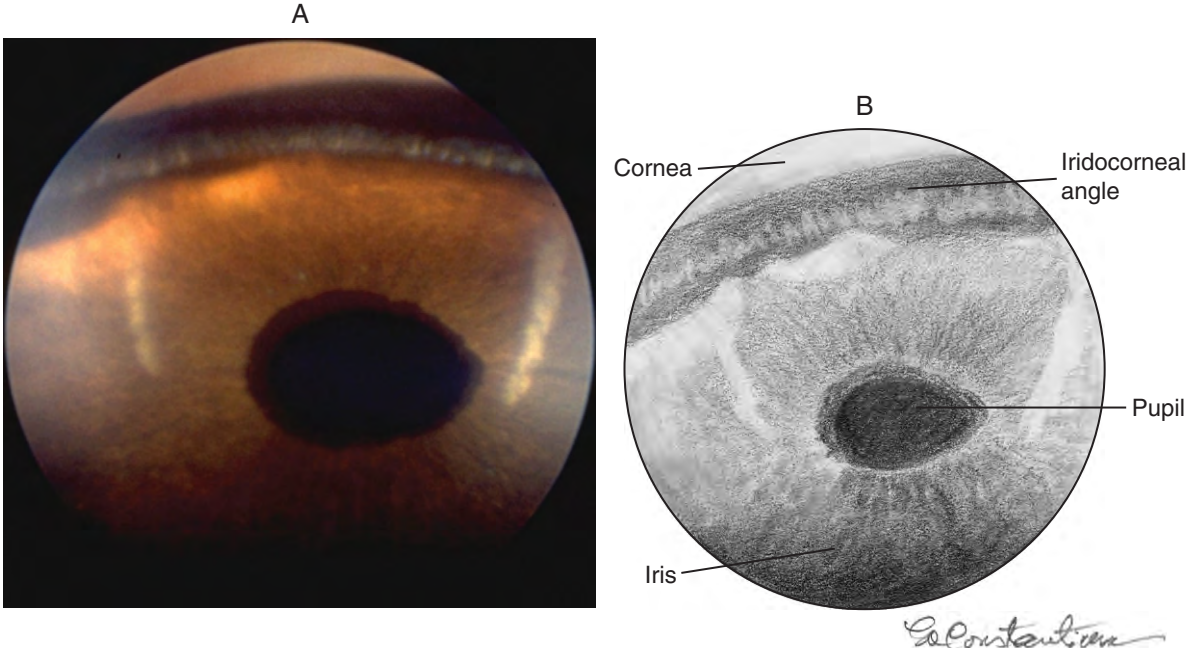



**Fig. 13-37**
Pupil and iris of a normal eye.

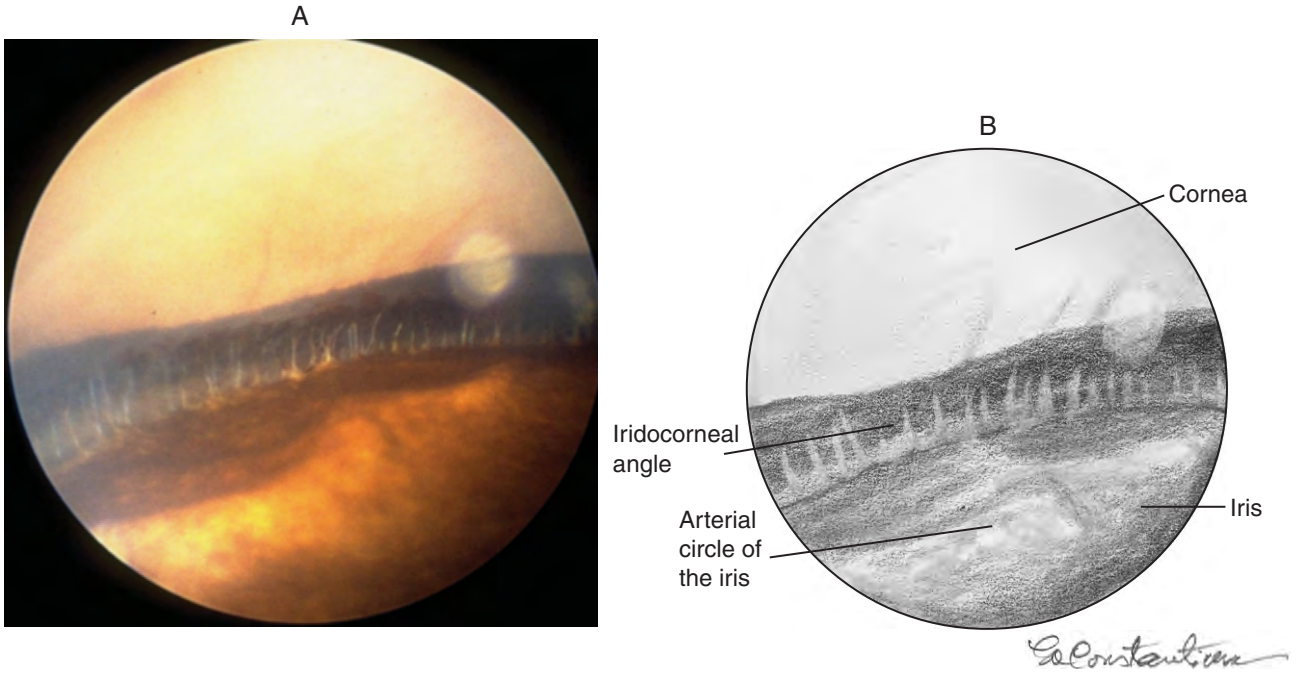



**Fig. 13-38**
Normal structure of the limbus of the eye.

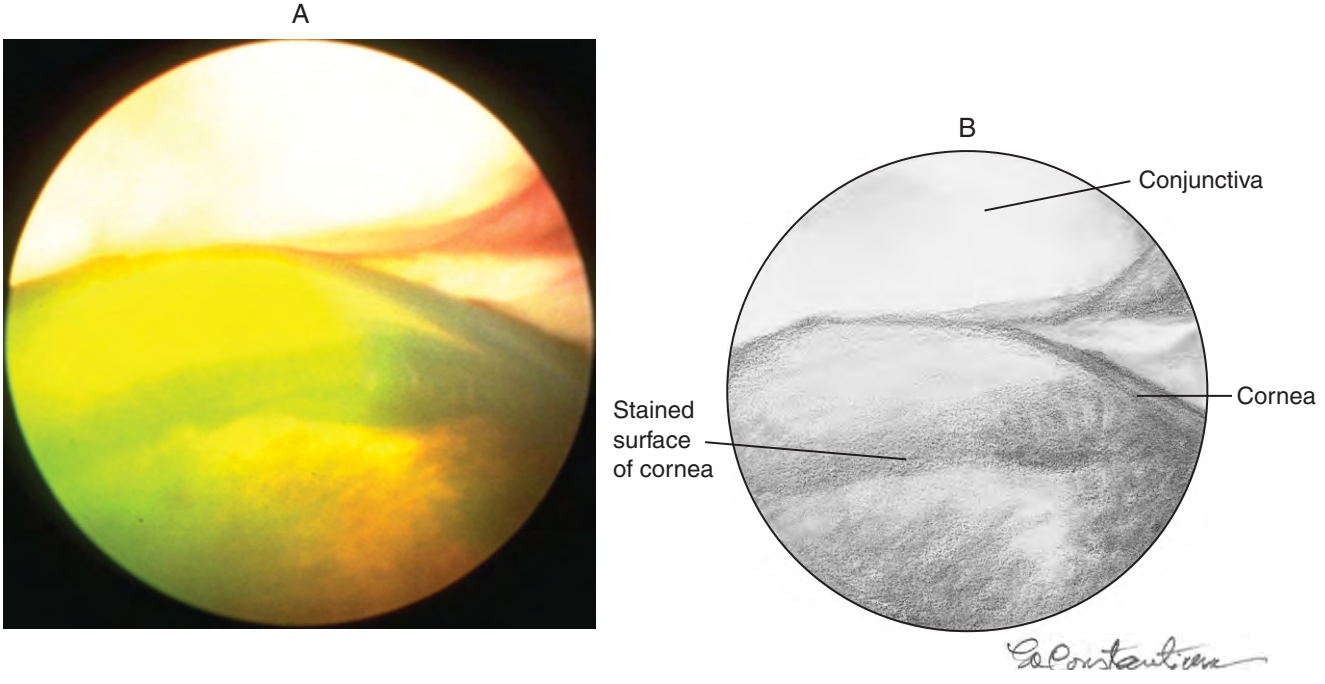



**Fig. 13-39**
Fluorescein staining of the cornea in a dog with a superficial corneal ulcer.

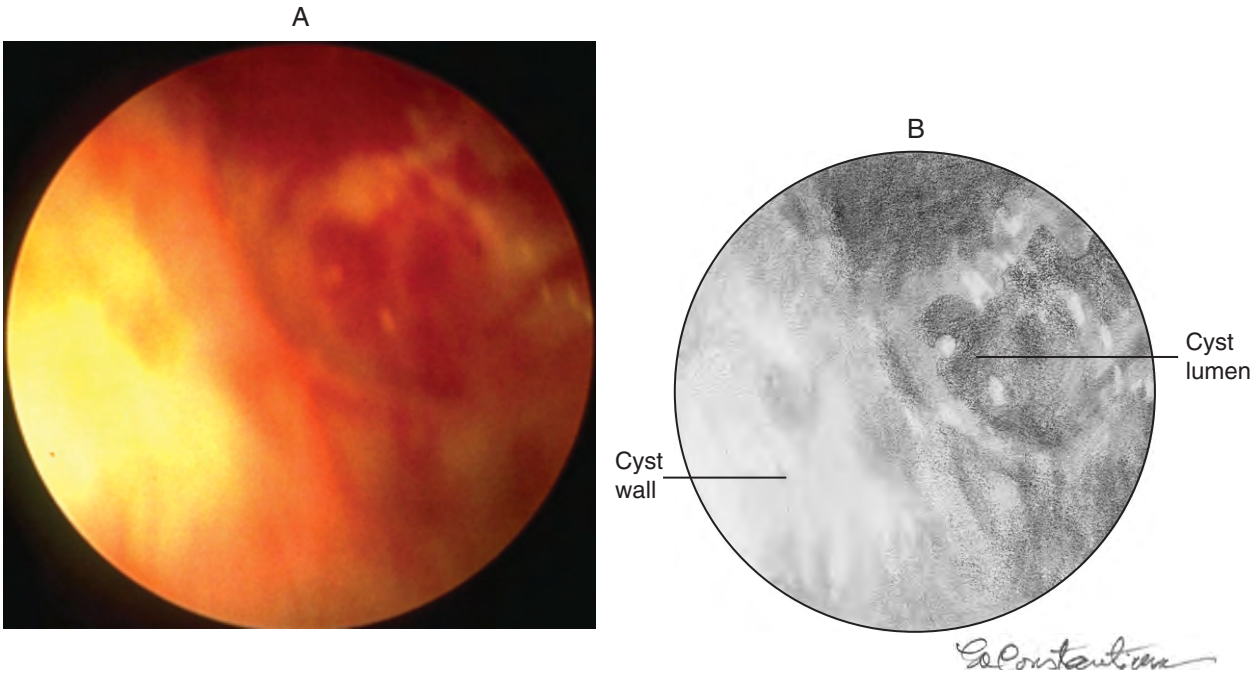



**Fig. 13-40**
The inside of a cystic tumor.

General anesthesia and aseptic technique are used. The cavity is irrigated with saline or Ringer's solution through the telescope cannula to establish a clear visual field. A second cannula is placed through a second penetration if needed for improved irrigation flow and for obtaining biopsy specimens. In some cases this is the least invasive and most effective approach for obtaining diagnostic biopsy specimens.

## ANALSACOSCOPY

If there is a hollow viscus with a naturally occurring orifice, we scope it; if there is a viscus or body cavity without an orifice, we make one; if there is no naturally occurring cavity, we create one. Anal sacs are a hollow viscus with a naturally occurring orifice and therefore are scoped. The indications for analsacoscopy need to be defined. Examination is performed using a 2.7-mm diameter, or smaller, telescope with an arthroscopy cannula and fluid irrigation.

## REFERENCES

1. Lindsay FEF: The normal endoscopic appearance of the caudal reproductive tract of the cyclic and noncyclic bitch: post-uterine endoscopy, *J Small Anim Pract* 24:1-15, 1983.
2. Brearley MJ, Cooper JE, Sullivan M: Vaginoscopy. In Brearley MJ, Cooper JE, Sullivan M, editors: *Color atlas of small animal endoscopy*, St Louis, 1991, Mosby.

# 14 Arthroscopy: Diagnostic and Surgical Applications in Small Animal Practice

*Timothy C. McCarthy*

Arthroscopy is the most significant advance in small animal orthopedics that has occurred in my professional lifetime. Arthroscopy can provide more information about intraarticular pathology than any other diagnostic technique except maybe postmortem examination using an operating microscope. The most important advantages of arthroscopy are visual access to more joint area, magnification produced by the telescopes, excellent illumination, and a clear visual field produced by continuous irrigation. Furthermore, arthroscopy is minimally invasive, reducing trauma, operative times, and recovery times. The small sizes of telescopes available allow placement into the deepest parts of joints and, combined with angulation of the field of view (30 degrees for most arthroscopes), provide visual access to more area of joints than can be achieved with open surgery. Arthroscopes magnify intraarticular structures, allowing visualization of anatomic details and pathologic changes that are beyond the resolution of radiographs, computed tomography (CT), and magnetic resonance imaging (MRI). Submacroscopic lesions that elude us with open surgical exploration can be easily visualized with arthroscopy. High-intensity lighting is passed directly through the arthroscope, providing perfect illumination of everything in the field of view of the telescope. Irrigation employed with arthroscopy maintains a clear field of view by continuously flushing blood and debris away from the end of the telescope. This is all done with minimally invasive technique and far less tissue trauma than with an arthrotomy. Speed is not the most important criteria or the most important advantage of arthroscopy over open arthrotomy, but for the experienced arthroscopic surgeon, anesthesia and procedure times are significantly shorter than with conventional surgery. Postoperative recovery after arthroscopy is also much faster than following an open arthrotomy. This time comparison is an important advantage of arthroscopy. Most dogs recover to their preoperative status of lameness and pain within a few hours after arthroscopy. Many dogs are better than their preoperative level of function by the time they are released from the hospital on the day after arthroscopy. Activity restriction is not needed for portal site healing. The time required for healing of intraarticular structures after arthroscopy for conditions such as osteochondritis dissecans (OCD) and medial coronoid process pathology (MCPP) (commonly termed *fragmented coronoid process* [FCP]) has not been studied or effectively compared with healing after open surgery.

There are few disadvantages of arthroscopy. The most significant disadvantage is its technical difficulty and the long difficult learning process both for diagnostic applications and for performing corrective surgical procedures. Expense of instrumentation is a relative disadvantage in that the cost of the equipment and instrumentation for arthroscopy is no more than for other sophisticated instrumentation used in small animal practice and it is considerably less than for some equipment. Limitations imposed by small patient size are less of a concern as skill level and experience increase. Of the endoscopic techniques, arthroscopy is the most difficult to master and requires considerable practice, patience, and persistence. Reasons for this difficulty are related to the small space involved, confinement by rigid bony structures, and the complexity of some joints such as the stifle. Even so, with time and effort, proficiency with diagnostic arthroscopy and with basic operative procedures can be achieved.

Arthroscopy is indicated whenever history, physical findings, radiographic changes, or laboratory results suggest joint disease. A history of lameness and stiffness; difficulty or reluctance to get up, to go up or down stairs, to get up and down off the couch or favorite chair, or to get into or out of the car or truck; joint pain, swelling, or thickening; crepitus; reduced range of joint motion; and joint instability on physical examination are potential reasons to perform arthroscopy. Radiographic abnormalities of increased joint fluid or joint capsule thickening, periarticular osteophytes, periarticular sclerosis, OCD lesions, ununited anconeal processes (UAPs), ununited caudal glenoid ossification center (UCGOC), intraarticular fractures or chips, periarticular bone lysis, or any other

radiographic abnormalities involving a joint are also indications for arthroscopy. Normal radiographic findings do not preclude arthroscopy as a diagnostic technique if history and physical findings point to joint involvement. Arthroscopy is indicated whenever more information about a joint is needed than can be obtained with a less invasive technique.

Arthroscopy is most commonly performed in the shoulder, elbow, and stifle in dogs. Arthroscopy is less commonly performed on the radiocarpal, hip, and tibiotarsal joints. Arthroscopy has been performed in the shoulder and stifle of cats but its use is largely unexplored in this species. Arthroscopy is easier to perform in large dogs, but it has been done effectively in dogs weighing as little as 7 pounds.

Conditions diagnosed with arthroscopy (Table 14-1) include OCD of the shoulder, stifle, elbow and tibiotarsal joints; partial and complete cranial and caudal cruciate ligament ruptures; meniscal injuries; MCPP (FCP); UCGOC, UAP, ununited supraglenoid tubercle, degenerative joint disease (DJD); intraarticular fractures; immune mediated arthritis; synovitis; bicipital tendinitis and partial or complete bicipital tendon rupture; intraarticular soft tissue injuries of the shoulder, radiocarpal joint, stifle, and hip; septic arthritis; and neoplasia. Arthroscopic assessment of femoral head and acetabular joint cartilage condition in young dysplastic dogs is used to prognose results with pelvic osteotomy surgery. Operative procedures currently being performed with arthroscopy (Table 14-2) include removal of OCD cartilage flaps and debridement of the cartilage defects, coronoid process fragment removal and coronoid process revision, free joint body removal, bicipital tendon transection, carpal chip removal, partial and total meniscectomy, cruciate ligament debridement, meniscal release, UCGOC removal, ununited supraglenoid tubercle removal, UAP removal, screw fixation of UAP fragments, osteophyte removal in chronic DJD of the elbow and tarsus, thermal modification for stabilization of medial soft tissue injuries of the shoulder, intraarticular repair of ruptured cranial cruciate ligaments, fixation of avulsed ligament attachments, and repair of lateral humeral condyle and acetabular fractures. Potential corrective procedures envisioned for the future include intraarticular repair of the glenohumeral ligament and subscapularis tendon, repair of lateral labial separation of the shoulder joint, radial carpal fracture repair, and additional intraarticular fracture repairs.

*Table* 14-1 Diagnoses with Arthroscopy

**All joints**
- Degenerative joint disease
- Chondromalacia
- Neoplasia
- Synovitis/villus synovial proliferation
- Intraarticular fractures
- Immune-mediated arthropathies

**Shoulder joint**
- OCD* of the humeral head
- Bicipital tendon ruptures—partial and complete
- Medial glenohumeral ligament and subscapularis tendon injuries
- Lateral glenoid labrum separations
- Ununited caudal glenoid ossification center
- Ununited supraglenoid tubercle
- Supraspinatus tendon injuries

**Elbow joint**
- Medial coronoid process pathology/fragmentation
- Lateral coronoid process pathology/fragmentation
- OCD of the humeral condyle
- Ununited anconeal process
- Joint incongruity
- Intracondylar fractures

**Radiocarpal joint**
- Radial carpal bone fractures
- Chip fractures of the dorsal margin of the distal radius
- Dorsal joint capsule tears

**Hip joint**
- Hip dysplasia
- Dorsal joint capsule tears

**Stifle joint**
- Cranial cruciate ligament ruptures—partial and complete
- Caudal cruciate ligament ruptures—partial and complete
- Meniscal injuries
- OCD of the femoral condyle
- Medial patellar luxation/lateral patellar ligament rupture
- Long digital extensor tendon injuries
- Cruciate stabilization failure

**Hock joint**
- OCD of the talus

*OCD, *osteochondritis dissecans*.

## INSTRUMENTATION AND EQUIPMENT

### Arthroscopes

Rigid telescopes used for arthroscopy range in size from 1.9 to 5 mm in diameter. Telescopes commonly used for small animal arthroscopy include a long 2.7-mm arthroscope,

*Table* **14-2 Operative Procedures Performed with Arthroscopy**

**Shoulder joint**

- OCD* cartilage flap removal and lesion debridement
- Bicipital tendon transection
- Ununited caudal glenoid ossification center fragment removal
- Ununited supraglenoid tubercle fragment removal
- Thermal modification of soft tissues
- Intraarticular fracture repair

**Elbow joint**

- Coronoid process fragment removal/process revision
- OCD cartilage flap removal and lesion debridement
- Anconeal process removal/fixation
- Osteophyte resection
- Intraarticular fracture repair

**Radiocarpal joint**

- Carpal chip removal

**Stifle joint**

- Cruciate ligament debridement/removal
- Meniscectomy—partial/total
- OCD cartilage flap removal and lesion debridement
- Meniscal release
- Intraarticular fracture repair

**Hock joint**

- OCD cartilage flap removal and lesion debridement
- Free joint body removal
- Tarsal chip fracture fragment removal

*OCD, *osteochondritis dissecans*.

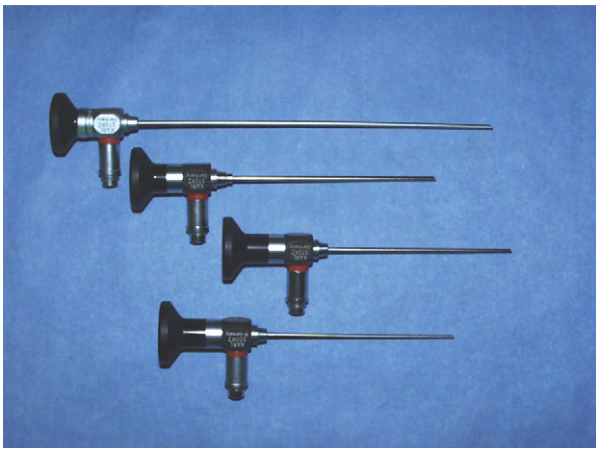


**Fig. 14-1**
Arthroscopes used in small animal practice, from top to bottom: long 2.7-mm multipurpose telescope, short 2.7-mm arthroscope, 2.4-mm arthroscope, and 1.9-mm arthroscope. All of these telescopes have a viewing angle of 30 degrees. The 2.7-mm multipurpose telescope has a working length of 18 cm and the arthroscopes have a working length of 10 cm.

also called the 2.7-mm multipurpose rigid telescope (Karl Storz #64018 BSA), a short 2.7-mm arthroscope (Karl Storz #67208 BA), a 2.4-mm arthroscope (Karl Storz #64300 BA), and a 1.9-mm arthroscope (Karl Storz #64301 BA) (Fig. 14-1). All of these telescopes have a 30-degree visual angle. Each has advantages, disadvantages, and specific best applications.

The 2.7-mm multipurpose telescope has two major advantages over the other arthroscopes, it has the best optics of all the small telescopes and its greater length allows it to be used for multiple endoscopic techniques. Of the 17 endoscopic techniques performed in small animal practice using rigid telescopes, this arthroscope can be used for 12; therefore, it is termed the *multipurpose rigid telescope*. The only disadvantage of this telescope is that its length makes manipulations more difficult for the finite movements needed for maneuvering the visual field within small joints, and the video camera produces a long fulcrum on the end of the telescope.

The other three arthroscopes are much shorter with working lengths of 10 cm vs. the 18-cm working length of the 2.7-mm multipurpose telescope. This shorter length is a major advantage in arthroscopy because it reduces the length of the lever arm from the tip of the telescope to the video camera. This makes handling the telescope in small joints much easier. Another advantage of this shorter length is that it allows the telescope to be held with the surgeon's index finger on the cannula at the skin of the portal site to accurately and easily maintain a constant depth of telescope insertion. This greatly reduces the number of times the field of view is lost because the telescope is inserted too deeply or the telescope is inadvertently pulled out of the joint, which is particularly problematic for beginners.

The diameter of the 2.4- and 1.9-mm short telescopes is not as much of an advantage as their shorter length. For smaller patients and for arthroscopy of the carpus and tarsus, the smaller scopes are relatively advantageous but are not necessary. These two telescopes, particularly the 1.9-mm arthroscope, are much more fragile than the 2.7-mm telescopes. They have a smaller field of view, which is a minor disadvantage, increasing the difficulty of joint visualization. The image is also smaller, the optics are not as good, and they are less effective for documentation purposes.

If the telescope is to be used exclusively for arthroscopy, the short 2.7- or the 2.4-mm arthroscopes are the

preferred choices for small animal arthroscopy. If the telescope will be used for different applications, such as rhinoscopy and cystoscopy, then the long 2.7-mm arthroscope is the best choice for a single telescope.

In addition to the telescope, there are several pieces of equipment and instruments that are necessary for arthroscopy. There is also some instrumentation and equipment that is optional.

## Telescope, Operative, and Egress Cannulae

### Telescope Cannulae (Fig. 14-2)

Arthroscopes are used with a cannula or sheath to protect the telescope and provide a channel for fluid inflow. A separate matched cannula is required for each specific telescope size (Karl Storz #64128 AR [2.7-mm MPRT cannula], #64147 BH [2.7-mm short arthroscope cannula], #64303 BN [2.4-mm arthroscope cannula], #64302 BN [1.9-mm arthroscope cannula]). Telescope cannulae come with a sharp trocar and a blunt obturator that are used for insertion into joints. The blunt obturator is preferred because it causes less damage to joint cartilage. These cannulae have a locking mechanism, which locks the cannula and telescope together with the telescope fully inserted into the cannula, and a luer connector for fluid inflow with a stopcock for controlling fluid flow. The locking mechanism protects both ends of the telescope by keeping the distal tip of the telescope aligned with the distal tip of the cannula to protect the distal lens of the telescope. It also prevents excessive bending stresses at the proximal end. The locking mechanism creates a watertight seal. It is very important that the telescope be properly locked in place to prevent telescope damage, to ensure proper fluid flow, and to prevent interference of the tip of the cannula with the visual field.



**Fig. 14-2**
Arthroscopy cannulae with blunt obturators and sharp trocars, from top to bottom: sharp trocar, blunt obturator, and cannula for the 2.7-mm long telescope; cannula for the 2.7-mm arthroscope; 2-mm operative cannula with its blunt obturator in the cannula (left); cannula for the 2.4-mm arthroscope with its blunt obturator in the cannula (right); blunt obturator for the 3.5-mm operative cannula (left); cannula for the 1.9-mm arthroscope (right); 3.5-mm operative cannula (left); blunt obturator for the 1.9-mm arthroscope cannula (right); 2.5-mm egress cannula with multiple side holes to improve drainage (left).

### Operative Cannulae (see Fig. 14-2)

Operative portals can be established with a cannula or by free passage of instruments through tissues overlying the joint without using a cannula. Conflicting opinions exist about which technique is best, but both are effective and each has its indications, advantages, and disadvantages. With a cannula, access for instrumentation is established and maintained by placing the cannula into the joint at the operative portal site. This technique facilitates removal and reinsertion of instruments. However, the size of instruments that can be placed into the joint and the size of tissue fragments that can be removed are limited. Operative cannulae can interfere with instrument manipulation because of small joint size and short distances between joint capsules and operative sites. They also have a tendency to come out with instrument and tissue removal. For free passage of instruments without a cannula, a portal is created by blunt dissection through tissues overlying the joint, and instruments are passed directly through the tissues. This allows passage of larger instruments, removal of larger pieces of tissue, and elimination of interference of the cannula with operative instrument manipulation. The primary disadvantage is increased difficulty of instrument reinsertion through the operative portal. The most effective arthroscopy is a combination of the two techniques, using the one technique that best fits the current procedure or stage of the procedure.

Operative cannulae used for small animal arthroscopy are 2 mm and 3.5 mm in diameter, about 5 cm long, and come with a sharp trocar or a blunt obturator for insertion (Karl Storz #64302 × [2-mm diameter] and #64169 × [3.5-mm diameter]). They are positioned under observation with the arthroscope to prevent intraarticular damage. A gasket provides a watertight seal around instruments to prevent leakage and allow control of fluid flow.

### Egress Cannulae (see Fig. 14-2)

A site for fluid outflow from joints is required. Fluid flow is necessary to maintain a clear visual field during arthroscopy, to provide joint distention, and to remove

debris created with operative procedures. Low outflow resistance, achieved with an egress cannula, is the best way to maintain adequate fluid flow without excessive pressure. Egress cannulae for small animal arthroscopy are 2 to 3 mm in diameter and have multiple side holes in the distal 1 to 2 cm of the cannula (Karl Storz #64146 T). This allows free access of fluid to the cannula and minimizes the possibility of occlusion. A luer connector with a stopcock at the proximal or outside end of the cannula allows connection of an outflow line to direct fluid away from the operative field and to control the rate of fluid egress. Most egress cannulae come with a sharp trocar for inserting the cannula into the joint. Observing cannula placement with the arthroscope can minimize intraarticular tissue damage.

Placement of an egress cannula is difficult in some smaller joints because of inadequate space within the joint or inadequate room for portal placement sites. In these cases and for simple diagnostic procedures in larger joints, a 20-gauge hypodermic needle can be used for an egress site. Egress can also be allowed to occur through operative portals. This simplifies the procedure by eliminating the step of egress cannula placement and by having the egress site close to the operative site, so debris from the procedure flows directly out of the joint rather than through the joint to a distant egress portal, decreasing the potential for leaving operative debris in the joint.

## Operative Hand Instruments

The number and variety of hand instruments available for arthroscopy is extensive but very few hand instruments are needed for basic operative arthroscopy for the most common conditions seen in small animals (Fig. 14-3). A basic set of hand instrumentation (Box 14-1) includes 2-, 3.5-, and 5-mm arthroscopic rongeurs (Karl Storz #64302 L [2 mm], #64166 A [3.5 mm] and #456003 B [5-mm Rhinoforce]); 2- and 3.5-mm arthroscopic grasping forceps (Karl Storz #64302 U [2 mm] and #64169 LS [3.5 mm]); hook probe (Karl Storz #64145 S [2-mm hook] and #64302 S [1-mm hook]); a microfracture chisel (Karl Storz #64728 CH [70 degree]); 3-0, 4-0, and 5-0 curettes (Miltex #19-704 [3-0], #19-702 [4-0], and #19-700 [5-0]); an exchange rod or switching stick (blunt IM pin), curved mosquito hemostats with and without teeth; 20-gauge, 1- and 1.5-inch hypodermic needles; 20-gauge, 2.5- or 3-inch spinal needles; number 10, 11, 12, and 15 scalpel blades; and a minor set of standard operative instruments. This basic instrument set is adequate for performing OCD surgery in all joints, for coronoid process revision, bicipital tendon transection, anconeal process removal, meniscal release, and bone chip removal. Additional hand instruments include larger rongeurs and grasping forceps, open curettes, a selection of arthroscopic knives, and curved meniscal resection forceps.



**Fig. 14-3**
Operative hand instruments for small animal arthroscopy, from top to bottom: hook probe; 5-mm arthroscopic rongeur (left); 3.5-mm arthroscopic grasping forceps (right); 3-0 (right), 4-0 (left), and 5-0 (right) curettes; 3.5-mm arthroscopic rongeur (left); small hook probe (center); exchange rod or switching stick (center); 2-mm arthroscopic grasping forceps (right); 2-mm arthroscopic rongeur (left); mosquito forceps with and without teeth (center); 70-degree microfracture chisel (bottom center); number 10, 11, 12, and 15 scalpel blades (lower left); 20-gauge 1-inch and 1.5-inch hypodermic needles and a 20-gauge 2.5-inch spinal needle (lower right).

**Box 14-1 Hand Instruments**

2-mm, 3.5-mm, and 5-mm arthroscopic rongeurs
2-mm and 3.5-mm arthroscopic grasping forceps
Hook probe
Microfracture chisel, 70 degree
3-0, 4-0, and 5-0 curettes
Exchange rod or switching stick
Curved mosquito hemostats with and without teeth
20-gauge, 1-inch and 1.5-inch hypodermic needles
20-gauge, 2.5-inch or 3-inch spinal needles
Number 10, 11, 12, and 15 scalpel blades
A minor set of standard operative instruments

## Power Equipment

### Power shaver (Fig. 14-4, *A*) (Karl Storz #28720003 U)

Power-operated cartilage shavers and burrs are a great asset to operative arthroscopy and can be used to remove cartilage, bone, and soft tissues. They greatly speed operative procedures and produce a better end result with a




**Fig. 14–4**
A, A power shaver appropriate for use in small animal arthroscopy. The handpiece is small and lightweight, facilitating use in small joints. B, Shaver blade types commonly used in small animal arthroscopy, from top to bottom: a full radius resector with smooth blades on both cutting surfaces, an aggressive full radius resector with a serrated blade in the inner cutting surface and a smooth blade on the outer cutting surface, an aggressive cutter with both blades serrated, and a round, shielded burr. These blades are available in sizes ranging from 2 to 4.5 mm depending on manufacturer.

smoother surface after tissue removal. Shavers are not absolutely necessary for many of the basic operative procedures, which can be performed effectively with hand instruments. Using a power-operated shaver when first learning to perform arthroscopy is not recommended because the potential for severe joint and instrument damage is greatly increased by putting power tools in the hands of an inexperienced operator. Extensive damage can be caused with a single step on the foot switch when the shaver blade is inappropriately placed. The additional expense of a power shaver is also a deterrent. Complex procedures performed by experienced surgeons are greatly facilitated with a shaver and an appropriate selection of blades; however, most basic operative arthroscopic procedures can be performed effectively with hand instruments.

A series of small shavers that was originally designed for maxillofacial surgery is currently being applied for small animal arthroscopy. These shaver handles are much smaller than human "small joint" shavers and their sizes are much more suitable for small animal arthroscopy. The primary difference among the different brands and models is in the fluid control mechanism. Several types and sizes of blades for the shavers are used for different applications. Commonly used shaver blades include burrs (2 to 4 mm) for removing bone and cartilage, aggressive cutters (2 to 4.5 mm) for removing soft tissue and cartilage, and sharp edge or smooth cutting blades (2 to 4 mm) for removing soft tissue (see Fig. 14-4, *B*). These blades are cannulated and debris from the cutting process flows out through the blade as shaving is performed. Suction is used with the shavers to facilitate debris removal and to pull soft tissues into the blade to enhance the cutting process. Larger sized blades speed soft tissue removal in procedures such as cruciate ligament debridement but are more difficult to use in small joints. Smaller blades are easier to use and are needed to access small joint spaces, such as for meniscus debridement but remove tissue more slowly and are more susceptible to occlusion with tissue debris. A selection of blade sizes and types is recommended to maximize shaver function.

## Radiofrequency/Electrocautery Instrumentation

Monopolar or bipolar radiofrequency instrumentation is used to cut tissue, to cauterize bleeding vessels, to shrink tissue by thermal modification of the joint capsule and ligaments, and for ablation of tissues. The most common use of radiofrequency that I have used has been for ablation of the fat pad and villus synovial reaction to improve visualization in the cruciate compromised stifle joint. I also use this technique for cranial cruciate ligament debridement or removal, for medial meniscal release by transection of the caudal meniscotibial ligament, and for partial or complete meniscectomies. Radiofrequency has also been used in the shoulder joint for thermal modification of medial soft tissue structures and for transection of the bicipital tendon. Ablation of villus synovial proliferation

with radiofrequency is beneficial in any joint to improve the visual field by removing excessive synovial tissue.

Specific instrumentation designed for arthroscopy is available in both bipolar and monopolar (Mitek Surgical Products VAPR II) configurations (Fig. 14-5, *A*). Multiple handpiece tip configurations and sizes facilitate access to structures within joints and are used for different tissue effects (see Fig. 14-5, *B*). The power settings of these units are adjustable for different applications. Specific tips containing thermocouples that regulate tissue temperature to achieve optimum tissue shrinkage without cutting or burning are used for thermal modification of tissue.

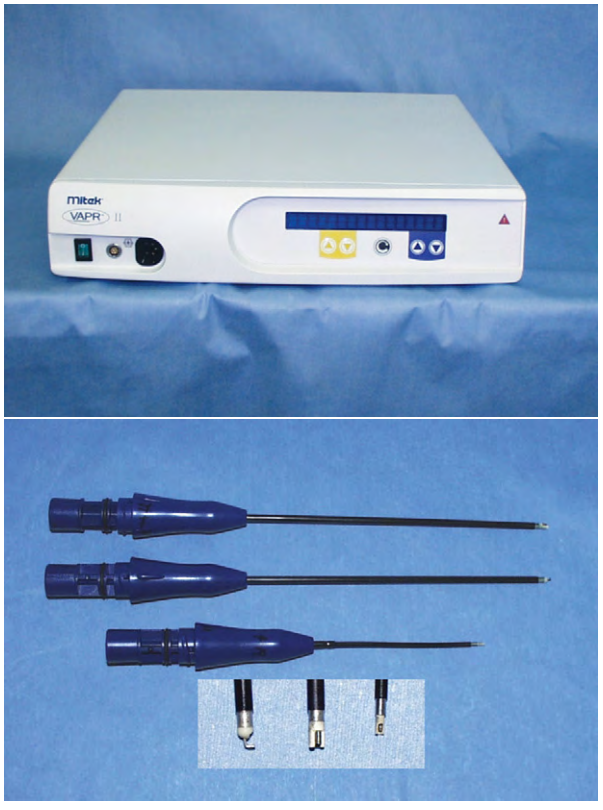



**Fig. 14-5**
A, A bipolar arthroscopic radiofrequency unit, the Mitek VAPR II. B, Electrodes for use with the Mitek VAPR II arthroscopic bipolar radiofrequency unit. Multiple handpiece configurations are available. Shown from top to bottom are 3.5-mm side effect electrode (*insert*, center), 3.5-mm hook electrode (*insert*, left), and a 2.3-mm side effect electrode (*insert*, right). Additional electrode configurations are end effect in 3.5-mm and 2.3-mm sizes, a 2.3-mm wedge electrode, and a 3.5-mm thermocouple temperature controlled electrode.

Specific arthroscopy tips are used to modify standard monopolar radiofrequency surgery units (Linvatek #8323 B [small joint electrode 90-degree tip]) (Fig. 14-6). This approach is effective for cutting and cauterizing but is less effective for thermal modification and ablation of large quantities of tissue.

## Irrigation Systems

The optical field for arthroscopy is established and maintained by irrigating the joint with fluid. Three different techniques can be used for maintaining fluid flow: gravity flow using liter containers of fluid placed above the patient with an intravenous (IV) set connected to the fluid portal on the telescope cannula, pressure-assisted flow with a manual pressure cuff added to the gravity flow system, and an automatic mechanical arthroscopic infusion pump. Ingress fluid flow through the telescope cannula assists in keeping a clear view by washing blood and debris away from the lens of the telescope and out of the visual field. Continuous drainage provided by the egress needle or cannula or through the operative portal allows for continuous fluid flow. A high-flow low-pressure system is effective in maintaining a clear visual field while decreasing the potential for periarticular fluid accumulation. This is achieved by decreasing outflow resistance rather than by increasing inflow pressure. Overzealous infusion of fluids can result in collection of fluid in the periarticular and subcutaneous tissues that interferes with joint examination by compressing the joint capsule.

Lactated Ringer's solution and physiologic saline solution are the most commonly used fluids for arthroscopy. There is not clear agreement on which is the preferred solution, and research has given conflicting results. This debate has been well reviewed.[1] Some studies have shown

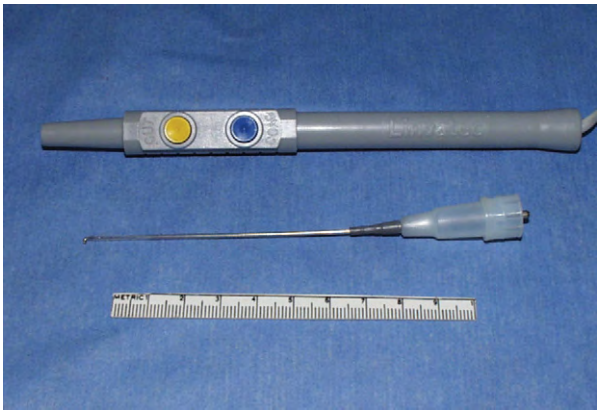


**Fig. 14-6**
An arthroscopy adaptor handpiece and tip for use with standard open surgical electrosurgery or radiofrequency units.

no difference in effect on cartilage metabolism of physiologic saline, lactated Ringer's solution, and sterile water.[2] Yet other studies have shown that sterile water has more adverse effect than lactated Ringer's solution and that lactated Ringer's solution has more adverse effect than saline.[3,4] And other studies have shown that Ringer's solution is more detrimental than sterile water.[5,6] An evaluation of ionic (lactated Ringer's solution and sterile water) and nonionic solutions (sorbitol, mannitol, and dextran 40) showed the least effect on mechanical properties and least proteoglycan loss with nonionic solutions.[6] The review of this debate concluded that "The author is unaware of any deleterious effects of normal saline solution. At the author's institution, normal saline is the most economic solution available."[1]

There is currently no clear scientific answer to the question as to which solution is best for arthroscopy. In a practical sense there are no proven clinical disadvantages or adverse effects of using lactated Ringer's solution or normal saline. Because saline and lactated Ringer's solutions are readily available and inexpensive, and because there are no valid clinical arguments against their use, they are the solutions currently used for arthroscopy.

### Gravity Flow

Gravity flow is the simplest, easiest, and least cumbersome technique for maintaining irrigation and works well for most diagnostic arthroscopies and many of the basic operative procedures. The technique uses 1-, 3-, or 5-L bags of sterile Ringer's solution, lactated Ringer's solution, or physiologic saline solution connected to an IV administration set, which is connected to the inflow port in the arthroscope cannula. The fluid bag is hung above the patient and the IV administration set flow controls are opened fully. The stopcock on the telescope cannula is then used to start and stop fluid flow. The level the bag is placed above the joint controls fluid pressure and joint distention. The rate of fluid flow is controlled by inflow pressure and by egress resistance. A high-flow low-pressure system is effective in maintaining a clear visual field while decreasing the potential for periarticular fluid accumulation. This is achieved by decreasing outflow resistance rather than by increasing inflow pressure.

### Pressure-Assisted Flow

Gravity flow is adequate in most cases for diagnostic and beginning operative arthroscopy. A pressure cuff on the fluid bag can be added to the system to increase pressure and flow when needed. A manually inflatable pressure cuff is placed on the fluid bag and inflated to create adequate pressure. This system is inexpensive and is easy to set up and use. The disadvantages are that pressure needs to be repeatedly added to the bag during the procedure, changing bags can be cumbersome, and the potential for periarticular fluid accumulation is increased if too much pressure is applied to the cuff.

### Mechanical Arthroscopic Fluid Pumps (Karl Storz #69330001) (Fig. 14-7)

Mechanical pumps that automatically manage intraarticular fluid pressure and flow are an asset to operative arthroscopy but are also an added expense and increase the complexity of operating room setup. They are not necessary for diagnostic arthroscopy or for basic operative arthroscopy. As the complexity of procedures increases, their benefits increase and advantages of having a fluid pump become more significant. These pumps are set to a specific pressure, 50 cm of water or less, which is maintained automatically by varying flow.

### Video System Tower

A video system is absolutely essential for arthroscopy. A video tower is a movable cart or cabinet on wheels containing the components of the video system needed for performing arthroscopy or other video endoscopic procedures. The necessary components of a video system are a video camera, video monitor, a xenon light source, and a cart or cabinet on wheels. Additional optional components include video recording or capture devices such as a video printer, video tape recorder, or digital capture device. The arthroscopic power shaver and mechanical fluid pump can be added to this tower or set up separately depending on the needs and application in the individual practice.

### Video Camera

Specifically designed cameras for arthroscopy and minimally invasive surgery are essential for arthroscopy (Karl Storz #69235106). The camera head attaches directly to the arthroscope eyepiece to create a one-piece operating system. The camera head that is in the operating field and attached to the telescope can be kept very small




**Fig. 14–7**
A mechanical arthroscopic fluid pump.

because most of the electronics for the system are in a control unit that is out of the operative field in the video system tower. Single-chip and three-chip cameras have analog or digital technology. A good quality autoexposure single-chip camera is more than adequate for small animal arthroscopy. These cameras are lightweight and compact, connect directly to the telescope, and provide an excellent image. Three-chip cameras have higher resolution and better color separation but are only necessary for publishing quality images.

### Video Monitor

A medical grade video monitor provides a superior image and is necessary for effective video endoscopy (Sony #9213B [13 inch]). Television (TV) sets and TV monitors are not adequate. The added expense of a medical grade monitor is minimal compared with that of the other components of the system and is well worth the money spent. Medical grade monitors are available in sizes from 13 to 19 inches. A 13-inch medical grade video monitor is of sufficient size for small animal practice and is more effective than a larger TV or monitor of lesser quality.

### Light Source

A good quality light source and fiberoptic light guide cable are required for arthroscopy. Halogen and xenon light sources vary greatly in cost. A xenon light source is preferred for arthroscopy in that they are much brighter and provide a light wavelength closer to that of natural light, giving tissues truer color (Karl Storz #201315-20). The flexible fiberoptic light cable is used to connect the light source to the telescope.

Documentation equipment is optional, and effective diagnostic and operative arthroscopy can be performed without a printer, video cassette recorder, or digital capture device. These are incorporated in the video system tower.

### Video Printer

A video printer is optional, but adding a video printer to the arthroscopy setup provides an inexpensive method of documentation and is a very effective marketing tool when pictures are given to clients and to referring veterinarians.

### Video Cassette Recorder

Videotaping of procedures is another method of documentation that can be used as a marketing tool, but still images are easier to manage because extensive editing of videotapes is usually necessary to provide an acceptable end product.

### Digital Capture Recorder

The highest quality still images are obtained with a digital capture recorder that takes images directly off of the camera during procedures. These captured images can then be transferred to a computer for editing, stored on disks, used for computer presentations, made into slides, or printed for distribution to clients or referring veterinarians.

## ANESTHESIA, PATIENT SUPPORT, AND PAIN MANAGEMENT

A surgical plane of general anesthesia is required for arthroscopy with the same considerations that would be used for any orthopedic surgery. Beyond this basic criterion, selection of preanesthetic medications, induction agents, maintenance anesthesia, and pain management are more patient-driven than they are procedure-driven. Anesthetic and support needs of the young dog undergoing shoulder arthroscopy for OCD are completely different than the needs of the geriatric dog undergoing multiportal elbow arthroscopy for debridement of DJD. Pain management needs also vary greatly depending on patient needs and on the specific arthroscopic procedure; however, pain medication needs are usually significantly less than those for an open arthrotomy or other open orthopedic procedure.

A typical patient management protocol that I use includes preanesthetic evaluation with complete blood count, blood chemistry profile, thoracic radiographs, electrocardiogram, and urinalysis. Premedication is with subcutaneous acepromazine and glycopyrrolate, induction is with intravenous propofol, and maintenance is with sevoflurane. Ketoprofen is given intramuscularly before the start of arthroscopy. Additional opioid pain medications may be indicated for responsive patients and for more extensive arthroscopic procedures such as multiportal elbow debridement or stifle debridement for management of cruciate ligament injuries. Intraarticular lidocaine, bupivacaine, or morphine may also be used at the end of more painful procedures. Intraarticular methylprednisolone has been used occasionally in severely inflamed joints. Supportive treatment typically includes intravenous lactated Ringer's solution for fluid therapy. Cefazolin is administered intravenously at the beginning of the arthroscopic procedure. Padded leg wraps are applied at the end of the procedure for distal joints including the elbow, carpus, stifle, and hock. The wraps are removed before release on the day following arthroscopy.

## POSTOPERATIVE CARE

Most patients are kept in the hospital until the day after arthroscopy was performed. Medications starting on the day after the procedure include oral etodolac and butorphanol. Patients are released with etodolac for 7 to 10 days and butorphanol for 2 to 5 days. Activity is restricted for at least 2 weeks. In-house activity is limited to walking with no running, jumping, roughhousing, going up or down stairs, or jumping up or down off of furniture.

Outside activity is limited to leash walking sufficient for urination and defecation. A recheck examination is performed at 2 weeks after arthroscopy and the activity level is adjusted based on the procedure that was performed and on patient progress. Additional pain medication is prescribed as indicated.

## GENERAL ARTHROSCOPIC TECHNIQUE

### Patient Preparation, Positioning, and Operating Room Setup

As a general rule, the patient is prepared and draped in a manner similar to what would be used for an open arthrotomy of the joint being examined. The limb or limbs are shaved, scrubbed, and draped for aseptic surgery as would be done for any open orthopedic procedure. Effective arthroscopy requires that the joint be freely movable and draping must allow a full range of flexion, extension, and rotation of the joint. Endoscopes and accessory instrumentation are sterilized with cold sterilization (glutaraldehyde), ethylene oxide, or autoclaving. The specific instrument manufacturer's recommendations for sterilization are followed.

The leg is positioned and stabilized by an assistant or it can be immobilized in a holding device. Basic principles of endoscopic operating room setup are followed.[7] The patient and video monitor are arranged so that the telescope is pointed toward the monitor for most of the procedure. This concept is essential to effective arthroscopy. The techniques are difficult enough to learn and master without the added disorientation of improper monitor placement. Operative portals are placed to achieve triangulation, which optimizes function for arthroscopic surgery with the telescope visual field and operative instruments positioned to converge on the intraarticular operative site in the same visual plane as seen by the surgeon (Fig. 14-8). The angle between the telescope and the instrument is kept between 30 and 60 degrees (absolutely less than 90 degrees); working at an angle of more than 90 degrees distorts the translation of hand movements to movement on the video monitor.

Patient positioning and operating room setup is specific for each joint and for specific procedures within each joint.

### Shoulder Joint

Unilateral procedures are performed with the patient positioned in lateral recumbency with the joint to be examined on the up side. If bilateral procedures are being performed under the same anesthesia, the patient is positioned in dorsal recumbency with both legs suspended and draping is done so that the patient can be rolled to each side to provide access to both joints. Bilateral shoulder OCD and bilateral UCGOC procedures are performed with the patient placed in dorsal recumbency with the monitor placed at the caudal end of the patient. When the legs have been draped, the patient is rolled toward the side to be operated first and the surgeon stands on the ventral side of the patient with the assistant standing caudal to the surgeon, between the surgeon and the monitor. After the first side has been completed, the surgeon and assistant move to the other side of the patient and the patient is rolled to expose the second shoulder. For bilateral bicipital tendon surgery and procedures involving the medial joint structures, patient positioning and transfer from side to side is the same as for OCD and UCGOC surgery, but the monitor is placed at the head of the patient and the assistant stands cranial to the surgeon, again between the surgeon and the monitor. Unilateral procedures are performed with the patient in lateral recumbency with surgeon and assistant positioning the same as for bilateral procedures and with the same monitor position as for bilateral procedures. An alternative technique places the monitor on the dorsal side of the patient directly across from the surgeon.

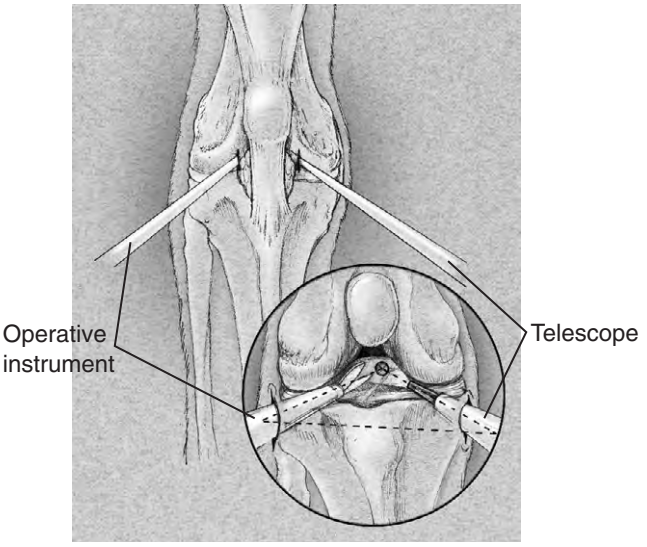



**Fig. 14–8**
Triangulation in the stifle joint with the telescope visual field and the operative instrument converging in the area of interest in the intercondylar notch for an operative procedure. *(From Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

### Elbow Joint

Elbow arthroscopy is typically performed bilaterally at the same anesthesia and dorsal recumbency is employed to allow access to both elbows. The patient is prepared with both legs suspended, and draping is done so that the legs are freely movable and can be abducted for access to both joints. Bilateral procedures for MCPP (FCP), for medial condylar ridge OCD lesions, and for general exploration

of the elbow joints using the medial telescope portal and craniomedial operative portal are performed with the patient in dorsal recumbency with the monitor placed at the head of the patient. The patient is held in dorsal recumbency with positioning supports, sandbags, or a "V" trough, the leg to be operated is abducted, and the surgeon stands on the same side as the joint being operated on. The assistant stands beside the surgeon on the patient's cranial side between the surgeon and the monitor. When the first joint arthroscopy has been completed, the surgeon and assistant move to the other side of the patient and the other leg is abducted for the second procedure. Arthroscopy for bilateral UAP removal is also performed with the patient in dorsal recumbency with the monitor at the caudal end of the table and the legs abducted to provide access to the medial aspect of the joint for placement of a standard medial telescope portal and a caudomedial operative portal. UAPs are commonly associated with MCPP (FCP), and this positioning and portal selection allows evaluation of the medial coronoid process at the same time as anconeal process fragment removal. This positioning does create the problem of working away from the monitor if coronoid process revision or fragment removal is required. Ideally, a second monitor is used for these procedures with one at each end of the table. If this is not possible, alternatives are to perform a unilateral procedure with the patient in dorsal or lateral recumbency with the monitor placed across from the surgeon on the opposite side of the patient or to use caudal portals for access the anconeal process with the patient in dorsal recumbency and the monitor at the head of the table. Multiportal elbow arthroscopy for debridement of DJD is typically performed as a unilateral procedure with the patient in dorsal recumbency so that the patient can be rolled from side to side for access to both medial and lateral aspects of the joint and with the monitor at the head of the patient.

### Radiocarpal Joint

Portals for radiocarpal joint arthroscopy are all on the dorsal aspect of the joint and procedures are typically unilateral. Dorsal recumbency with the leg pulled caudally or lateral recumbency with the limb rotated outward are used for unilateral arthroscopy, and bilateral procedures are performed with the patient in dorsal recumbency. With the patient in dorsal recumbency, the monitor is placed at the head of the table and the assistant stands cranial to the surgeon. For lateral recumbency, the monitor is placed across the table from the surgeon.

### Hip Joint

Lateral recumbency is used for arthroscopy of the hip joint and procedures are performed unilaterally. The most common indication for hip joint arthroscopy is in young dysplastic dogs before performing pelvic osteotomy surgery so the patient is positioned, prepared, and draped for the surgery. The monitor is placed at the head of the table or obliquely on the ventral side of the patient and far enough cranially to be out of the way for the surgical procedure. The surgeon stands on the dorsal side of the patient or at the caudal end of the patient. The assistant stands ventral to the patient in a position to apply traction to the leg and countertraction to the ventral midline.

### Stifle Joint

The most common diagnosis with stifle arthroscopy is injury to the cranial cruciate ligament, and unless there is another definitive diagnosis before arthroscopy, the patient is placed in the position and is draped for the corrective surgical procedure that will be performed after the cruciate ligament injury diagnosis is confirmed. Both dorsal recumbency with the leg extended caudally and lateral recumbency with the leg to be examined uppermost and rotated outward can be used for diagnostic stifle arthroscopy, but dorsal recumbency with the leg extended caudally provides easier manipulation of the joint and more complete access for operative procedures. When the patient is placed in dorsal recumbency, the monitor is placed at the head of the table or obliquely on the side of the leg being examined, far enough cranially to allow appropriate telescope orientation and to be out of the way of the sterile operative field for the surgical procedure. The surgeon stands at the foot of the table and the assistant stands lateral to the patient on the same side as the joint that is being operated on. For stifle arthroscopy in the lateral position, the monitor is placed dorsal to the patient, the surgeon stands ventral to the patient, and the assistant stands at the foot of the table. Dorsal recumbency is used for bilateral arthroscopy of the stifles with the monitor at the head of the table, the surgeon at the foot of the table, and the assistant moving to the lateral side of the joint being operated on.

### Tibiotarsal Joint

Portals for tibiotarsal joint arthroscopy are on all four quadrants of the joint: dorsomedial, dorsolateral, plantaromedial, and plantarolateral. A medial operative portal has also been used for removal of OCD fragments from the medial ridge of the talus. Dorsal recumbency with the hind legs extended caudally is used for bilateral or unilateral procedures and provides the most flexibility for joint manipulation and access to the greatest number of portals. OCD lesions on the plantar portion of the medial ridge of the talus, the most common condition found with arthroscopy of the tibiotarsal joint, are approached using a plantaromedial telescope portal and a medial operative portal with the patient in dorsal recumbency and the hind legs abducted and extended. Ventral recumbency allows

simultaneous placement of plantaromedial and plantarolateral portals, but access to the dorsal portals is limited. Lateral recumbency with the limb to be operated on the upper side can be used for unilateral tibiotarsal arthroscopy with internal or external rotation of the limb for reasonable access to all four portals, but does not have any advantages over dorsal recumbency. The monitor is placed at the head of the table for either dorsal or ventral recumbent positions or can be placed obliquely on either side of the patient far enough cranially to be out of the way of the sterile field. The surgeon and assistant stand at the foot of the table. Dorsal recumbency is the most commonly used position because, in addition to giving the most flexibility for access to all quadrants of the joint, it facilitates conversion to an open procedure if necessary.

## Portal Placement—General

Portals have been established for diagnostic arthroscopy and for the more common operative procedures for the six joints currently being examined with arthroscopy. There is not complete agreement over the exact location of some portals or in the sequence of portal placement, although similarities of the portals used by various surgeons in the field are far greater than their differences. Arthroscopy in small animal practice is a relatively new, evolving technique and, over time, the preferred locations for specific procedures may change. Telescope portals are more definitively established and more consistent than egress and operative portals. The sequence of portal insertion and location of portal sites are more variable for the egress portal than for the telescope portal and operative portals.

For initial portal placement, the joint is palpated and landmarks for portal placement are identified. A 20-gauge, 1- to 1.5-inch hypodermic needle is inserted into the joint at the site selected for telescope placement and synovial fluid is withdrawn to ensure intraarticular placement (Fig. 14-9, *A*). Joint fluid is saved for analysis and culture, and is submitted if indicated after arthroscopic examination of the joint has been completed. The joint is distended with sterile lactated Ringer's solution or saline using a syringe (see Fig. 14-9, *B*). Fluid infusion is continued until there is sufficient pressure in the joint to push the syringe plunger back when inflow pressure is released. A small stab incision is made in the skin, subcutaneous tissues, and fascia with a number 10 blade at the site of needle insertion. A number 10 blade is used, rather than a smaller number 15 blade, so that the skin incision is large enough to allow easy insertion of the telescope cannula and to facilitate egress of any fluid that escapes from the joint during the procedure to minimize periarticular and subcutaneous fluid accumulation. The telescope cannula is inserted into the joint using the blunt obturator (Fig. 14-10). The blunt obturator is preferred over the sharp trocar, even though more force is required to enter the joint using the blunt obturator, as the risk of damage to intraarticular structures is dramatically reduced. Using a blunt obturator also allows palpation of the joint space with the obturator to assist in locating the joint. To do this the blunt obturator is walked back and forth across the joint space "feeling" the bone on both sides of the joint and the indentation of the joint. This is especially helpful when entering the shoulder and elbow joints. When the cannula is properly positioned the obturator is removed (see Fig. 14-10), the arthroscope is inserted, and the telescope is locked into position in the cannula (Fig. 14-11). If manipulation for positioning of the arthroscope is required after placement of the cannula within the joint prior to examination the blunt obturator is used to prevent damage to articular cartilage and to the telescope.

Continuous flow of irrigation solution, Ringer's solution, lactated Ringer's solution, or sterile physiologic saline solution is initiated to provide a clear visual field and to maintain joint distention during examination.

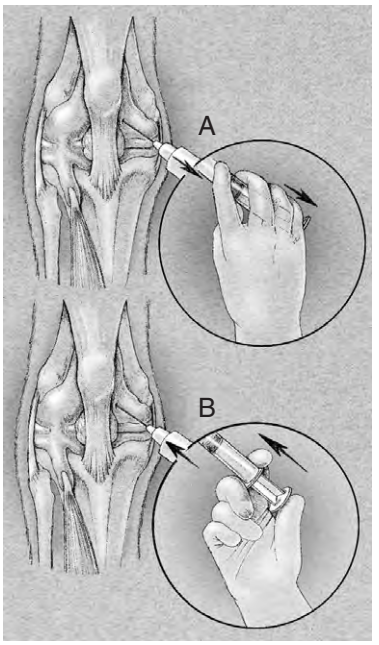



**Fig. 14–9**
A, The first step in portal placement is arthrocentesis. A 20-gauge 1-inch or 1.5-inch needle is inserted into the joint and synovial fluid is withdrawn to confirm intraarticular needle placement. A sample of fluid is saved for analysis and culture if indicated after arthroscopy has been completed. B, Saline, Ringer's solution, or lactated Ringer's solution is injected to distend the joint. *(From Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

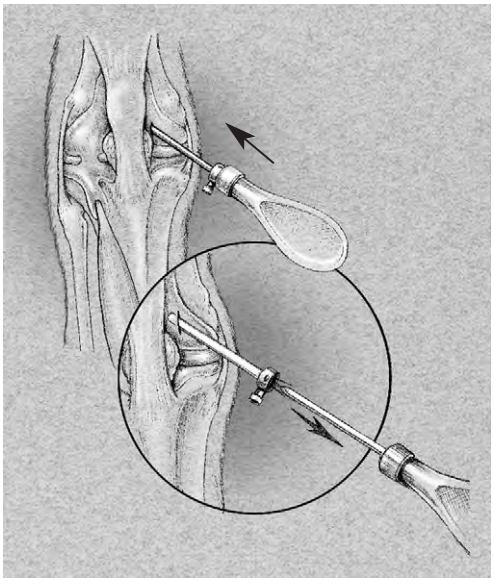


**Fig. 14–10**
The telescope cannula is inserted into the joint using a blunt obturator. When the cannula is properly positioned, the blunt obturator is removed. *(Modified from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

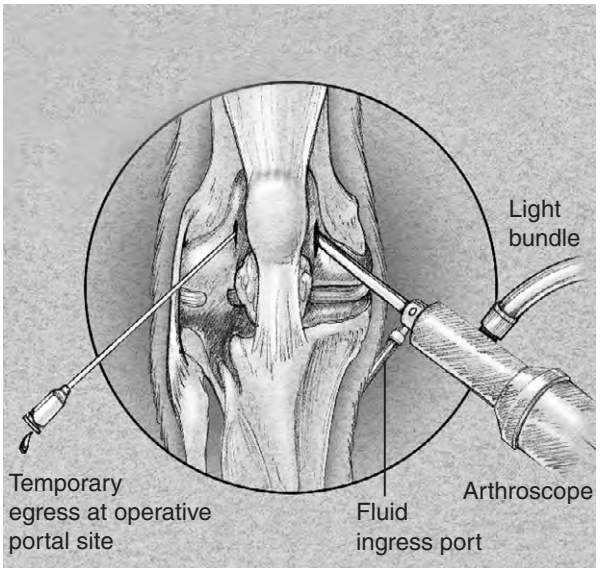



**Fig. 14–11**
The telescope is inserted into the cannula and is locked in place. A 20-gauge, 1-inch or 1.5-inch needle is placed for temporary egress at the intended operative portal site. *(Modified from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

A sterile intravenous administration set that has been connected to a liter container of fluid is attached to the telescope cannula injection port and fluid flow is initiated. The hypodermic needle at the site used for initial joint distention or a hypodermic needle placed at another location is used for temporary egress (see Fig. 14-11) until an egress cannula can be placed or an operative portal established to allow for egress.

The primary purposes of fluid flow through the joint are to maintain a clear visual field and to provide a visual space by distention of the joint. While distention of the joint capsule is necessary to visualize the joint surfaces, dogs are especially susceptible to fluid extravasation into the periarticular and subcutaneous tissues. Fluid accumulation into periarticular tissues compresses the joint capsule and interferes with joint examination and operative procedures. Pressures greater than 50 mm Hg are thought to produce extravasation of fluid in the dog. A high-flow, low-pressure system with just enough pressure to distend the joint facilitates visualization without increasing the risk of periarticular fluid accumulation. A high-flow, low-pressure system can be achieved most easily with a large multiport egress cannula or a relatively large operative portal that will allow fluid leakage. Increased input pressure will distend the joint and improve fluid flow but without easy egress a clear field will not be maintained and there will be increased risk of periarticular fluid accumulation. Inflow pressure and egress flow are balanced to maintain adequate joint distention with a clear field. Inflow pressure can be adjusted by changing the elevation of the fluid bag above the patient for the gravity system, increasing or decreasing cuff pressure for the pressure assisted system, or by adjusting the controls on an automatic mechanical arthroscopy pump.

Periarticular or subcutaneous fluid entrapment can also be decreased or minimized by creating tapered portals with the skin and subcutaneous tissue incision larger than the joint capsule opening. This allows any fluid that leaks out of the joint to escape from the skin portal without being trapped in the periarticular or subcutaneous tissues. Wise port placement and configuration, adequate egress, minimal joint movement, and avoiding excessive fluid distention pressures will all help minimize fluid extravasation.

When adequate fluid flow has been established to provide a clear visual field and adequate joint distention an initial examination of the joint is performed. This initial examination provides an overview of the joint pathology for planing surgical procedures and placement of additional joint portals for insertion of operative instrumentation. Additional telescope portals can also be created for more complete joint examinations when needed. The principle of triangulation is employed for additional port placement so that the telescope does not

interfere with the operative procedure being performed (see Fig. 14-8). Triangulation is a term used to describe positioning instruments inside a joint to optimize function. The concept is visualized with the telescope as one side of a triangle, the operative instrument as the second side of the triangle, the skin as the base of the triangle, and the intra articular lesion at the apex of the triangle. Selection of the angle of convergence of the two sides of the triangle is critical to facilitating operative arthroscopy. Too narrow or too wide a triangle increases the difficulty of instrument manipulation, orientation, and increases interference of the telescope with the operative instruments. The other critical factor in forming the optimal triangle is that the tip of the operative instrument and the optical field of the telescope must meet at the desired point within the joint. In addition to the point of intersection of the telescope and operative instrument and their angle of convergence the anatomy of the joint must be considered when selecting the point and angle of insertion to avoid interference from the surrounding bony structures.

The joint is palpated and landmarks for operative portal placement are identified. To confirm the correct location for operative port placement a 20-gauge, 1- to 1.5-inch hypodermic needle is placed into the joint at the intended portal site. The intraarticular operative site and the instrument insertion point inside the joint are visualized and the needle is repositioned until the optimal point of insertion and the correct angle of placement are achieved. A small skin incision is made at the portal site with a number 10 blade and the operative portal is created with blunt dissection with a curved mosquito hemostat, or an operative cannula is placed into the joint.

For many operative procedures, it is easier to insert instruments directly into the joint through the tissue tract without using a cannula.

When the procedure has been completed, the joint is flushed to remove debris. The telescope is moved around the joint to look for debris, and the fluid flow from the telescope cannula is used to wash the debris out of the joint. Placing a cannula in the operative portal site and moving the cannula into the area of the debris to enhance flow can facilitate removal. A palpation probe can also be used to dislodge debris fragments or they can be grasped with forceps and removed. With completion of this important step, the instruments, telescope, and cannulae are removed. Skin sutures are placed at each portal site.

## ARTHROSCOPY OF THE SHOULDER JOINT

### Indications

Arthroscopy of the shoulder joint is indicated when there is front leg lameness with shoulder pain, crepitus, or instability; or radiographic changes suggestive of OCD, UCGOC, ununited supraglenoid tubercle, mineralization of the bicipital or supraspinatus tendons, intraarticular fractures, or DJD. OCD and UCGOCs commonly occur bilaterally and arthroscopy of the contralateral joint is recommended. The pattern of shoulder pain may localize the site of the disease process and reorder the index of suspicion for shoulder disease, but typically shoulder pain cannot be localized sufficiently to make a definitive diagnosis. Hyperextension pain is the classic finding with shoulder OCD, but it can also occur with UCGOC, bicipital tendon injuries, and soft tissue injuries of the caudal, medial, and lateral structures of the shoulder. Pain on palpation of the craniomedial aspect of the joint over the bicipital grove, on hyperflexion of the shoulder while the elbow is extended, or on forced internal rotation of the shoulder is suggestive of bicipital tendon pain. Instability of the shoulder is also an indication for shoulder arthroscopy and is inconsistently detected as craniocaudal drawer instability, mediolateral drawer instability, or abduction instability. There is considerable variation in the degree of instability that can be defined with soft tissue injuries of the shoulder joint, the normal shoulder is not totally stable in these manipulations, and there can be bilateral involvement making comparative evaluation very difficult. Radiographic changes defining shoulder pathology such as OCD, UCGOC, ununited supraglenoid tubercle, supraspinatus or bicipital tendon mineralization, and intraarticular fractures provide a diagnosis and confirm indication for arthroscopy, but most soft tissue injuries of the shoulder do not show any radiographic changes. A significant increase in joint fluid volume obtained by arthrocentesis can be helpful in confirming joint involvement and providing additional incentive for performing arthroscopy. Increased joint fluid seen with CT or MRI is also sufficient information to warrant arthroscopy, even if there are no other findings with these imaging techniques. Many conditions involving the shoulder joint are subtle and difficult to define, even with all the aforementioned techniques, and exploratory arthroscopy may be required to establish a diagnosis or to rule out the shoulder as a source of the lameness.

### Patient Preparation, Positioning, and Operating Room Setup

For unilateral shoulder arthroscopy, the patient is placed in lateral recumbency with the shoulder to be examined on the up side, the monitor is placed dorsal to the patient, and the leg is suspended for preparation and draping. The surgeon and assistant stand ventral to the patient with the assistant either to the right or left of the surgeon. When undergoing bilateral shoulder arthroscopy, the patient is placed in dorsal recumbency with both legs suspended for preparation and draping. Preparation and draping are done to allow the patient to be rolled from

one side to the other during the procedure. The monitor is placed at the foot of the table for procedures performed in the caudal portion of the joint (e.g., for OCD or UCGOC) or at the head of the table for bicipital tendon evaluation and transection, and for procedures involving the medial aspect of the joint. The assistant and surgeon stand on the same side of the table on the side away from the joint to be examined. The patient is rolled toward the surgeon to expose the first shoulder for arthroscopy. When the first shoulder procedure has been completed, the surgeon and assistant move to the other side of the table and the patient is rolled to expose the second shoulder. Bilateral procedures can be easily performed in this manner and are well tolerated by the patient. Because OCD and UCGOC are commonly bilateral conditions, this technique is frequently used.

## Portal Sites and Portal Placement

### Telescope Portals

A lateral or craniolateral portal is the most commonly used telescope portal for shoulder arthroscopy and provides access for procedures in the caudal, cranial, and medial areas of the joint (Fig. 14-12, *A*). This portal is placed distal to the tip of the acromion process and cranial to the acromion portion of the deltoideus muscle. An indentation is palpable at this site where the joint capsule is covered with only subcutaneous tissue and skin. In thin dogs, the lateral margin of the articulation of the scapula with the humerus can be palpated at this site as the joint is moved. The exact distance of this portal from to the tip of the acromion process depends on patient size and conformation. Evaluation of preoperative shoulder radiographs is helpful in establishing the correct portal site. Variations in the location of this portal range from this site cranial to the deltoid muscle caudad up to 2 cm and through or caudal to the acromion portion of the deltoideus muscle.

A cranial or craniomedial telescope portal is used occasionally for assessment of the lateral labrum of the glenoid and for access to the medial aspect of the joint (see Fig. 14-12, *B*). These portals are rarely placed as the initial telescope portal and are most commonly established after examination of the joint from the craniolateral portal determines that this portal is needed. The portal is placed medial (craniomedial portal) or lateral (cranial portal) to the origin of the bicipital tendon into the cranial compartment of the joint. The location for this portal is established using the same procedure as is used for locating operative portal site placement, by inserting a 20-gauge hypodermic needle into the joint under arthroscopic guidance. Two techniques have been used to establish these portals as a telescope portal site. When the desired location has been determined, an operative cannula is inserted using visual guidance with the arthroscope, an exchange rod or switching stick is placed into the operative cannula, the operative cannula is removed, the telescope and cannula are removed from the original lateral portal, the telescope cannula is inserted at the new site

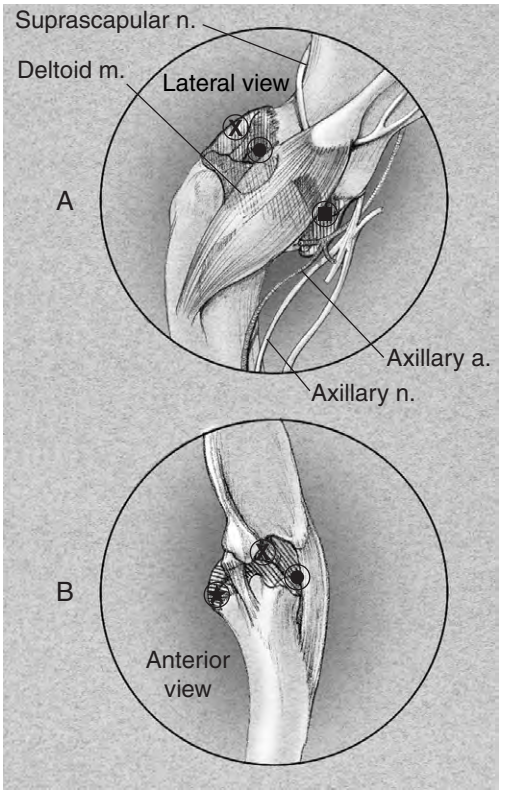



**Fig. 14–12**
A, Arthroscopy portals on the lateral aspect of the shoulder joint. The three portals shown are the cranial (*X*), lateral or craniolateral (*circle*), and the caudal (*square*) portal. The lateral or craniolateral portal site is the most common telescope portal site and is located distal and cranial to the tip of the acromion process, either through or cranial to the acromion body of the deltoid muscle. The cranial portal site is used for the cranial operative portal and for the cranial telescope portal, and as an egress portal site. The caudal portal is used as the operative portal site for osteochondritis dissecans and ununited caudal glenoid ossification center lesion removal and as an egress portal site for procedures using the cranial portal as an operative portal. B, Arthroscopy portals on the cranial aspect of the shoulder joint. The three portals shown are the craniolateral telescope portal (*circle*); the cranial portal lateral to the bicipital tendon that can be used for the telescope, as an operative portal, or for egress cannula placement (*X*); and the craniomedial telescope portal medial to the bicipital tendon (*star*). *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

over the switching stick, and the telescope is reinserted into its cannula. Another method of establishing this portal is to visually position the tip of the telescope into the cranial or craniomedial portal site from inside the joint. The telescope is removed from the cannula, leaving the cannula in the joint with the tip of the cannula held in the new portal site. The sharp trocar is inserted into the cannula and locked in place, the cannula is pushed through the joint capsule and overlying tissues until it exits from the skin, the trocar is removed, a switching stick is inserted into the tip of the cannula, the cannula is removed from the original portal site, the cannula is slid over the switching stick into the new portal site, the switching stick is removed, and the telescope is replaced.

## Operative Portals

A caudolateral portal is used for removing OCD cartilage flaps, for debriding OCD cartilage defects, for removing caudal cul-de-sac joint mice, and for removing UCGOC lesions (see Figs. 14-12, *A,* and 14-13). This portal is placed 1.5 to 3 cm caudal and 1 to 1.5 cm distal to the camera portal and is in the same area as the caudolateral surgical approach to the humeral head for removal of OCD lesions. It is helpful to determine the distance from the telescope portal site to the operative portal site on radiographs before surgery. To locate this portal site, the OCD lesion is visualized with the telescope and a 1.5- to 2-inch, 20-gauge hypodermic or spinal needle is directed into the joint to intersect the axis of the telescope at the caudal margin of the shoulder joint. Correct needle placement is confirmed by intraarticular visualization of the needle with the telescope. A short incision is made at the needle site with a number 10 blade through skin, subcutaneous tissues, and superficial muscle fascia. A curved mosquito hemostat with the curved tip pointed cranially is used to bluntly dissect through the muscle and into the joint. The hemostat jaws are spread to create a large enough tissue tract for removal of OCD cartilage fragments. To place an operative portal cannula, a stab incision is made at the needle site with a number 10 blade and the needle is replaced with the operative cannula. This is one of the more difficult portals to place due to muscle thickness over the joint, the angle at which the joint is approached, and the lack of close bony landmarks.

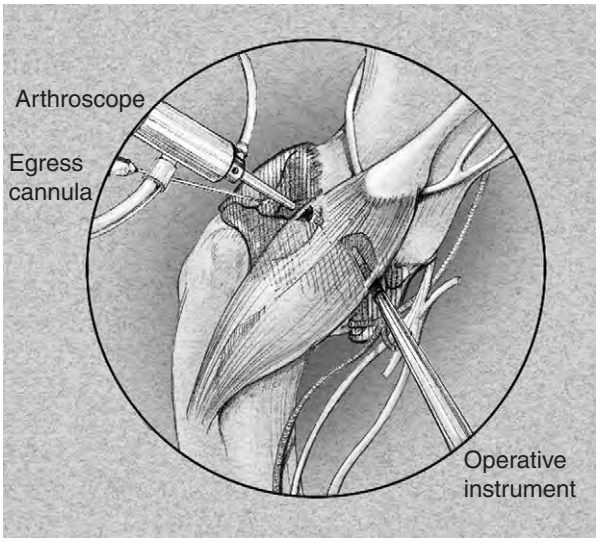



**Fig. 14–13**
Arthroscopy portals used for access to lesions in the caudal portion of the shoulder joint. The telescope is in the craniolateral portal and is directed caudally to allow visualization of humeral head osteochondritis dissecans lesions and ununited caudal glenoid ossification center lesions and for examination of the caudal cul-de-sac and caudal joint capsule. An instrument in the caudolateral operative portal provides triangulation with the telescope visual field. An egress cannula is present at the cranial portal site. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

A cranial operative portal site is used for transecting the bicipital tendon, for medial ligament and joint capsule procedures, and for removal of loose joint bodies in the cranial area of the joint (see Figs. 14-12 and 14-14). This portal is placed medial to the greater tubercle of the humerus and lateral to the bicipital tendon. The site for this portal is determined by palpation of the greater tubercle and the bicipital groove. A 1- to 1.5-inch, 20-gauge hypodermic needle is inserted at the selected site and correct needle placement is viewed from inside the joint with the arthroscope. A skin incision is made with a number 10 blade and an operative cannula is placed or a tissue tract is dissected with a mosquito hemostat. Joint entry is visualized with the arthroscope from inside the joint to ensure accurate placement and prevent joint damage.

## Egress Portals

Placement of an egress portal for shoulder joint procedures is optional and egress is typically allowed through the operative portals (see Fig. 14-12). When an egress portal is needed for operative procedures in the caudal portion of the joint, it is placed at the same site as the cranial operative portal and is inserted using the same technique. Operative procedures in the cranial portion of the joint use the caudolateral operative portal site as an egress portal if one is needed.

## Examination Protocol and Normal Arthroscopic Anatomy

When first entering the shoulder joint through the lateral or craniolateral telescope portal, anatomic structures are

identified that allow orientation within the joint. The concave glenoid articular surface, the convex humeral head articular surface, the medial glenohumeral ligament, and the subscapularis tendon are important and easily identifiable structures to use for orientation (Fig. 14-15). Once orientation is achieved, the joint is examined in a systematic manner to ensure examination of all the important structures of the joint. By angling the tip of the telescope cranially, the bicipital tendon is identified, originating on the supraglenoid tubercle of the scapula (Fig. 14-16). The bicipital groove is evaluated as far distally as possible (Fig. 14-17). The telescope is swept caudally to visualize the articular surfaces of the scapula and humeral head. Particular attention is given to the articular cartilage on the caudal portion of the humeral head and the caudal margin of the glenoid (Fig. 14-18). The caudal movement of the telescope is continued to evaluate the caudal cul-de-sac of the joint (Fig. 14-19). The medial margin of the glenoid (Fig. 14-20) and medial soft tissue structures of the joint, including the glenohumeral ligament (see Fig. 14-20), the subscapularis tendon (see Fig. 14-15), and the craniomedial joint space (Fig. 14-21), are examined by redirecting the tip of the telescope from caudally to cranially. The lateral labrum of the glenoid is visualized by retracting the telescope as far as possible without exiting the joint and angling the scope cranially with the angle of view directed dorsally (Fig. 14-22). Rotation of the telescope to position the viewing angle

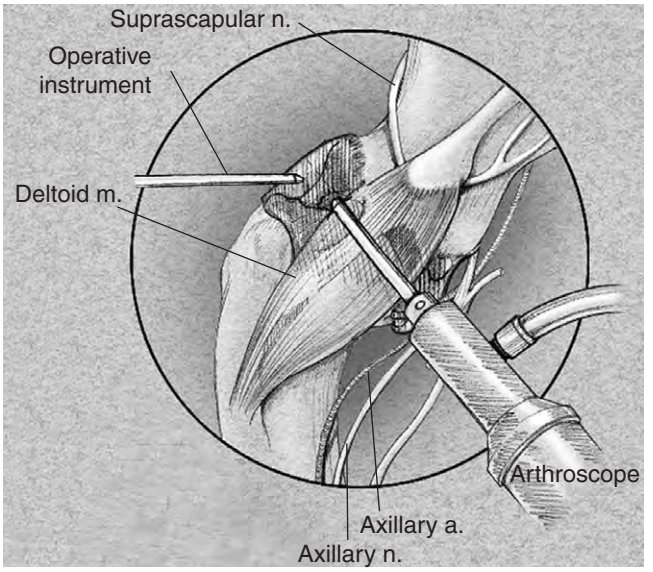



**Fig. 14–14**
Arthroscopy portals used for access to lesions in the cranial portion of the shoulder joint. The lateral or craniolateral telescope portal is used with the telescope directed cranially to allow visualization of the bicipital tendon, bicipital groove, medial ligaments, and cranial area of the joint. An instrument present in the cranial portal provides triangulation with the telescope visual field. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

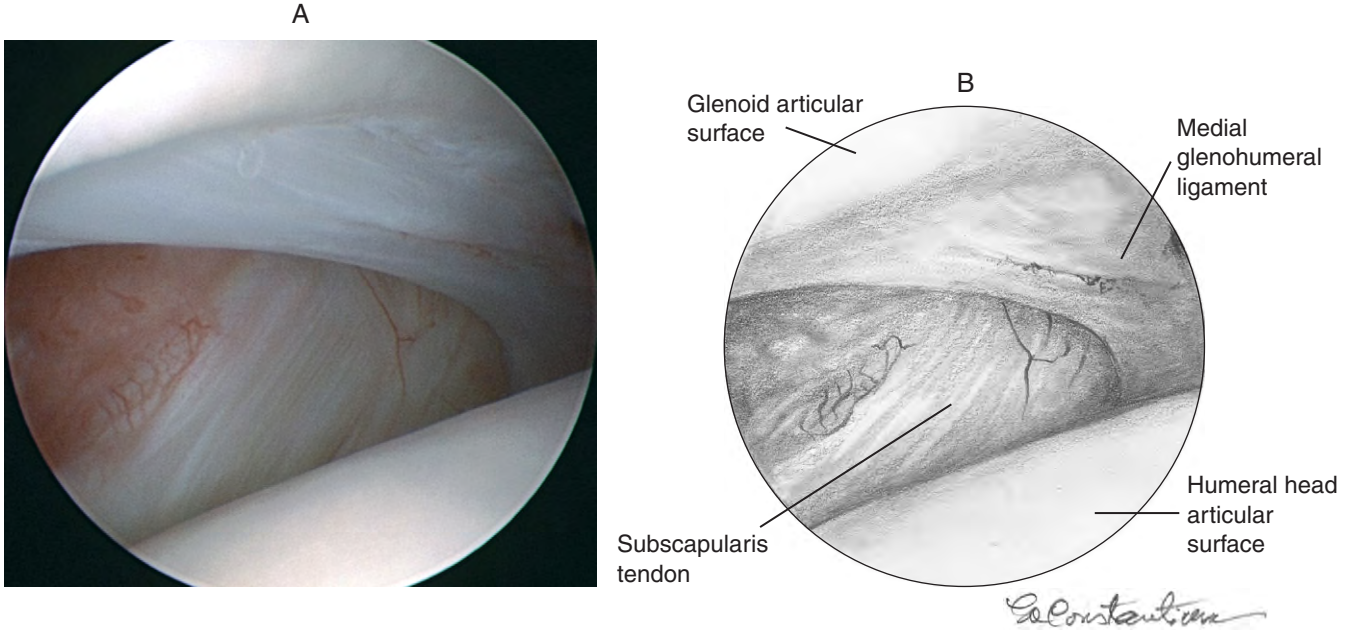



**Fig. 14–15**
Normal structures in the shoulder joint used for orientation from the lateral telescope portal are the concave glenoid articular surface, the convex humeral head articular surface, the medial glenohumeral ligament, and the subscapularis tendon.

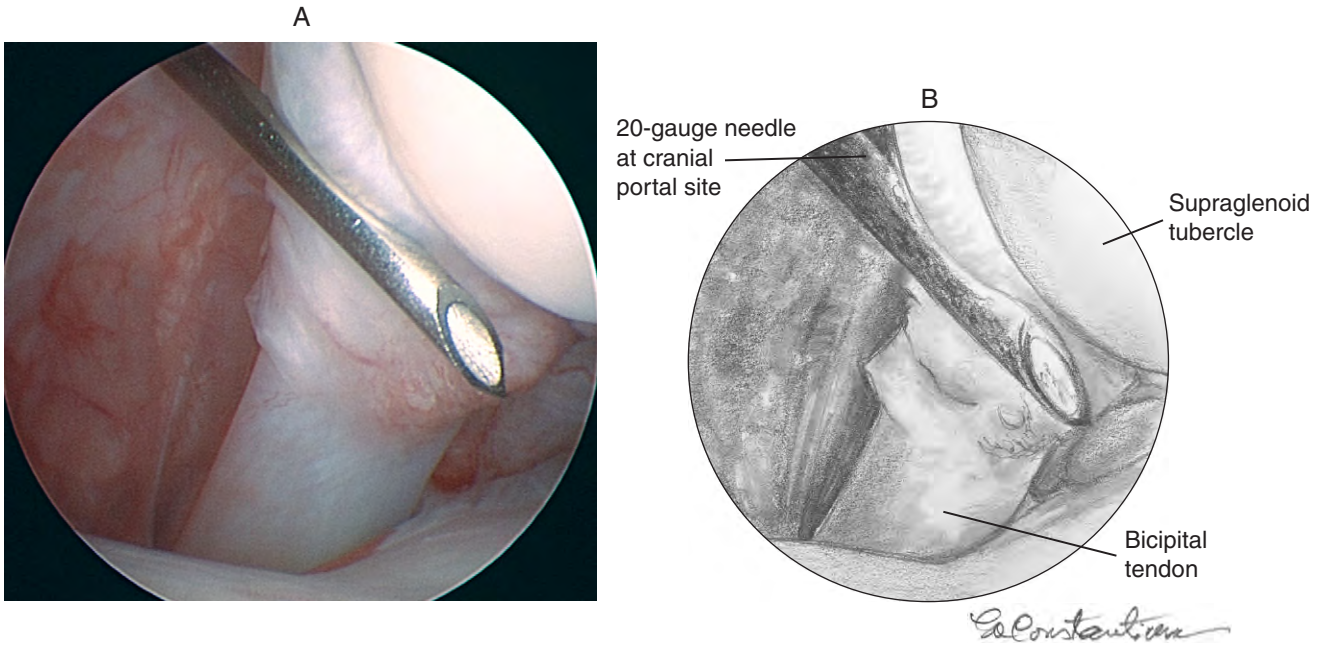



**Fig. 14–16**
A normal-appearing bicipital tendon originating from the supraglenoid tubercle. A 20-gauge needle has been placed for initial egress and to establish the location for cranial portal placement.

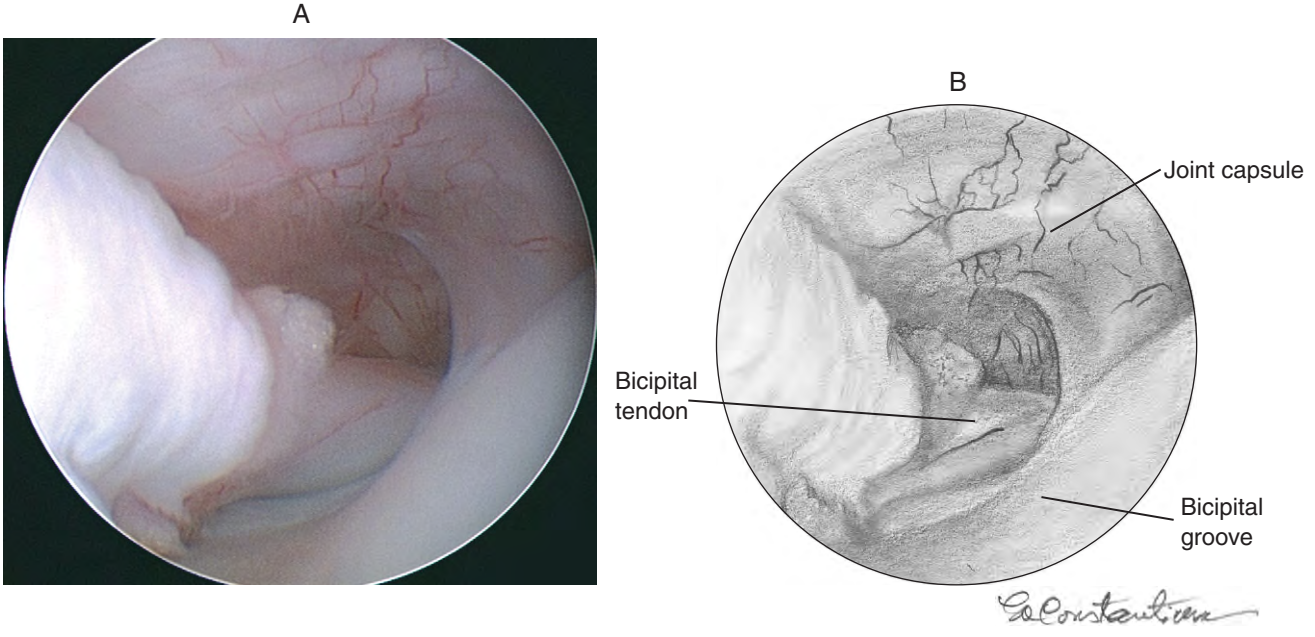



**Fig. 14–17**
The bicipital tendon traversing distally in the bicipital groove.

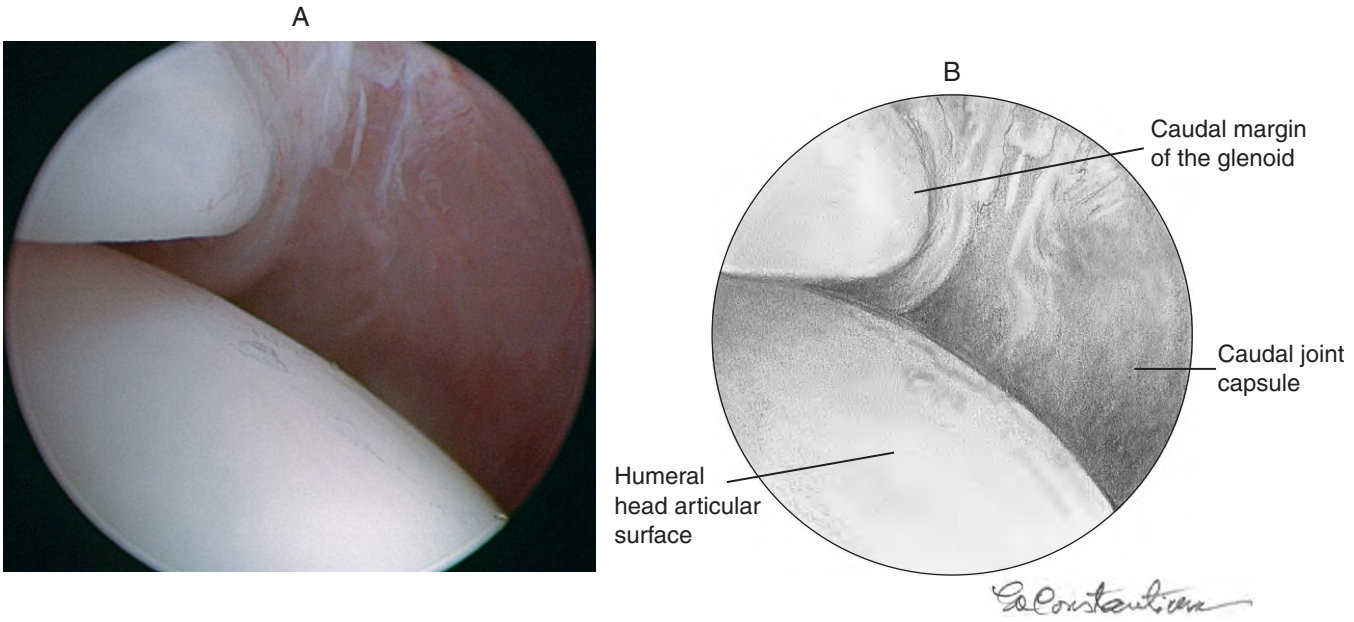



**Fig. 14–18**
Normal caudal humeral head articular surface and caudal margin of the glenoid.

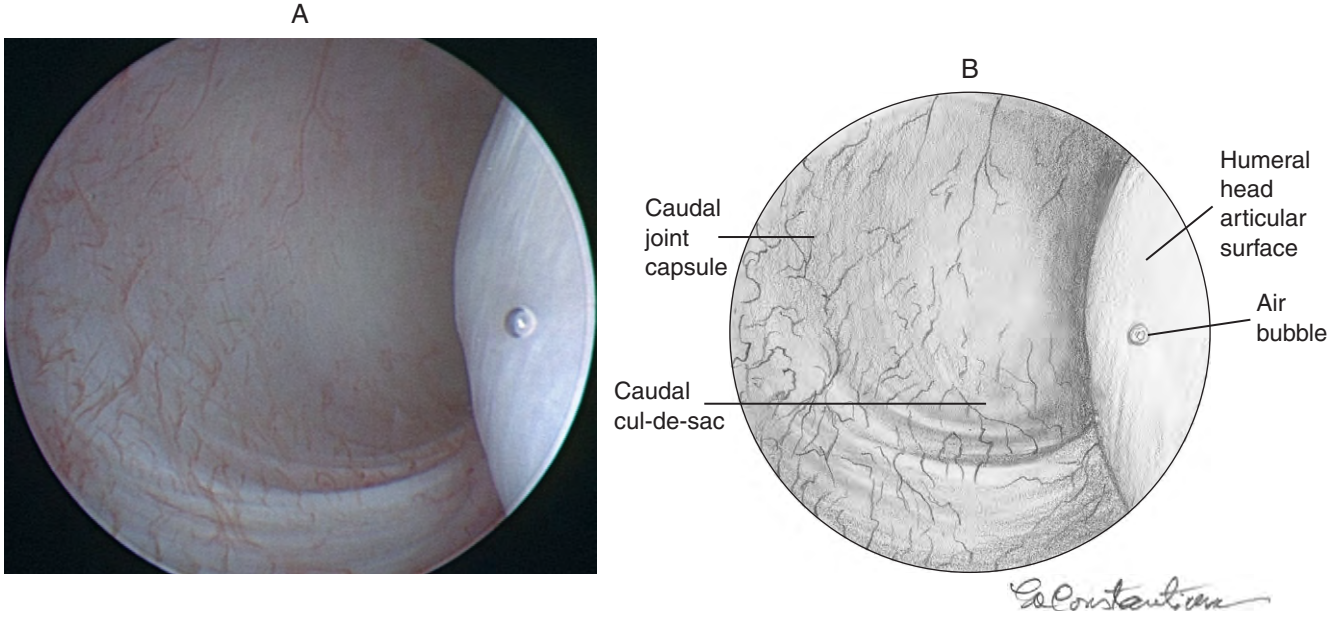



**Fig. 14–19**
Normal caudal cul-de-sac with the caudal margin of the humeral head articular surface and the attachment of the joint capsule to the humerus.

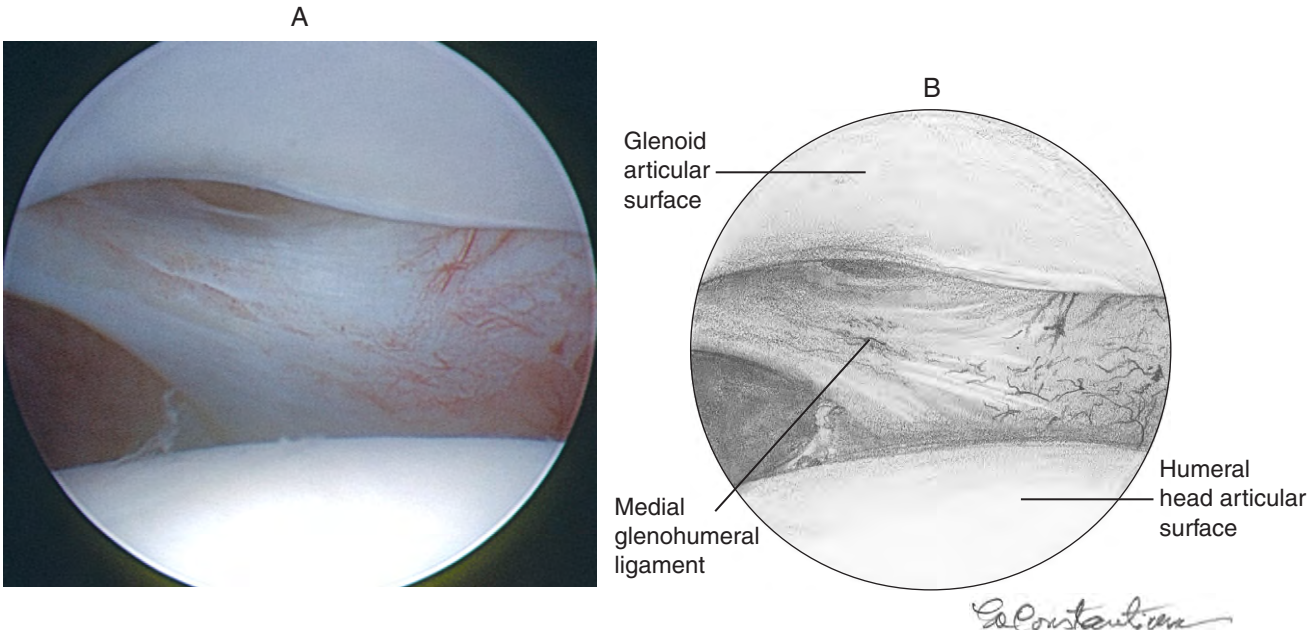



**Fig. 14–20**
Normal medial glenohumeral ligament demonstrating the classic "Y" shape, normal medial margin of the glenoid articular surface, and normal humeral head articular surface.

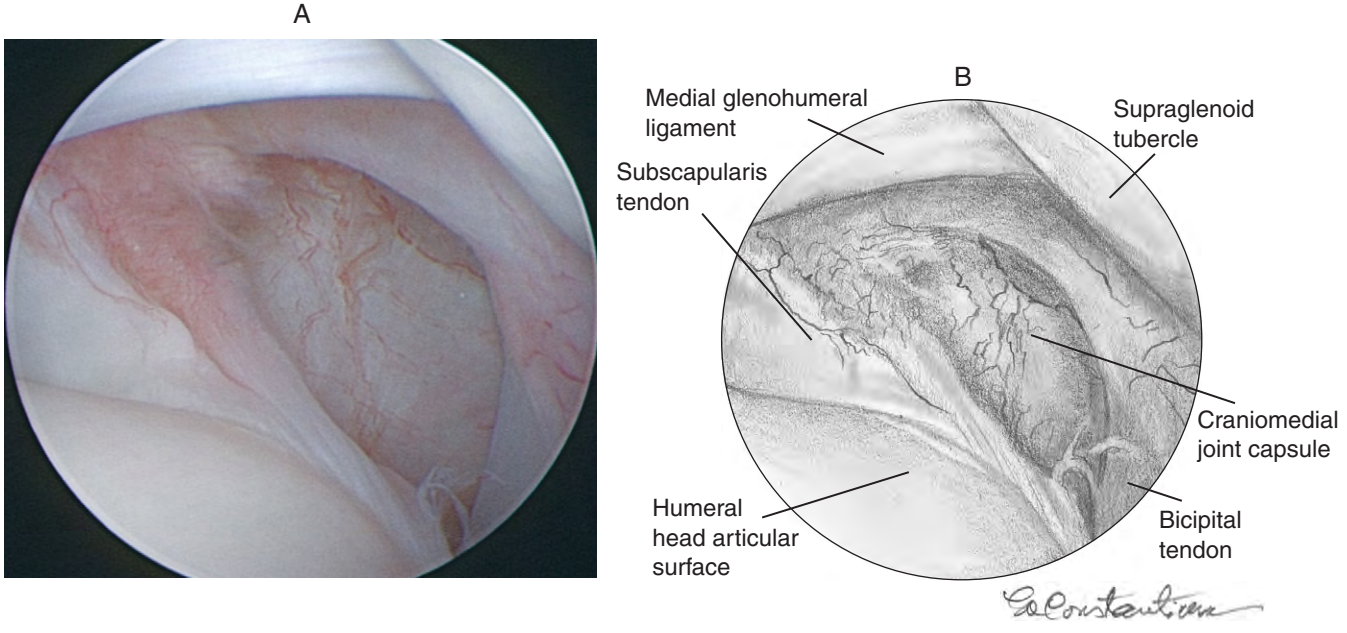



**Fig. 14–21**
The craniomedial joint space where the glenohumeral ligament, subscapularis tendon, and bicipital tendon border the joint capsule.

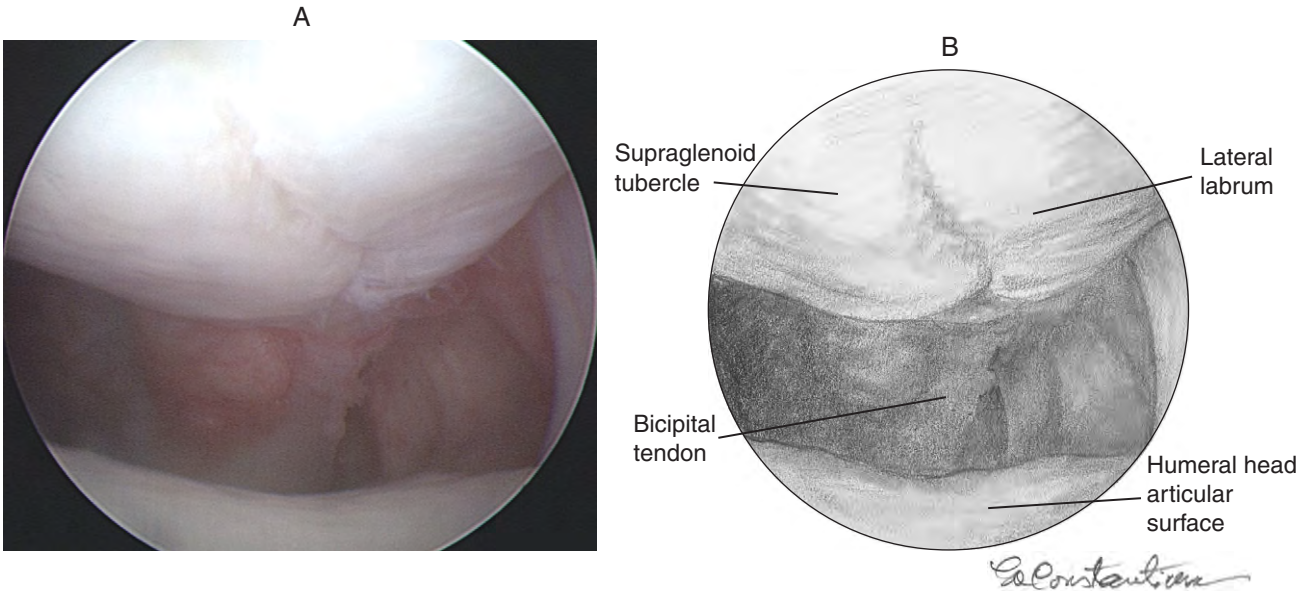



**Fig. 14–22**
The cranial portion of the lateral cartilaginous labrum of the glenoid visualized by retracting the telescope, directing the tip cranially, and rotating the viewing angle dorsally.

laterally allows visualization of the lateral collateral ligament of the shoulder joint. This routine examination of the joint can be completed in most patients with the joint in a neutral position, but in some cases, flexion, extension, abduction, and rotation of the joint may be required to access and assess all areas of the joint. For complete assessment of the lateral joint capsule, lateral collateral ligament, and lateral labrum of the glenoid, a cranial or craniomedial telescope portal is required.

## Diseases of the Shoulder Diagnosed and Managed with Arthroscopy

### Osteochondritis Dissecans

OCD is the most common diagnosis that is made with arthroscopy in the shoulder joint. The classic presentation of front leg lameness in a young, large breed dog with pain on hyperextension of the shoulder joint is sufficient indication for arthroscopy. Radiographs confirm diagnosis before arthroscopy, but normal radiographs do not rule out OCD or preclude arthroscopic exploration of the joint. Bilateral shoulder arthroscopy is routinely recommended even in the presence of unilateral presentation, because OCD is commonly a bilateral disease and it is far easier for the patient and more economical for the client to have a bilateral procedure done rather than two unilateral procedures.

Arthroscopy for OCD is performed with a lateral or craniolateral telescope portal and a caudolateral operative portal. Egress is through the operative portal site; a cranial egress portal can be used but is seldom necessary. OCD lesions are typically easily visible on the caudal surface of the humeral head as a loose flap of cartilage with easily defined free margins (Fig. 14-23), although they can appear as loose cartilage with attached margins (Fig. 14-24), or as areas of soft cartilage or movable cartilage with no defined margins (Fig. 14-25). When the lesion has been identified, a needle is inserted into the joint at the operative portal site to confirm the best location for portal placement (see Fig. 14-23) and the operative portal is established using a curved mosquito hemostat to bluntly dissect into the joint. OCD lesion removal is typically performed without an operative portal cannula. The tip of the hemostat is used to free the cartilage flap until it is almost completely detached (Fig. 14-26). A small point of attachment is left in the craniomedial margin of the flap to hold the flap in place until it can be grasped with the hemostat. If the flap is completely detached, it can escape into the medial or cranial areas of the joint and be much more difficult to grasp for removal. When the cartilage flap has been appropriately loosened, the jaws of the hemostat are opened and placed over the cartilage flap as far as possible so that the jaws extend across the flap, and the hemostat is closed onto the flap (Fig. 14-27). The flap is pulled off of its final point of attachment and the hemostat is retracted until the leading margin of the flap is against the joint capsule at the operative portal site. The hemostat is rotated or an oscillating rotation is used as the hemostat is withdrawn so that the flap rolls up around the hemostat as it slides through the tissues of the operative portal. Using this technique, most OCD lesions can be removed in one large

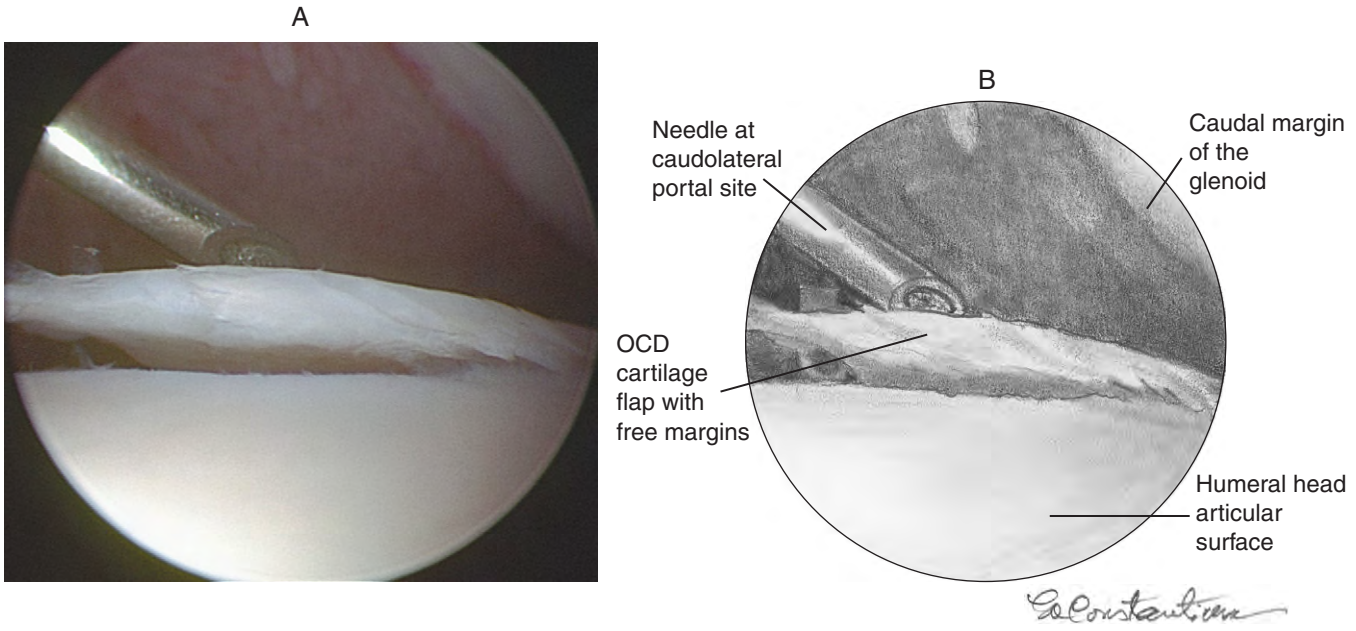



**Fig. 14–23**
A humeral head osteochondritis dissecans lesion with an easily visible cartilage flap and free margin. A needle has been placed to establish the location for the operative portal site.

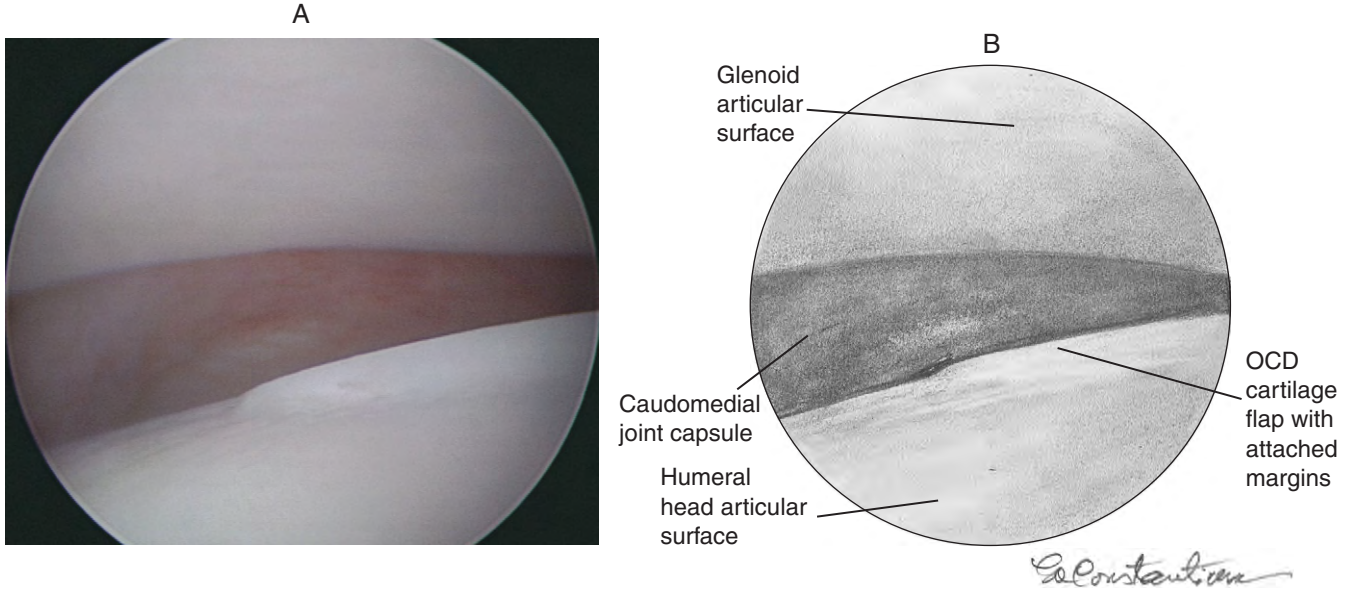



**Fig. 14–24**
An osteochondritis dissecans lesion in the humeral head with loose cartilage but unbroken lesion margins.

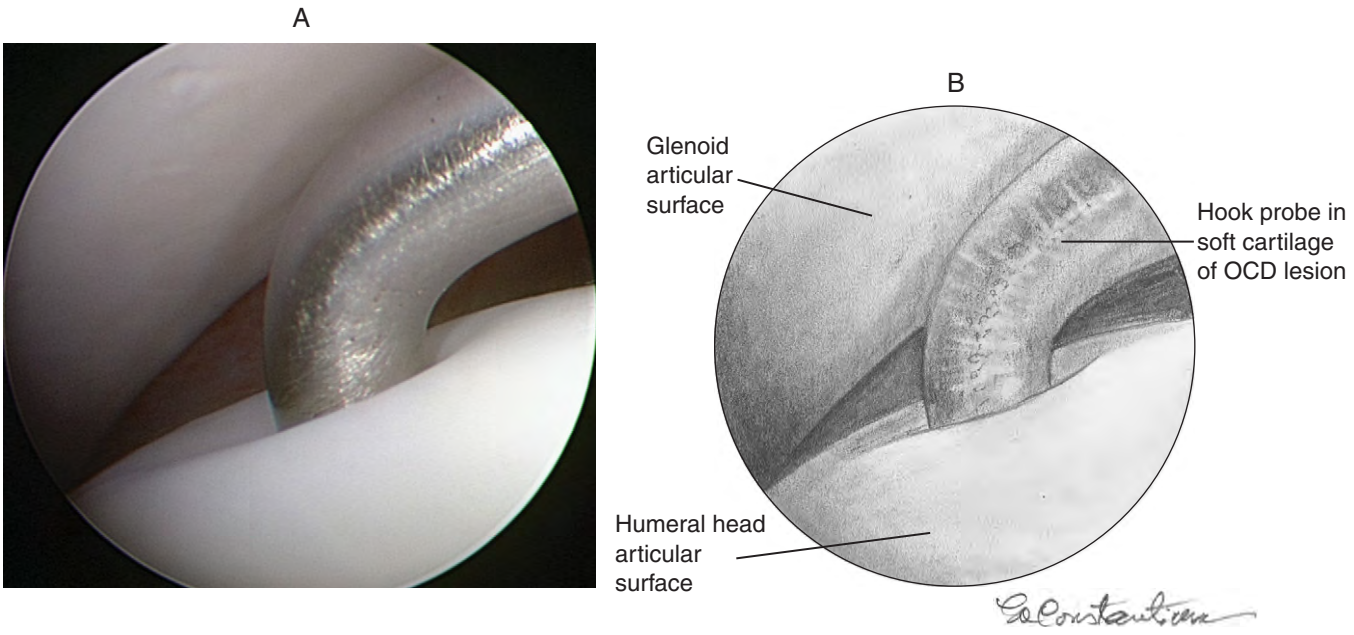



**Fig. 14-25**
An osteochondritis dissecans lesion in the humeral head evidenced by soft cartilage with no visible margins. The hook probe is being used to palpate and define the area of abnormal cartilage.

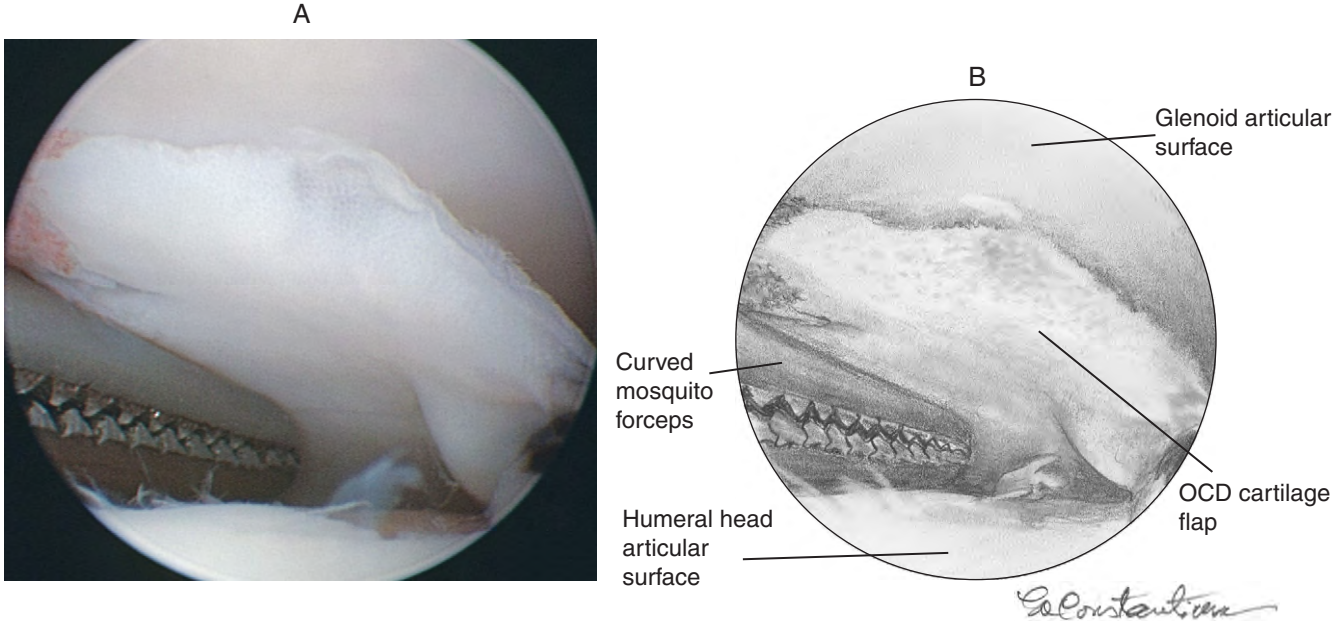



**Fig. 14-26**
A curved mosquito hemostat is placed into the joint and is used to elevate the osteochondritis dissecans cartilage flap off of the bone, leaving a small portion of the craniomedial attachment intact.

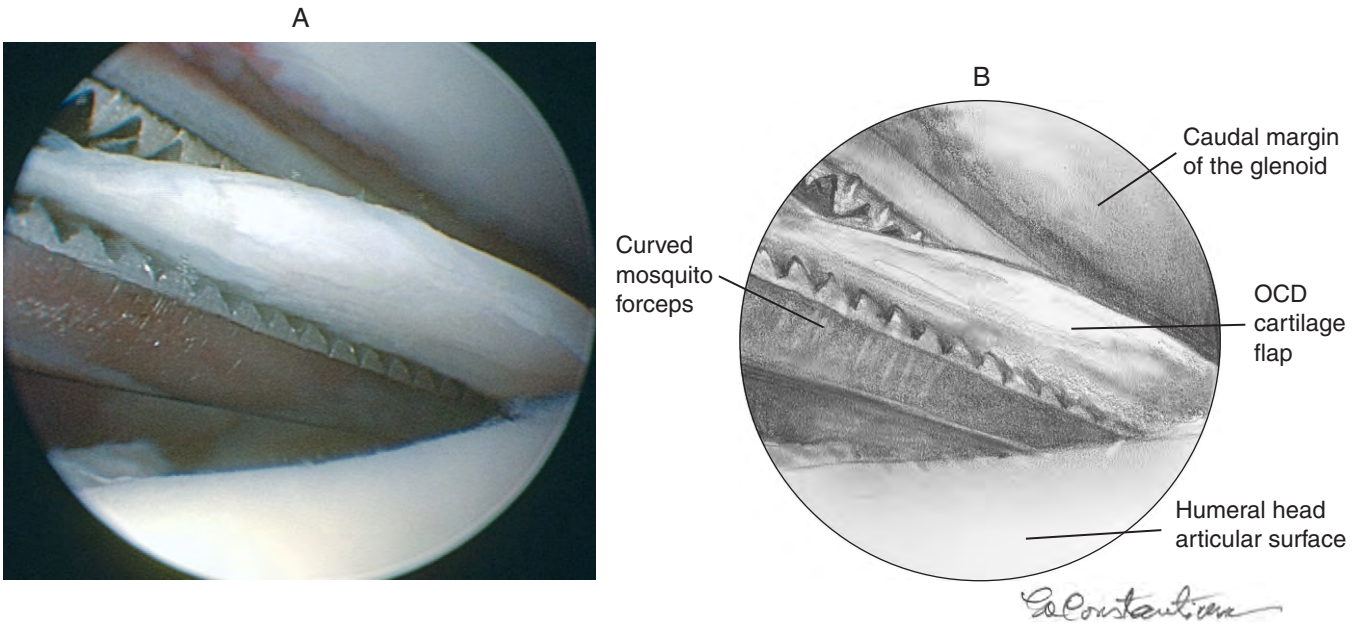



**Fig. 14-27**
The jaws of the hemostat are opened, placed across the cartilage flap as far as possible, and then closed.

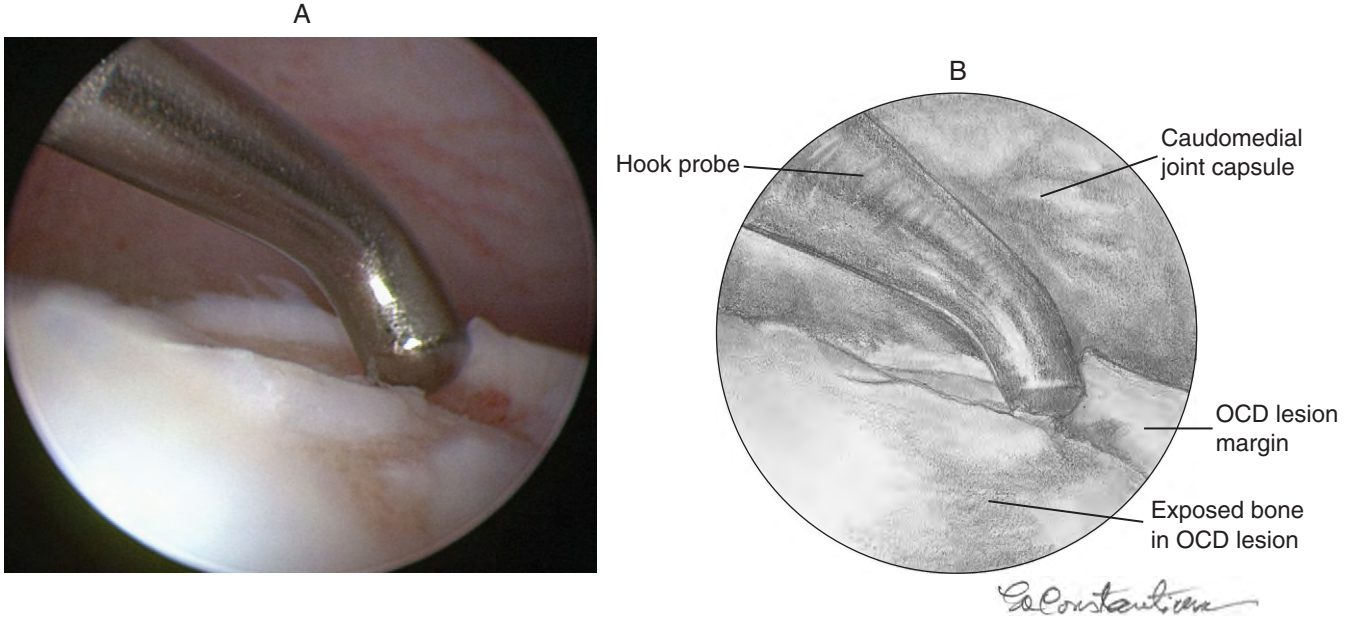



**Fig. 14-28**
The margins of the cartilage defect are palpated with the hook probe to look for any remaining loose cartilage.

piece. If the flap breaks during removal, the hemostat is reinserted to remove the remaining fragments.

The cartilage defect is evaluated after the flap is removed. A hook probe is inserted and the margins of the cartilage are palpated for any loose cartilage (Fig. 14-28). Residual loose cartilage is removed from the margin and bed of the lesion with hand instruments or with a power shaver. Loose cartilage fragments are removed but fixed islands of attached cartilage that are a chondrocyte source for cartilage regeneration are left in place (see Fig. 14-28). The bed of the defect is assessed further to determine whether there is viable (Fig. 14-29) or avascular

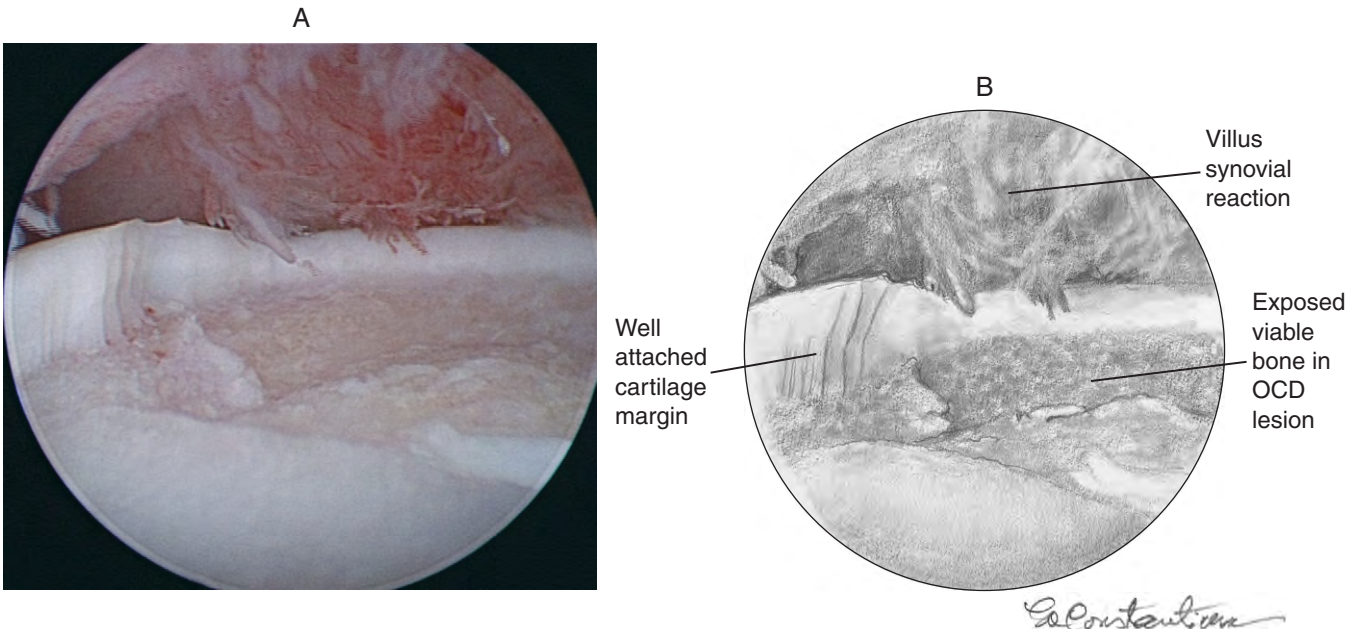



**Fig. 14–29**
Viable bone in the bed of a humeral head osteochondritis dissecans lesion after removal of the free cartilage flap. Note the well-attached clean margin. Also note the villus synovial reaction.

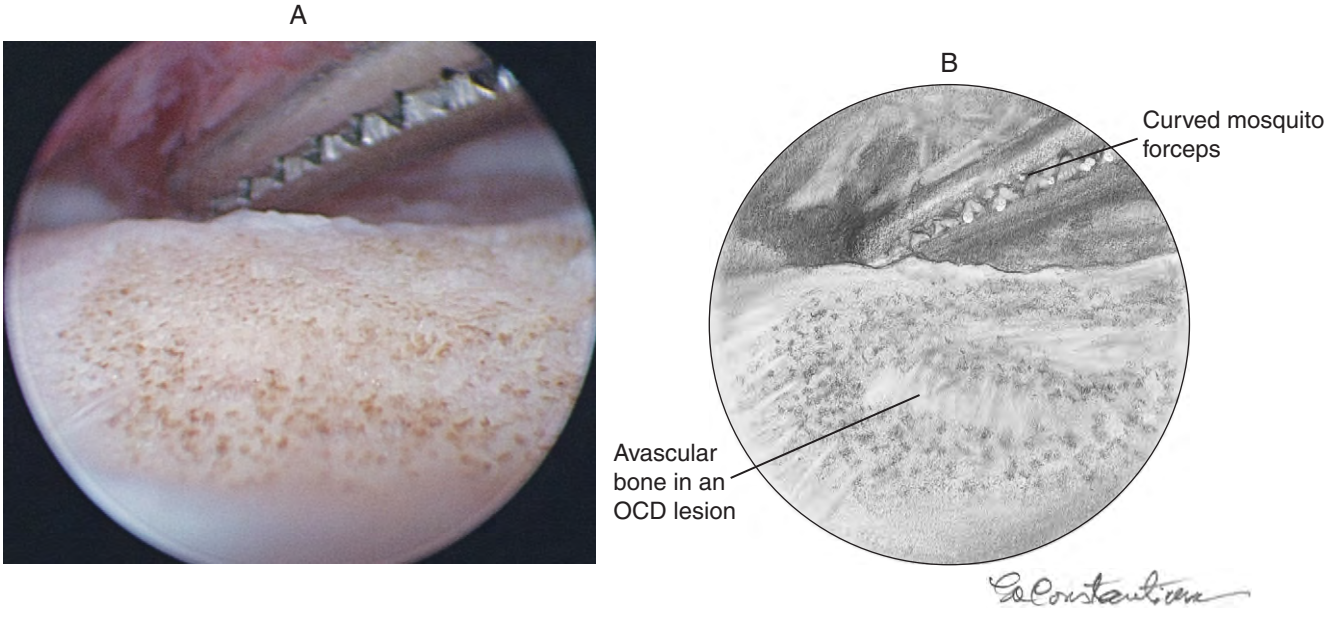



**Fig. 14–30**
The bed of a humeral head osteochondritis dissecans lesion covered with avascular or necrotic bone.

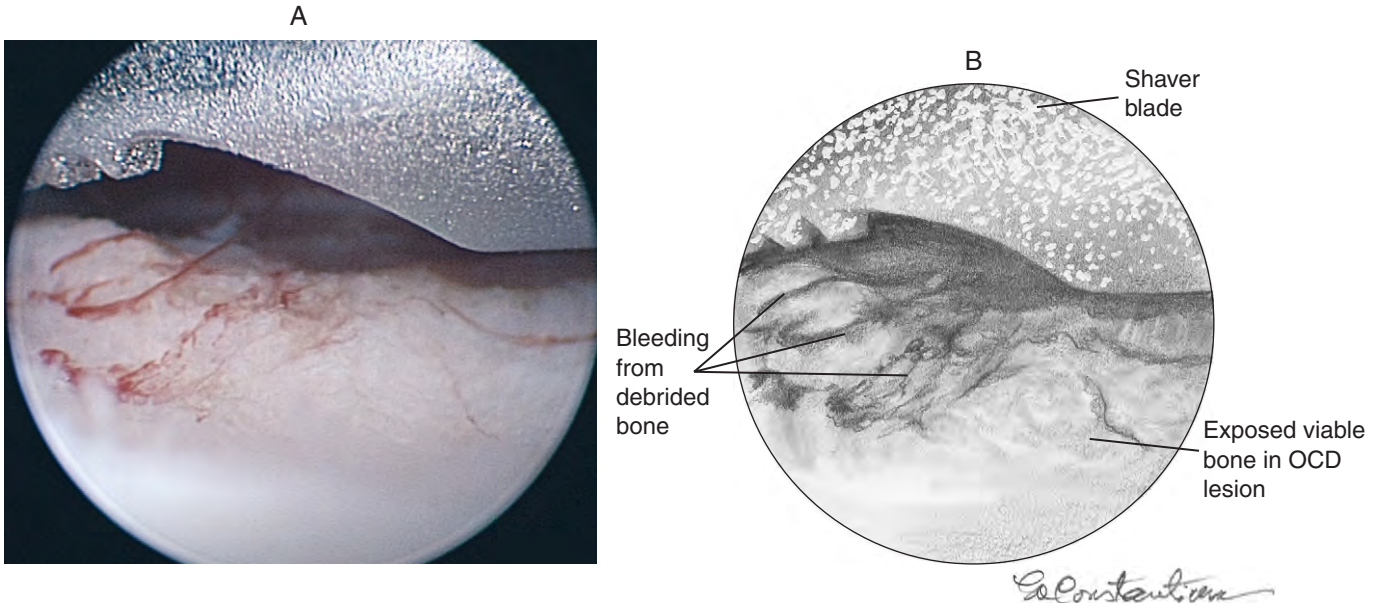



**Fig. 14–31**
Avascular or necrotic bone is removed from the bed of the osteochondritis dissecans lesion with a cartilage shaver until bleeding bone is identified. A large quantity of bone is not removed; rather, only a sufficient amount is removed to expose viable tissue.

bone (Fig. 14-30). Treatment of the bed of the defect varies with the tissue that is present. Avascular bone is removed with hand instruments or with the power shaver until bleeding bone is identified (Fig. 14-31). Defects with viable vascular bone are not debrided other than to remove any loose cartilage or bone fragments. In some cases, microfractures are created with a bone pick to improve vascular access (Fig. 14-32).

The joint is examined for any loose fragments of cartilage, which are removed with hand instruments. To complete the procedure, the joint is irrigated to remove any residual debris. An operative cannula or an egress cannula is placed into the joint through the operative portal and the cannula is moved around the joint to "vacuum" any debris out of the joint. Suction is not employed on the cannula; the ingress flow pressure combined with the low resistance outflow of the cannula is sufficient to remove any debris. Closure is with single skin sutures at the portal sites.

## Bicipital Tendon Injuries

Partial or complete rupture of the bicipital tendon is a relatively common injury to the shoulder joint and is a defined component of the complex group of soft tissue injuries of the shoulder joint. Bicipital tendon injuries can occur as an isolated independent problem or with other injuries to the supportive soft tissues of the joint. The term or diagnosis of *bicipital tendinitis* is not a real entity, but clinically significant bicipital tendon pathology is typically a partial tear of the tendon. Villus synovial reaction commonly seen around the origin of the bicipital tendon (Fig. 14-33) can occur with any pathology of the shoulder joint and is not specific or indicative of bicipital tendon pathology. Without arthroscopy, diagnosing and managing cases of front leg lameness with shoulder joint pain and normal radiographic findings can be a challenging and frustrating endeavor. Arthroscopy greatly facilitates diagnosis and, in some cases, provides the least traumatic and most effective treatment.

Bicipital tendon injuries present as front leg lameness with shoulder pain most commonly in large breed dogs. Onset can be acute and severe or chronic and insidious. Sometimes the pain pattern on orthopedic examination can order the index of suspicion to specify a bicipital tendon injury, but this is not consistent and is not relied upon to make a definitive diagnosis, but only to list bicipital tendon rupture as a rule out. Preoperative radiographs are routinely obtained but are not diagnostically helpful in most cases with bicipital tendon injuries except to rule out other entities that show bony changes. Occasionally the tendon avulses from the scapula and creates radiographically visible bony fragments. Osteophytes in the area of the bicipital groove and mineralized densities in or around the bicipital groove may or may not be related or specific to bicipital tendon injury. MRI or CT scan of the shoulder may define bicipital tendon pathology but normal findings do not rule out a partial tear of the

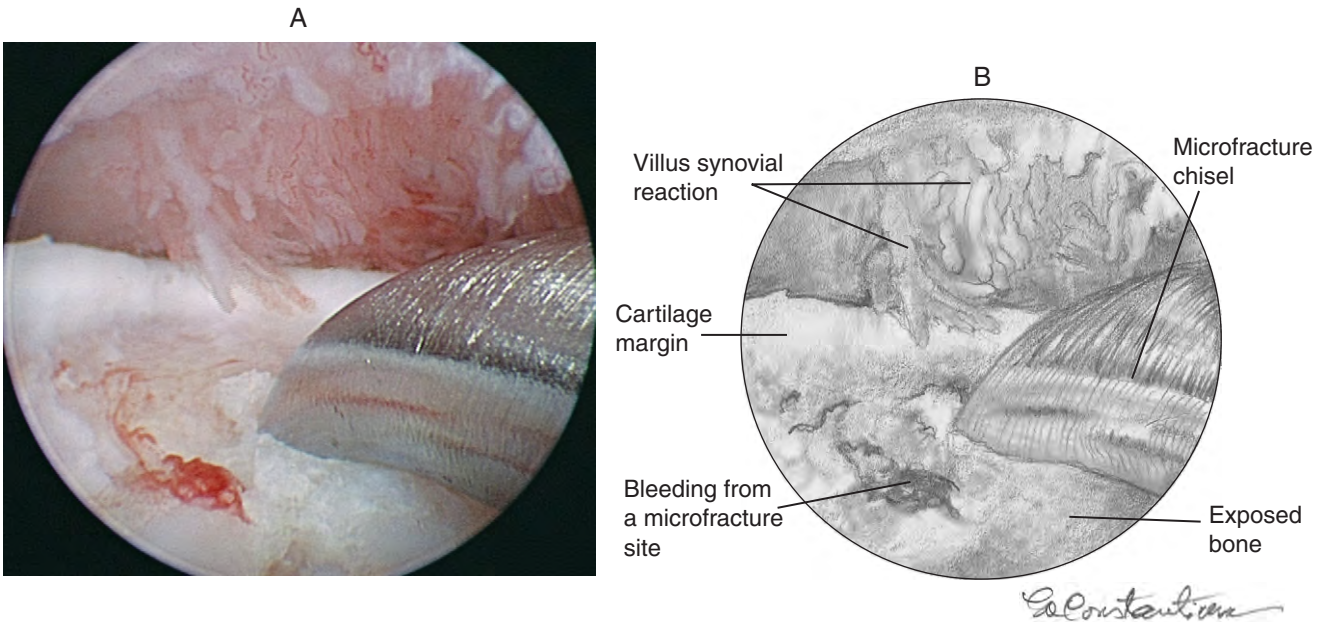



**Fig. 14–32**
A microfracture chisel is used to create microfractures in the bed of a humeral head osteochondritis dissecans lesion to increase vascular invasion and stimulation of fibrocartilage formation.

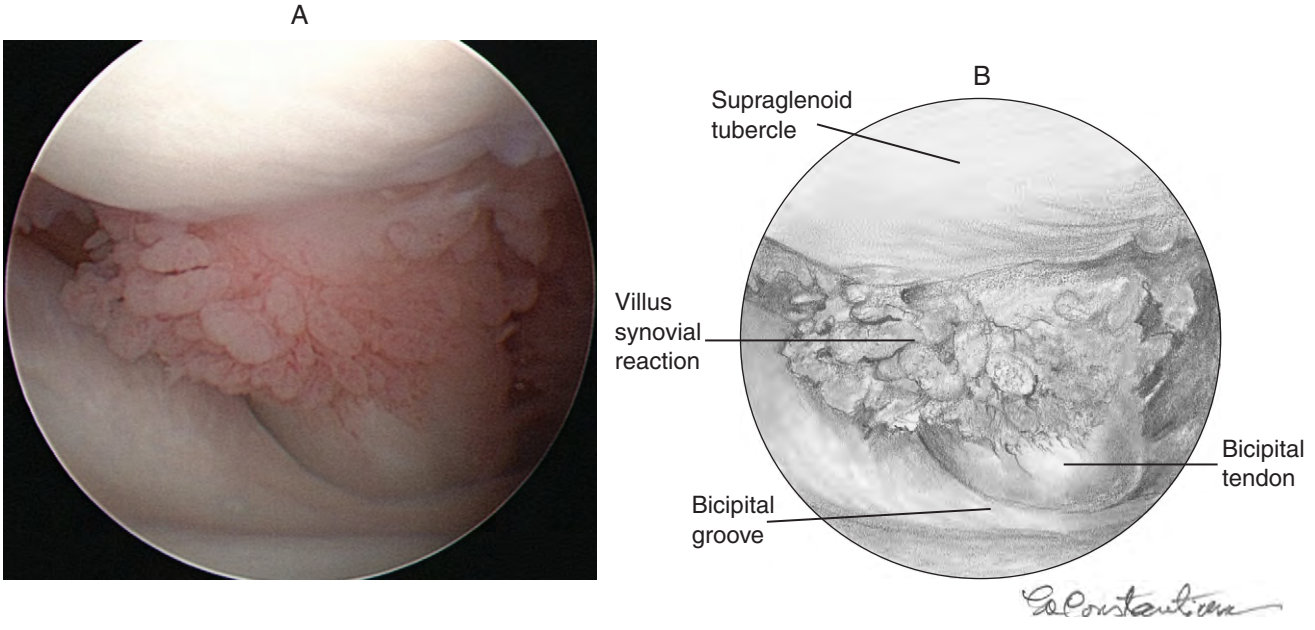



**Fig. 14–33**
Villus synovial reaction around the origin of a normal bicipital tendon in a dog with osteochondritis dissecans of the humeral head.

bicipital tendon. Front leg lameness with shoulder pain is sufficient indication for arthroscopy of the shoulder joint, and with the minimally invasive nature of arthroscopy, this is the procedure of choice to establish a diagnosis.

Arthroscopy for evaluation of the bicipital tendon is performed with a lateral telescope portal. Because this is an exploratory procedure, an operative portal is not placed until the joint has been examined and a diagnosis established. Egress for the exploratory portion of the procedure can be achieved with a 20-gauge needle placed anywhere that the joint can be accessed. If egress through the needle is inadequate or if access is required for placement of a palpation probe, a cranial operative portal is established. A complete examination of the joint is conducted to define all of the pathology present. Bicipital tendon injuries can be obvious (Fig. 14-34) or subtle, with only a few strands of visible ruptured tendon (Fig. 14-35), and can occur with or without secondary villus synovial reaction. Villus synovial reaction around the origin of the tendon or in the bicipital groove may obscure the tendon and make examination difficult. Use of the palpation probe may facilitate examination and occasionally debridement of the villi is required for an accurate examination. It is important to remember that the bicipital tendon may be normal under the reactive synovium, any shoulder pathology can cause villus synovial reaction around the bicipital tendon, and the clinically significant pathology causing the synovial reaction, shoulder pain, and lameness may lie elsewhere in the joint. It is also important to remember that bicipital tendon injury can occur by itself or in combination with other injuries to the soft tissue supportive structures of the shoulder joint.

Partial rupture of the bicipital tendon is treated by transection of the tendon at its origin within the shoulder joint under arthroscopic guidance. A cranial operative portal is used for this procedure. The exact site for the portal is established with a 20-gauge hypodermic needle placed into the joint space lateral to the origin of the tendon (see Fig. 14-16). When this site has been established, a stab incision is made into the joint with a scalpel blade and instrumentation for tendon transection is inserted. Both the skin entry location and the angle of insertion are important to facilitate tendon transection. Instruments that can be used for tendon transection include an 18-gauge, 1.5-inch hypodermic needle; a number 11 scalpel blade; and monopolar (Fig. 14-36) or bipolar (Fig. 14-37) radiofrequency electrocautery. Radiofrequency electrocautery is the most effective technique when there is significant synovial reaction at the transection site because it controls hemorrhage during the tenotomy. If a scalpel blade is used, there is typically sufficient bleeding to obscure the visual field and make completion of the transection much more difficult (or impossible). Use of electrocautery eliminates this issue. In the occasional case with no synovial reaction around the tendon, a number 11 scalpel blade works well. When transecting the tendon, it is important to cut all the attachments of the tendon not only to the bone but also

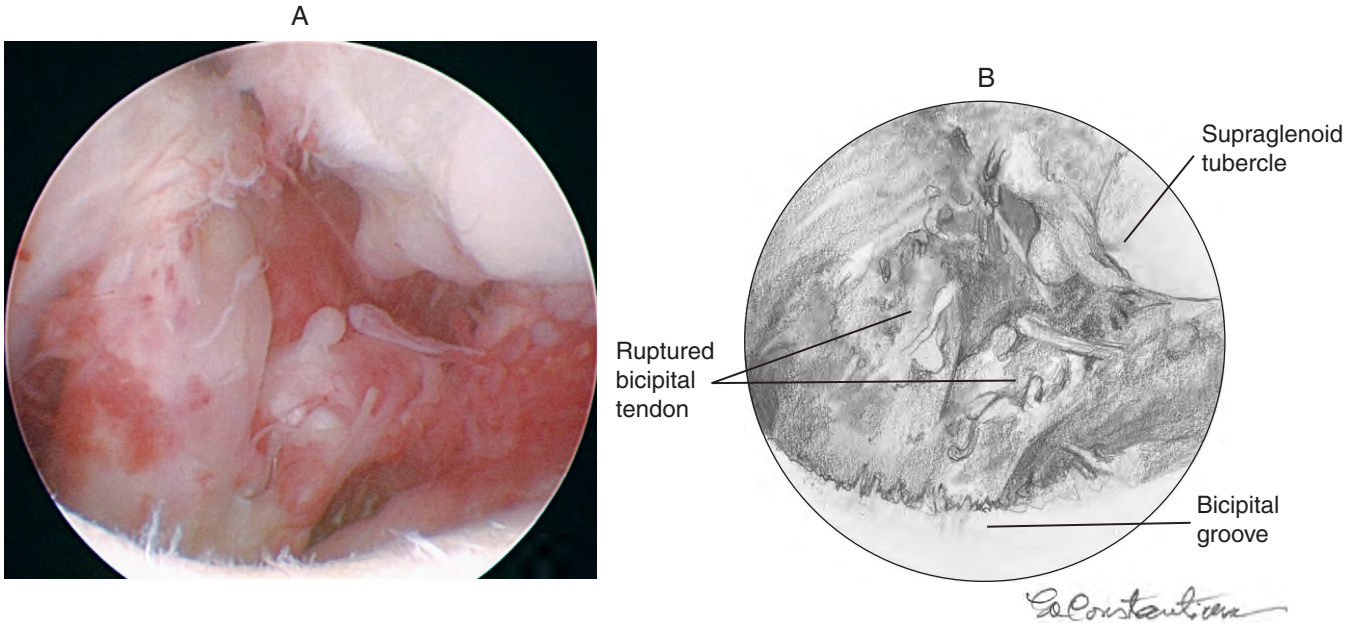



**Fig. 14–34**
A ruptured bicipital tendon with obvious major injury.

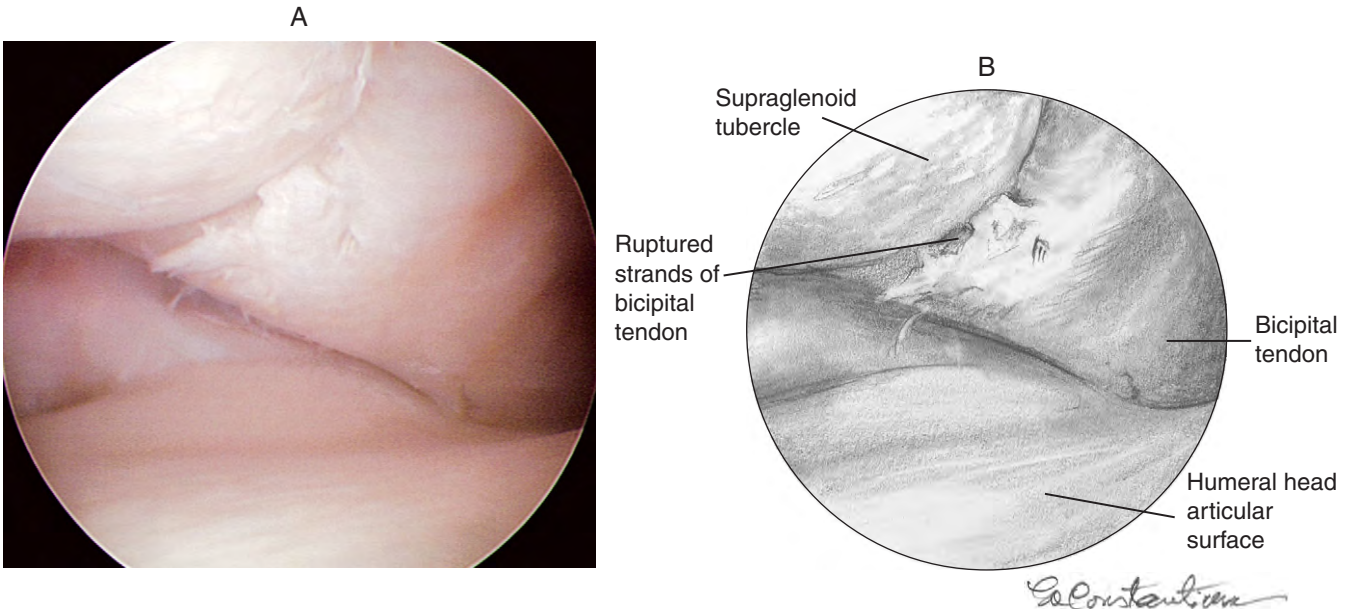



**Fig. 14–35**
A subtle injury to the bicipital tendon with minor partial avulsion of the origin of the tendon with a few visible damaged tendon strands and no visible synovial reaction.

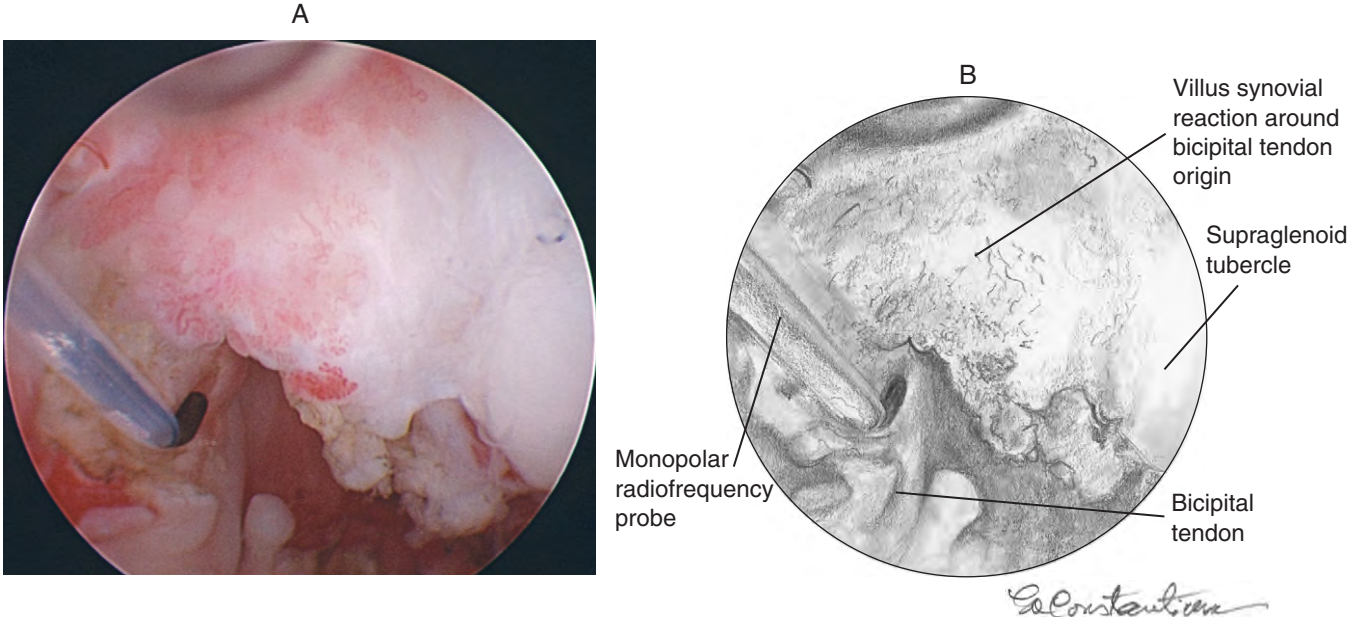



**Fig. 14–36**
Cutting a partially ruptured bicipital tendon using a standard surgical monopolar radiofrequency electrocautery with a Linvatec adaptor handpiece and tip placed into the joint through the cranial operative portal.

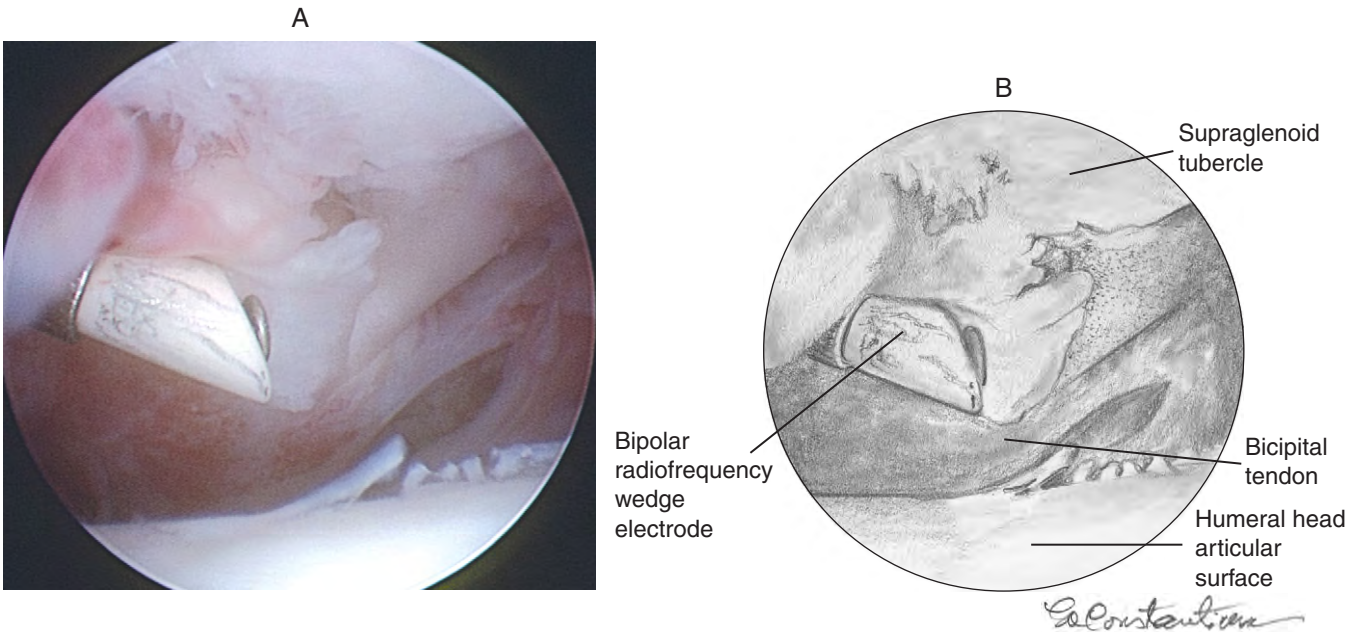



**Fig. 14–37**
Cutting a partially ruptured bicipital tendon using the Mitek VAPR bipolar unit with a 2.3-mm wedge effect electrode placed into the joint through the cranial operative portal.

to the soft tissues so that the cut end of the tendon is completely free in the bicipital groove. Following transection of the tendon, the joint is irrigated with saline to remove debris, and if there is significant synovial reaction, instillation of intraarticular steroid is considered. Skin closure is with single skin sutures at the portal sites.

## Soft Tissue Injuries of the Shoulder with Shoulder Instability

The shoulder joint is comprised of two slightly curved bone surfaces held together by a cuff of soft tissue structures including the medial glenohumeral ligament, subscapularis tendon, supraspinatus tendon, bicipital tendon, infraspinatus tendon, lateral labrum, lateral glenohumeral ligament, and joint capsule. Any or all of these structures can be damaged, resulting in lameness, joint pain, instability, and DJD. Bicipital tendon injury has been discussed separately from this group of injuries because its treatment is significantly different from the treatment of injuries to other soft tissue structures. This group of soft tissue injuries is also a relatively new diagnosis that has evolved with the increased use of arthroscopy as a diagnostic procedure. The pathology of these injuries is still being defined and approaches to treatment are being investigated and evaluated.

Soft tissue injuries of the shoulder joint present as front leg lameness with shoulder pain that can vary from marked and obvious to subtle and inconsistent. Onset can be acute and severe or chronic and insidious. Instability of the shoulder joint may be present with cranial to caudal drawer instability, medial to lateral drawer instability, and increased range of shoulder joint abduction. Manipulation of the shoulder joint for instability is conducted in both the awake and anesthetized patient. Preoperative radiographs are routinely obtained but are not diagnostically helpful in most cases except to rule out other entities that do show radiographic changes. Generalized degenerative changes may be seen on shoulder radiographs in cases of chronic shoulder joint instability but this is not a diagnostically specific finding. MRI or CT study of the shoulder may be helpful in defining shoulder joint pathology but normal findings do not rule out soft tissue injuries. In the case of subtle evidence of shoulder involvement, a joint tap can be informative. An increased quantity of fluid confirms the presence of shoulder involvement and increases the indication for arthroscopy. Front leg lameness with shoulder pain is sufficient indication for arthroscopy of the shoulder joint and, because of the minimally invasive nature of arthroscopy, this is the procedure of choice to establish a diagnosis.

Diagnosing and managing cases of front leg lameness with shoulder joint pain with normal or nonspecific radiographic findings can be a challenging and frustrating endeavor. Arthroscopy greatly facilitates diagnosis and in some cases provides the least traumatic and most effective treatment.

Arthroscopic exploration of the shoulder joint for suspected soft tissue injury is performed through a lateral

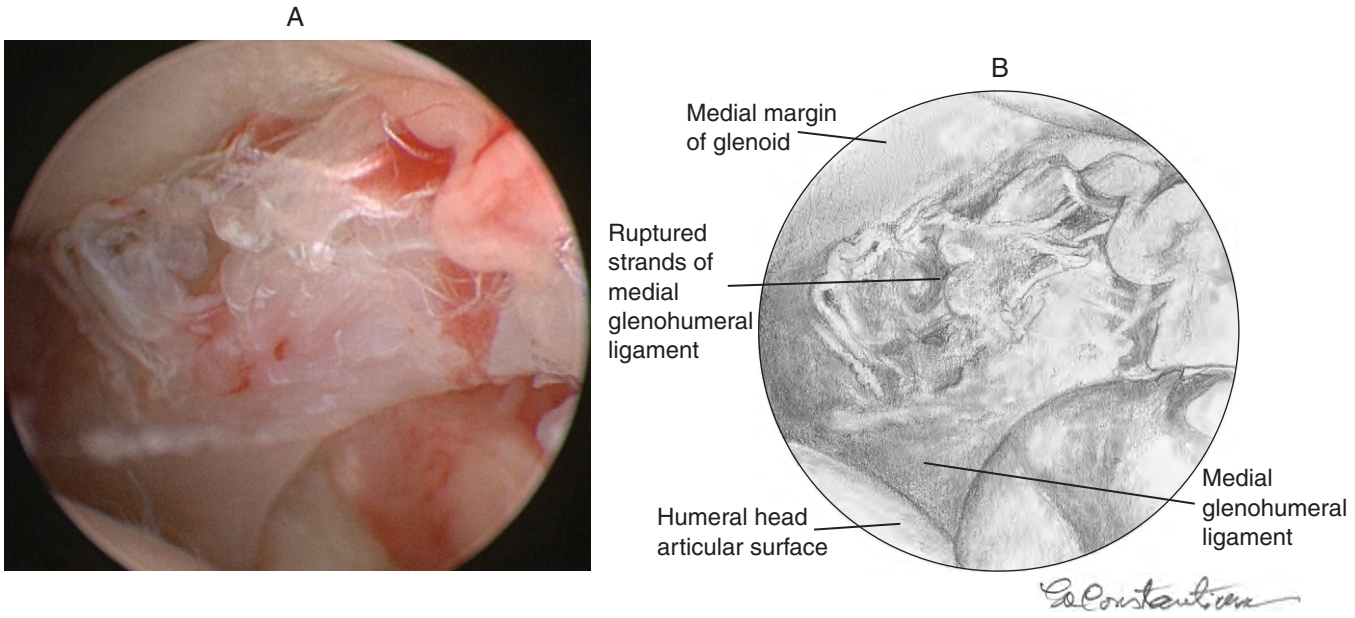



**Fig. 14-38**
Partial rupture of the medial glenohumeral ligament.

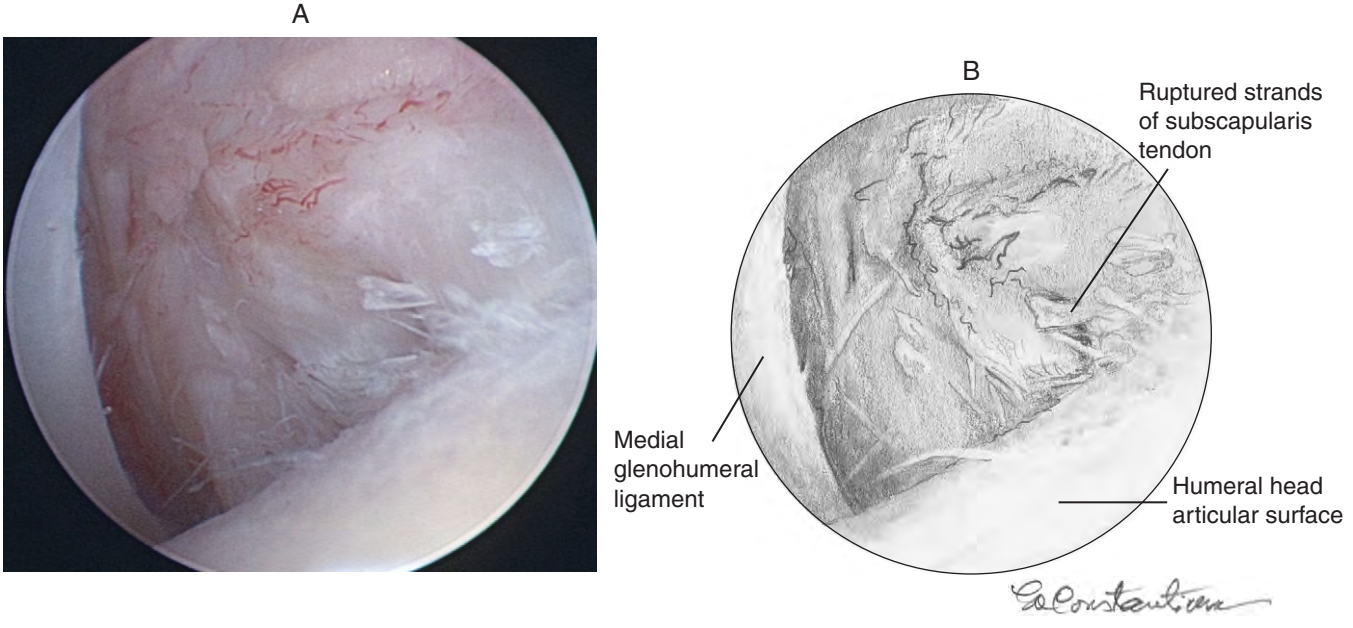



**Fig. 14-39**
Subscapularis tendon injury.

telescope portal with initial egress through a 20-gauge hypodermic needle placed cranially or caudally. When the initial examination has been completed and if significant pathology is found, an appropriate operative portal is placed to access the lesions. A cranial operative portal is the most commonly used site for soft tissue injuries. Currently defined lesions include injuries of the medial glenohumeral ligament (Fig. 14-38), subscapularis tendon (Fig. 14-39), supraspinatus tendon (Fig. 14-40), lateral labrum (Fig. 14-41), caudal joint capsule (Fig. 14-42), and the previously discussed bicipital tendon injuries. Complete assessment of the lateral labrum and lateral glenohumeral

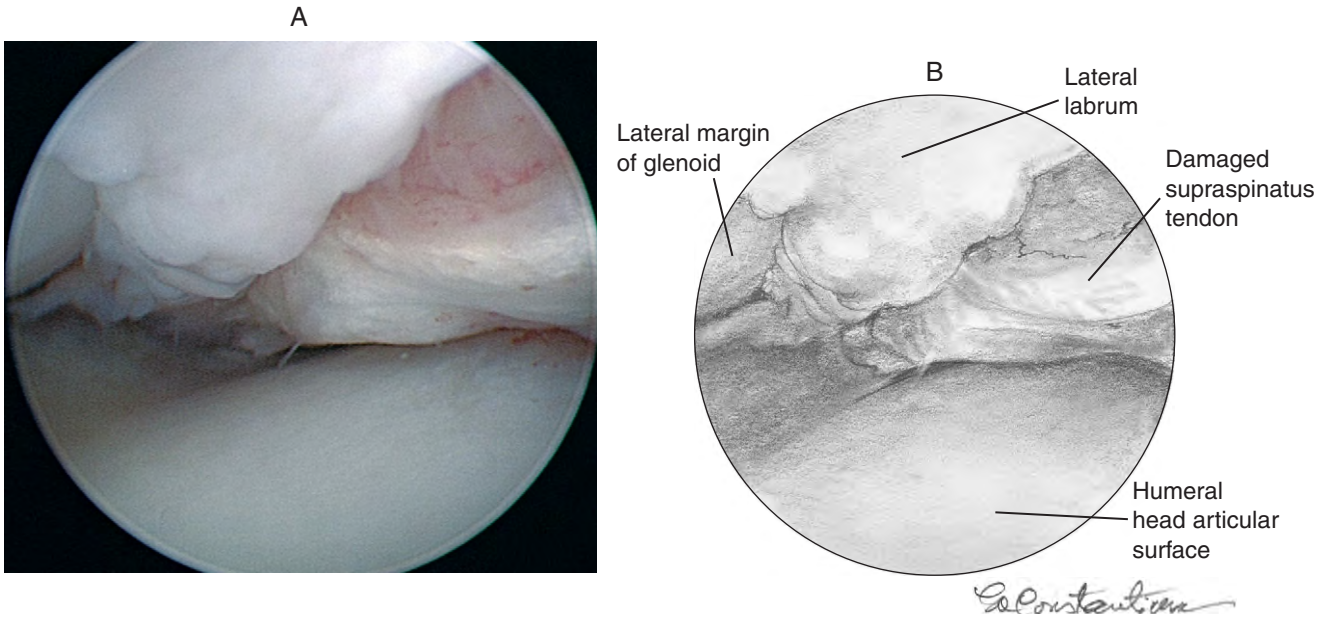



**Fig. 14–40**
Damaged supraspinatus tendon visible lateral to the cranial portion of the lateral labrum.

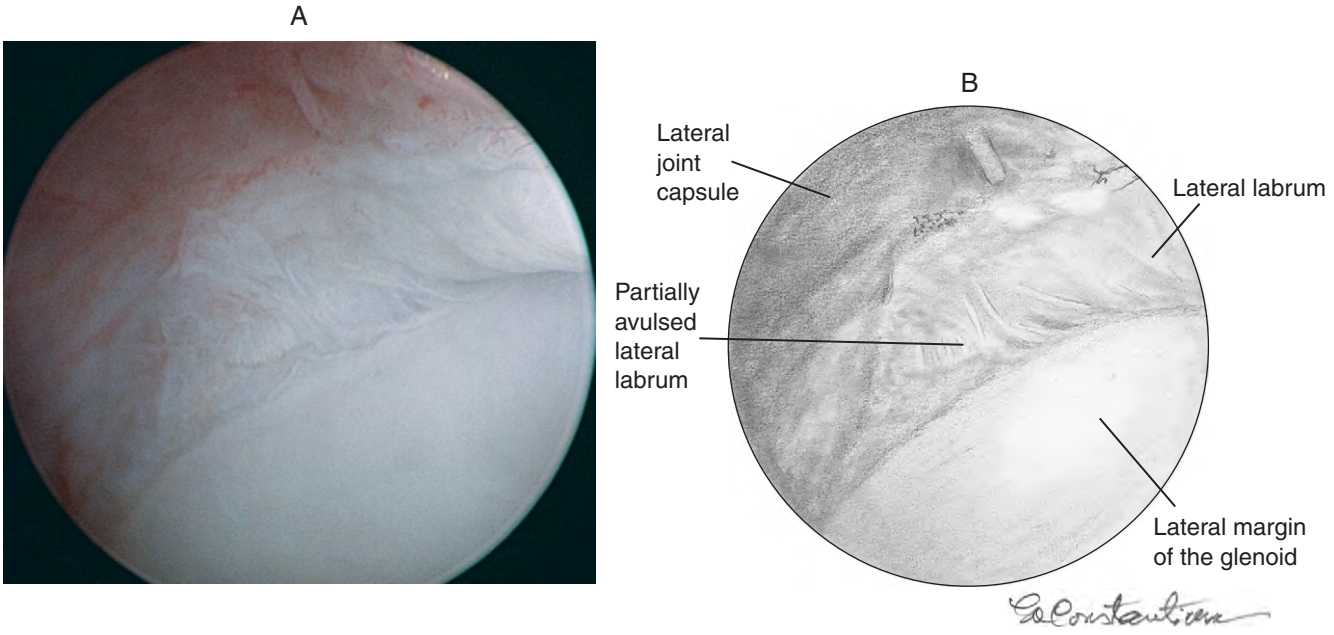



**Fig. 14–41**
Partial avulsion of the caudal portion of the lateral labrum from the glenoid.

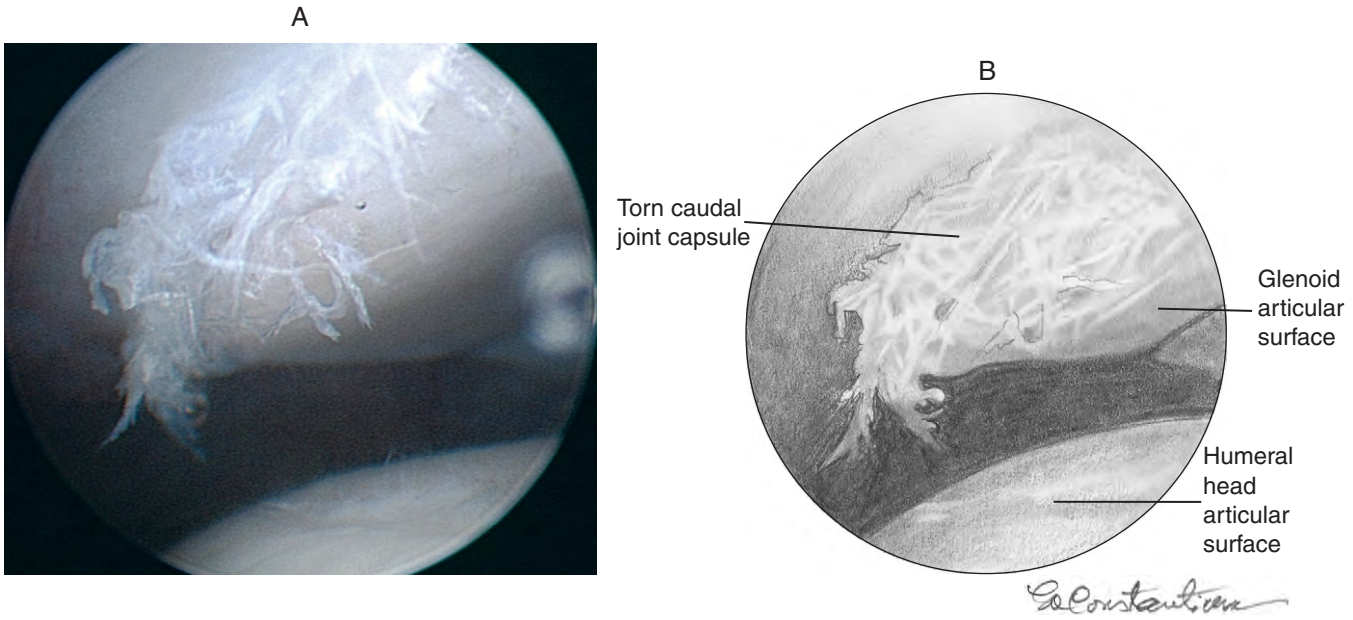



**Fig. 14–42**
Tearing of the caudal joint capsule at its attachment to the caudal rim of the glenoid.

ligament requires placement of a craniomedial telescope portal through the space between the origin of the bicipital tendon and the subscapularis tendon.

Treatment approaches for soft tissue injuries have included open surgical reconstructions, arthroscopically guided thermal modification (heat shrinking), and conservative medical management with activity restriction and antiinflammatory drugs (steroids or nonsteroidal antiinflammatory drugs). Case selection for each treatment approach is undefined at this time. Considerable additional work is needed to establish appropriate criteria for the most effective application of each treatment method. Currently, I use open surgical reconstruction when there is complete or substantial rupture of one or more structures resulting in significant joint instability. Arthroscopic treatment with heat modification of tissues is used when there is partial rupture of the medial glenohumeral ligament or subscapularis tendon with sufficient residual tissue to provide joint support following thermal modification (Fig. 14-43). Conservative medical treatment is typically used when arthroscopy has not been performed and a definitive diagnosis has not been established.

Postoperative care is critical to achieve optimal results with arthroscopic treatment. Thermally modified tissues require up to 12 weeks for remodeling to reestablish normal strength.[8] Joint movement and stress must be limited and controlled during this period or the effects of shrinkage are lost by breakdown of the tissues. Maintaining adequate activity restriction and limitation of joint movement and stress for this period is difficult for the patient and the client, limiting its effective application in practice. At this time, the postoperative management protocol for these cases is application of a modified Robert Jones type splint with a shoulder extension that keeps the shoulder in a normal standing position. This splint is maintained for 8 weeks if possible. It is tolerated well by some patients but is difficult to manage in others. During this time, the patient is confined to one floor or room in the house, or caged if needed, and taken outside on a leash only to urinate and defecate. After the splint is removed, this level of activity restriction is continued for another 4 weeks. Increasing duration of leash walks is instituted after 12 weeks with off-leash activity starting when the patient can tolerate extended leash walks (defined by how far the client wants to walk) without lameness. Off-leash activity is increased as tolerated to normal by 4 to 6 months.

## Ununited Caudal Glenoid Ossification Center

Failure of the separate caudal glenoid rim ossification center to fuse with the glenoid can cause lameness and shoulder pain. This diagnosis is usually made in young, large breed dogs with front leg lameness of variable duration and severity, and nonspecific shoulder pain. Radiographs of the shoulder joint reveal a separate mineralized density caudal to the caudal margin of the glenoid on a standard lateral radiographic projection of the shoulder joint. A similar radiographic finding can also be seen in older dogs with generalized degenerative changes of the shoulder joint. It has not been fully established whether this is a chronic ununited ossification center that

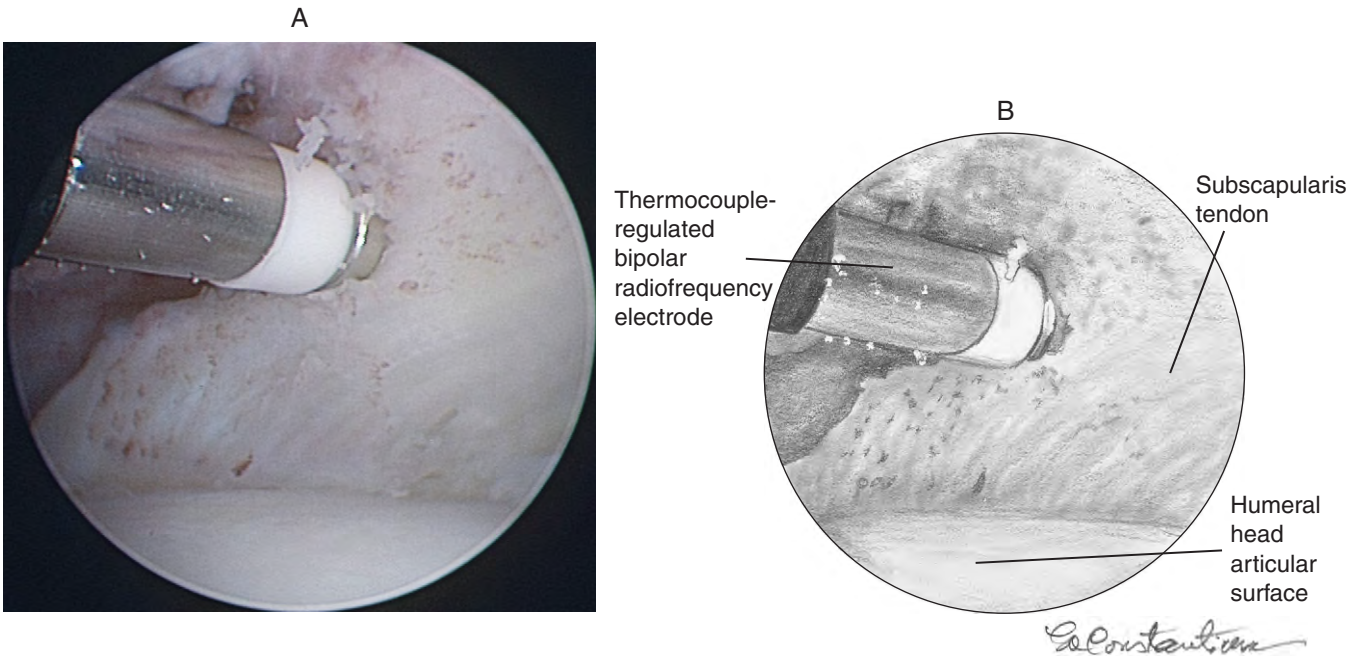



**Fig. 14-43**
Thermal modification of the subscapularis tendon using the Mitek VAPR bipolar radiofrequency electrosurgery unit with a thermocouple-regulated electrode.

is the cause of the DJD or a ridge of osteophytes secondary to the degenerative process. The radiographic finding of a separate caudal glenoid mineralized density in a patient with lameness and shoulder pain is an indication for arthroscopy regardless of the difference in etiology of the density.

Arthroscopy of the shoulder joint for UCGOC uses a lateral or craniolateral telescope portal and a caudal operative portal with the same placement and technique as for OCD of the shoulder. Complete exploration of the joint is conducted to look for other pathology or etiology for osteophyte formation, especially in the older dog, and any additional pathology is addressed. UCGOC appears as a ridge of bone on the caudal margin of the glenoid (Fig. 14-44). Clinically significant caudal glenoid mineralized densities are unstable and palpation with the probe determines whether the fragment is movable. The free ridge of bone is removed with hand instruments (3.5- to 5-mm rongeurs) (Fig. 14-45), with the power shaver (Fig. 14-46), or with a combination of hand and power instruments. All loose bone is removed. The joint is irrigated with saline at completion of the procedure and closure is with individual skin sutures at the portal sites.

## Supraspinatus Tendon Pathology (Degeneration/Mineralization/Partial Rupture)

Pathology in the supraspinatus tendon can be a source of lameness and shoulder pain. Radiographs can be normal or show mineralized densities in the area of the bicipital groove and greater tubercle. CT or MRI may be helpful in identifying abnormality in the supraspinatus tendon. In cases with extensive tendon involvement, the lesions may be visible with arthroscopy cranial and lateral to the origin of the bicipital tendon (see Fig. 14-40). Open surgical debridement of the lesions has produced variable results.

## Ununited Supraglenoid Tubercle

The ossification center of the supraglenoid tubercle can fail to fuse with the body of the scapula, resulting in loose intraarticular bone fragments within the origin of the bicipital tendon (Fig. 14-47). Arthroscopic assessment of the joint and fragments can be used to determine the extent of involvement, articular cartilage damage, whether the fragment should be removed or stabilized, and whether bicipital tendon transection is required.

## Arthroscopic-Assisted Intraarticular Fracture Repair

Anatomic reconstruction of fractures involving the articular surfaces can be facilitated with arthroscopy either through typical portals in the closed joint or with the joint open. The telescope is placed into the joint space and irrigation establishes a clear field so that the fracture line is visualized. The fracture is manipulated and adequacy of reduction is evaluated with arthroscopic visualization (Fig. 14-48). Small intraarticular chip fracture fragments can be removed with arthroscopy as part of an open fracture reconstruction or when they occur as individual lesions.

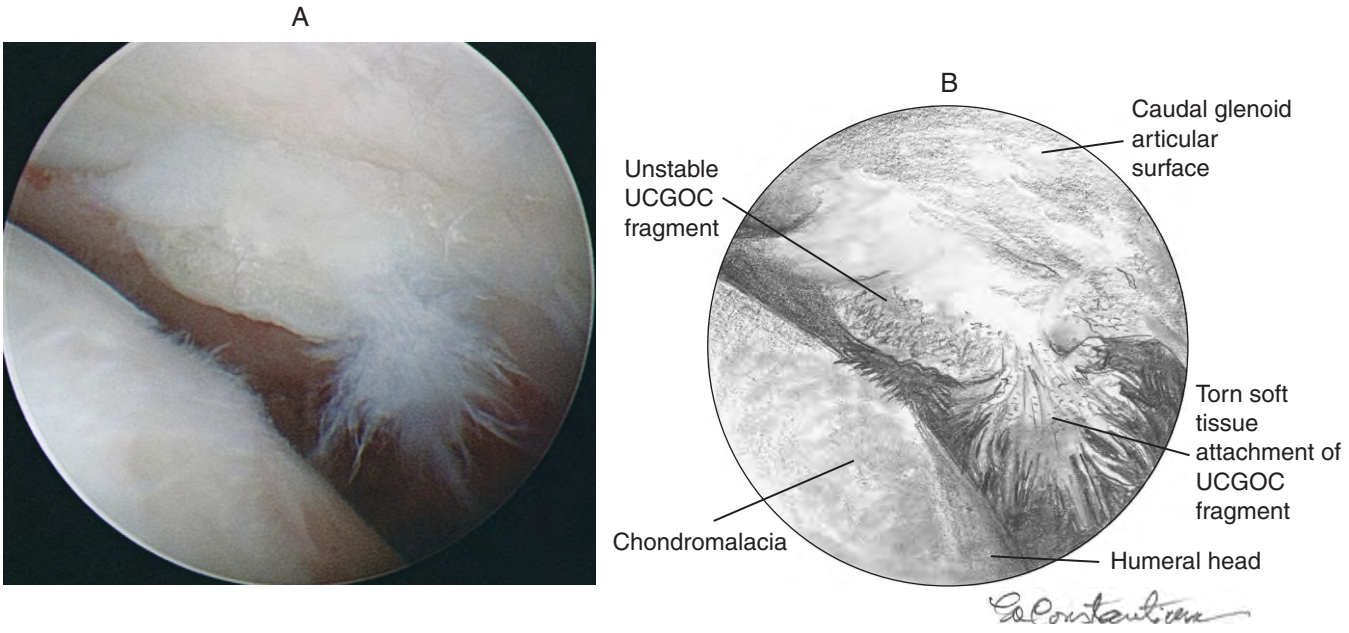



**Fig. 14–44**
An unstable caudal glenoid ossification center fragment.

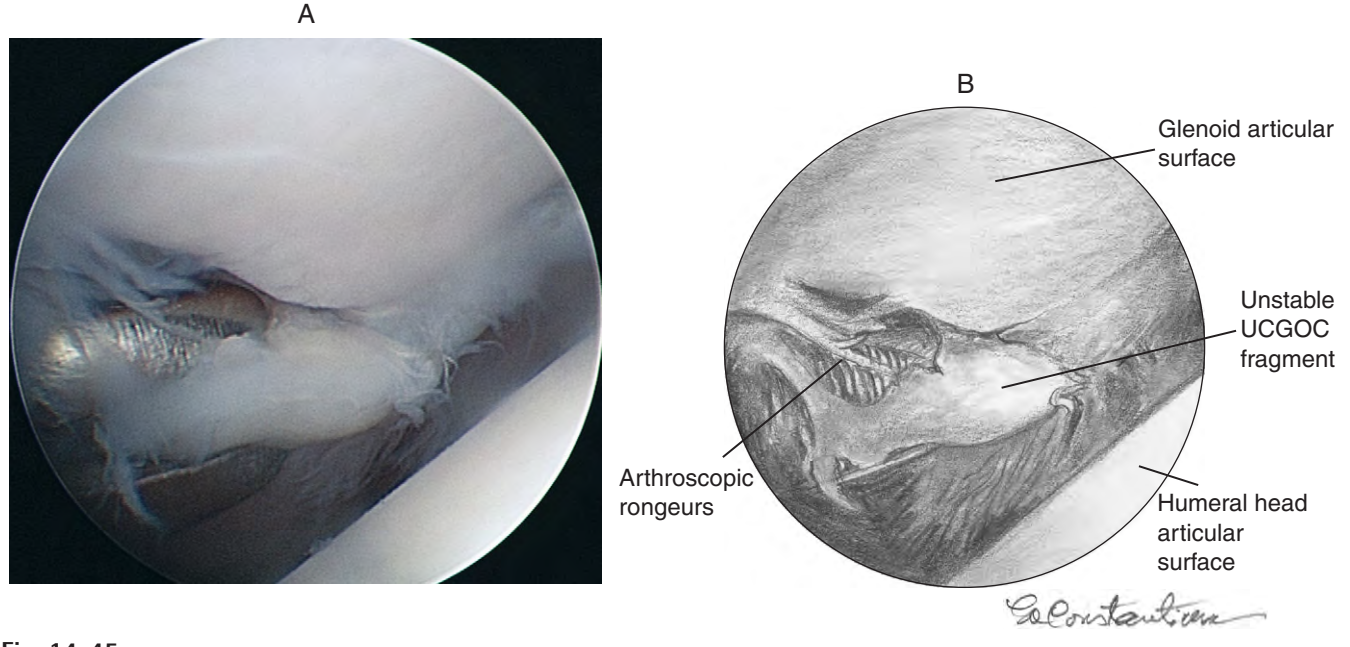



**Fig. 14–45**
Removing a loose ununited caudal glenoid ossification center fragment with 3.5-mm arthroscopic rongeurs.

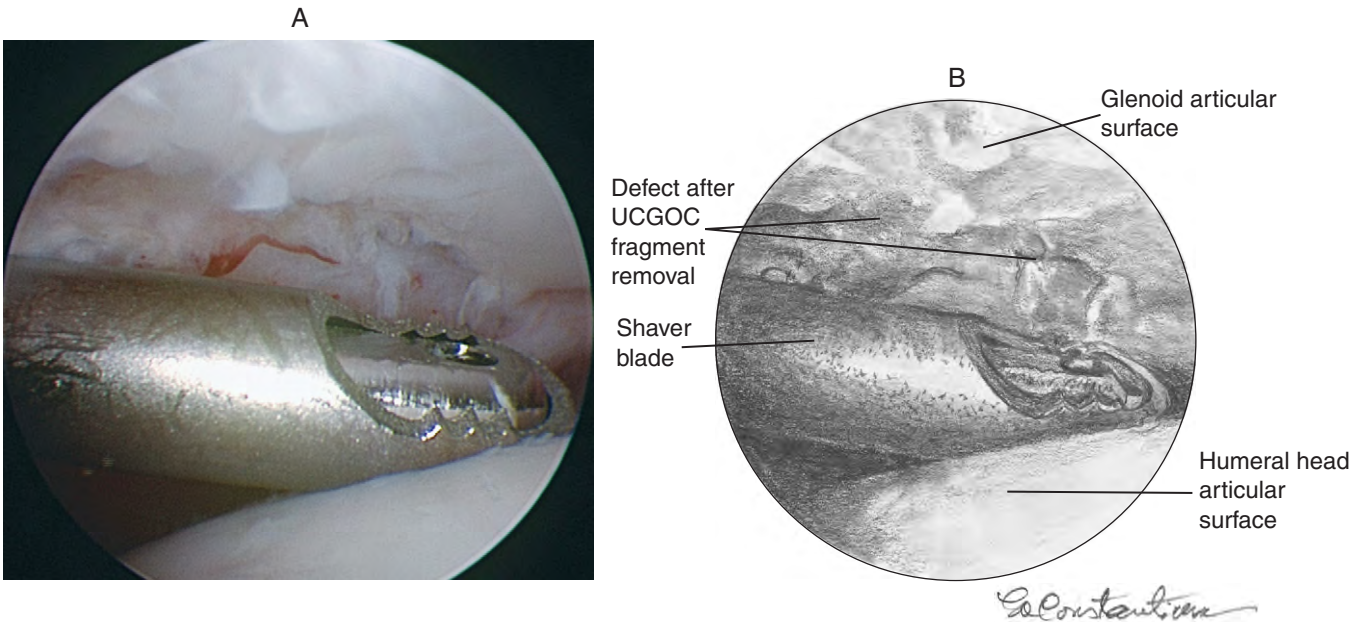



**Fig. 14–46**
Using the power shaver with a 3.5-mm aggressive blade to debride the fixed caudal margin of the glenoid after removal of an ununited caudal glenoid ossification center fragment.

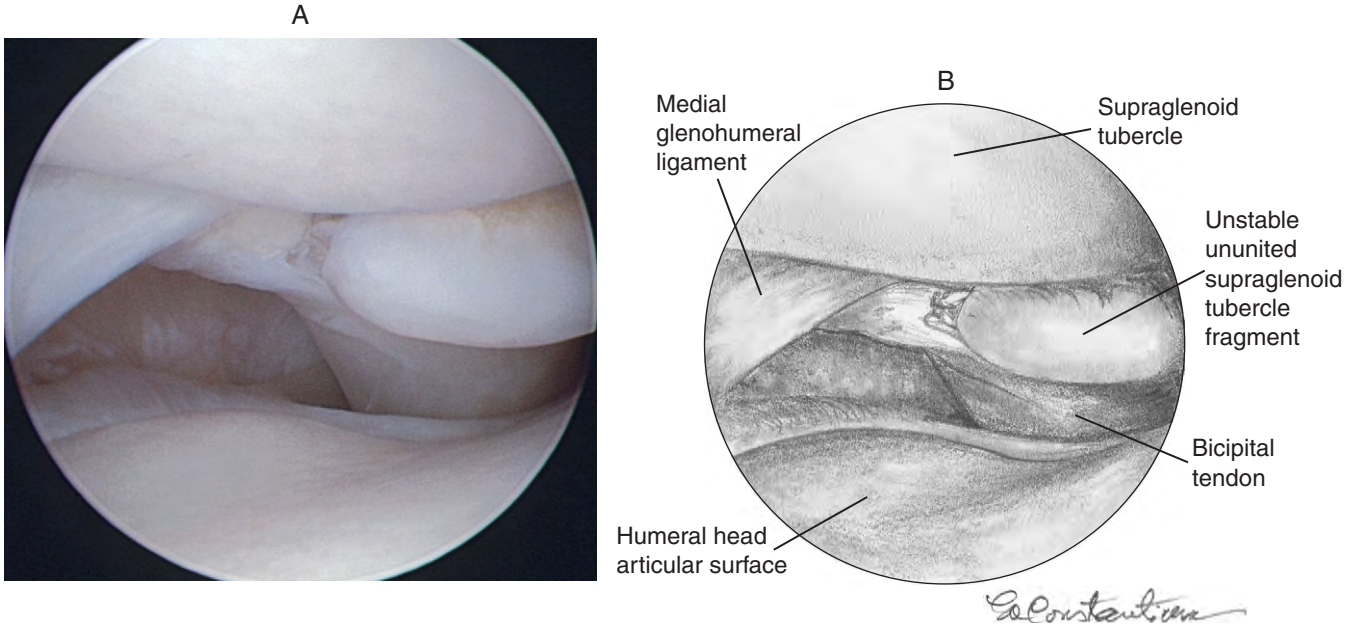



**Fig. 14–47**
A loose ununited supraglenoid tubercle fragment in the origin of the bicipital tendon.

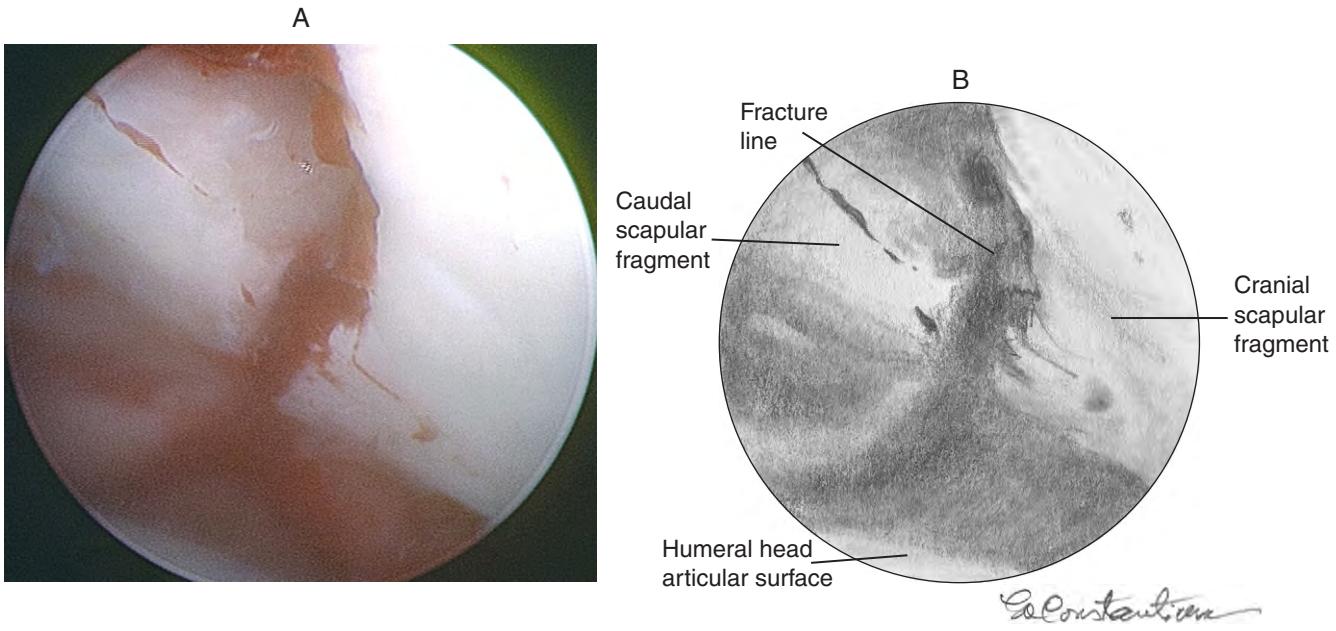



**Fig. 14–48**
The articular surface of a reduced scapular fracture visualized with arthroscopy.

### Arthroscopic Biopsy of Intraarticular Neoplasia

Intraarticular neoplastic masses can be found with arthroscopy during shoulder exploration in cases of lameness and shoulder pain that do not have radiographic changes. Arthroscopy can also be used to obtain biopsy specimens of epiphyseal bone lesions seen on radiographs; in many cases, this is the least traumatic approach for obtaining specimens.

## ARTHROSCOPY OF THE ELBOW JOINT

### Indications

Elbow joint arthroscopy is indicated when there is front leg lameness with elbow pain, crepitus, joint capsule distention, joint thickening or swelling, or reduced range of joint motion combined with radiographic changes compatible with MCPP (FCP), OCD, UAP, intraarticular fractures, or any evidence of degenerative changes. Significant MCPP (FCP) can be present in the radiographically normal joint so even very subtle radiographic changes compatible with MCPP (FCP) are a definite indication for arthroscopy. Pain on palpation of the craniomedial aspect of the elbow joint over the medial coronoid process or with internal or external rotation of the antibrachium is strongly suggestive of MCPP (FCP), but absence of pain does not rule out the disease. Localized swelling in the craniomedial aspect of the joint over the medial coronoid process can also be helpful in establishing an indication for arthroscopy. Crepitus is uncommonly detected with MCPP (FCP) and is more likely to be found when there is UAP. Joint capsule distention is nonspecific and can be seen with any of the disease conditions that occur in the elbow joint, but it is a clear indication for arthroscopy. Generalized swelling or thickening of the joint is also nonspecific, is an indication for arthroscopy, and typically is suggestive of severe joint disease, especially when combined with reduced range of joint motion. Joints with reduced range of motion and swelling may require a more aggressive multiportal approach to the joint for treatment of the originating pathology and for removal of multiple secondary osteophytes. It is not important to differentiate between MCPP (FCP) and OCD of the elbow joint before arthroscopy because patient positioning and portal placement are the same for both conditions. Unless radiographs are normal, CT or MRI scans are not needed to establish an indication for arthroscopy. If radiographs are normal, then CT or MRI may be indicated to define coronoid process pathology, OCD lesions, or increased joint fluid. CT and MRI are also helpful in the presence of severe joint pathology with multiple large osteophytes to define the location of osteophytes that need to be removed, which is beneficial in planning the arthroscopic procedure.

### Patient Preparation, Positioning, and Operating Room Setup

The patient is typically placed in dorsal recumbency for elbow arthroscopy, whether for a bilateral or a unilateral procedure. The leg or legs are suspended, prepared, and draped to allow free manipulation of the leg and access

to all sides of the elbow joint or joints. For unilateral procedures, the contralateral limb is retracted caudally out of the way and is tied to the surgery table. The monitor is placed at the head of the table for bilateral MCPP (FCP) and OCD procedures with the assistant and surgeon on the same side of the table with the assistant standing on the cranial side of the surgeon between the monitor and the surgeon. For unilateral MCPP (FCP), OCD, UAP, and multiportal joint debridement procedures, the monitor can also be placed across the table from the surgeon with the assistant standing on the cranial side of the surgeon. Arthroscopy for bilateral UAP is best done with two monitors, one at the head of the table and one at the foot of the table. MCPP (FCP) is commonly associated with UAP and evaluation of MCPP (FCP) with appropriate treatment is an important portion of arthroscopic management of UAP. An operative procedure in the craniomedial portion of the joint and in the caudal joint compartment are required for UAP management, so, without two monitors, one of the procedures is performed working with the telescope pointing away from the monitor. Alternatives are to move the monitor between the different parts of the procedure or to perform unilateral procedures with the monitor placed across the table from the surgeon. Complete joint debridement with removal of multiple osteophytes through multiple telescope and operative portals are performed as unilateral procedures with the monitor placed at the head of the table. This allows the patient to be rolled from side to side, allowing for access to the medial and lateral aspects of the joint, and for placement of caudal compartment portals.

## Portal Sites and Portal Placement

### Telescope Portals (Medial, Craniolateral, and Caudal)

The most common telescope portal for the elbow joint is the medial portal (Fig. 14-49). This portal is located 1 to 1.5 cm directly distal or distal and caudal to the tip of the medial epicondyle of the humerus. If the shaft of the humerus is used for alignment, the portal is directly distal to the tip of the epicondyle, but if the outside contour of the limb is used for alignment, the portal is distal and caudal to the tip of the epicondyle. This portal site is located by palpating the tip of the epicondyle then sliding distally, in alignment with the humeral shaft, until the distal (caudal) margin of the superficial digital flexor muscle is palpated. External rotation and abduction of the antibrachium to open the medial aspect of the joint facilitates telescope insertion. In thin dogs the medial margin of the articular surface of the semilunar notch can be palpated when the antibrachium is externally and internally rotated, opening and closing the medial aspect of the joint. A 20-gauge, 1-inch hypodermic needle is placed into the joint at this site to confirm accurate placement of the portal, joint fluid is aspirated, the joint is distended with saline, the needle is removed, a stab incision is made with a number 10 scalpel blade parallel to the muscle fibers, and the telescope cannula is placed using the blunt obturator.

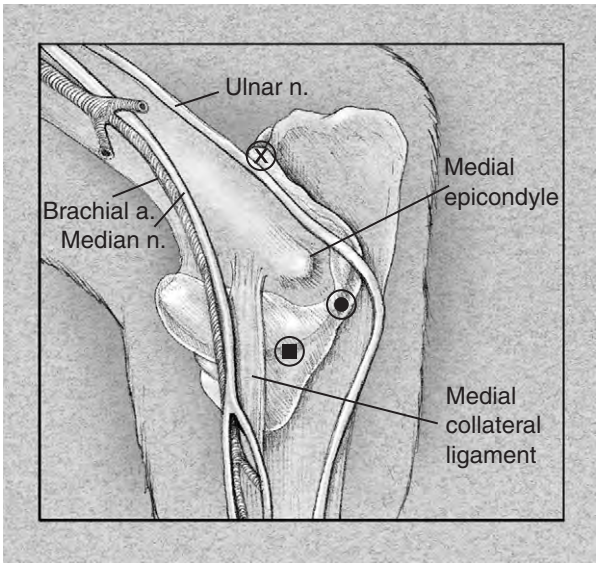



**Fig. 14-49**
Portal sites on the medial aspect of the elbow joint. The three portals shown are the medial telescope portal (*circle*), the craniomedial operative portal (*square*), and the caudomedial egress portal (*X*). The medial telescope portal is 1 to 1.5 cm distal or distal and caudal to the medial epicondyle of the humerus. The craniomedial operative portal is directly over the medial coronoid process, 1 to 2 cm cranial and slightly proximal to the medial telescope portal, and is caudal to the medial collateral ligament. The caudomedial portal is commonly used for an egress portal but the same site is also used for the caudomedial telescope or operative portal. This portal is located caudal to the caudal margin of the supracondylar ridge of the humerus, proximal to the olecranon, and into the anconeal fossa. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

The craniolateral telescope portal (Fig. 14-50) was the original telescope portal for the elbow joint but has been largely replaced by the medial portal and is not commonly used. The primary indications for this portal are for access to the elbow joint when the patient is in lateral recumbency for other procedures with the joint to be examined on the uppermost side, for complete debridement of the elbow joint using multiple portals, for removal of coronoid process fragments that escape into

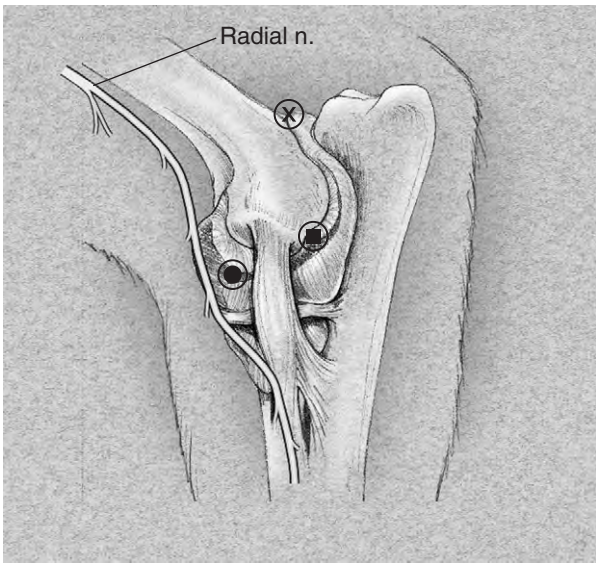



**Fig. 14–50**
Portal sites on the lateral aspect of the elbow joint. The three portals shown are the craniolateral telescope portal (*circle*), the lateral operative portal (*square*), and the caudolateral egress portal (*X*). The craniolateral telescope portal is placed at the junction of the cranial margin of the radial head and the cranial surface of the lateral ridge of the humeral condyle. This craniolateral portal is also used as an operative portal for access to the cranial compartment of the joint. The lateral operative portal is placed directly over the lateral coronoid process of the ulna and is caudal to the collateral ligament. The caudolateral portal is commonly used as an egress portal but the same site is used for the caudolateral operative or telescope portal. This portal is placed caudal to the caudal margin of the supracondylar ridge of the humerus, proximal to the olecranon, and into the anconeal fossa. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

the cranial compartment of the joint, and for arthroscopically assisted lateral humeral condyle fracture repair. The portal is at the intersection of the cranial margin of the radial head and the cranial aspect of the capitulum. The notch produced by this intersection can be palpated before joint capsule distention. When the joint is distended, the joint capsule protrudes at this point to make a small bump and the telescope is inserted through this joint capsule prominence. If there is adequate joint distention due to the disease process, a 20-gauge, 1-inch hypodermic needle is inserted at the portal site, joint fluid is aspirated, and the joint is distended with saline. A stab incision is made with a number 15 scalpel blade and the telescope cannula is inserted with the blunt obturator. If there is inadequate joint distention secondary to elbow disease, a 20-gauge, 1.5- to 2-inch hypodermic needle is placed into the caudal joint compartment and the joint is distended with saline to allow portal placement. This portal can be difficult to place because there is a tendency for the blunt obturator of the telescope cannula to slip off of the joint capsule and slide across the cranial aspect of the humeral condyle without entering the joint. This can be corrected by extending the stab incision through the joint capsule or by using the sharp trocar for joint entry. The structures of the cranial compartment of the joint, including the medial coronoid process, can be evaluated with this portal by passing the telescope medially across the cranial aspect of the humeral condyle.

Caudal telescope portals (see Figs. 14-49 and 14-50) are placed into the caudal joint compartment by insertion into the olecranon fossa either medial or lateral to the triceps tendon. These portals allow visualization of the anconeal process and the olecranon fossa. The caudolateral portal can also provide access to the lateral coronoid process. The primary application of these portals is for removal of anconeal process osteophytes that interfere with joint extension as part of complete multiportal joint debridement. They can also be used for removal of lateral coronoid process pathology that cannot be accessed from the medial telescope portal. UAP fragment removal is generally performed through the medial telescope portal, but these portals can be used to evaluate the caudal compartment and remove any residual loose debris after the fragment has been removed.

The craniomedial operative portal site can be used as a telescope portal site for visualization of radial head osteophytes, humeral condyle fractures, and MCPP (FCP) fragments that have escaped into the cranial compartment of the joint. This site is used as a telescope portal site after it has been used as an operative portal site, and the transfer can be done with a switching stick or the telescope cannula can be passed through the portal with the blunt obturator.

## Operative Portals (Craniomedial, Lateral, and Craniolateral)

The craniomedial operative portal (see Fig. 14-49) is the most common operative portal for the elbow joint and is used for medial coronoid process revision and for removal of OCD lesions of the trochlea or medial humeral condyle. This site is caudal to the medial collateral ligament and is located 1 to 2 cm cranial and slightly proximal to the telescope portal. This site is directly over the medial coronoid process of the ulna, providing excellent access and triangulation for coronoid process revision (Fig. 14-51). The portal site is located with a 20-gauge, 1-inch needle, with accuracy of placement confirmed by visualizing the

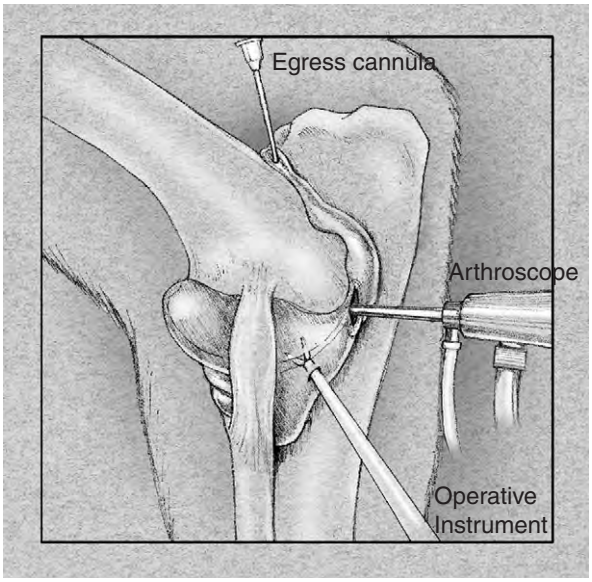



**Fig. 14-51**
The medial telescope portal and the craniomedial operative portal provide excellent access and triangulation for medial coronoid process revision. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

needle inside the joint with the telescope, the needle is removed, a stab incision is made with a number 10 scalpel blade parallel to the muscle fibers, and a curved mosquito hemostat is used to dissect a portal tract into the joint.

Access to the lateral coronoid process of the ulna and capitulum can be obtained by entering the lateral aspect of the joint distal to the epicondyle using landmarks similar to the medial telescope portal but on the lateral side (see Fig. 14-50). This operative portal can be combined with a craniolateral or caudolateral telescope portal, or it can be used with a medial telescope portal for procedures requiring limited manipulations. Uses of this portal are for removal of lateral coronoid process pathology and for removal of medial coronoid process fragments or OCD fragments that escape into the lateral joint space.

An operative portal can also be established at the craniolateral telescope portal site (see Fig. 14-50). This operative portal is used for removal of coronoid process fragments that escape into the cranial compartment of the joint and for removal of dorsal radial head osteophytes as part of a multiportal elbow debridement procedure. It is usually placed from inside the joint using a craniomedial operative portal cannula and a switching stick.

Caudal compartment operative portals (see Figs. 14-49 and 14-50) are placed either medial or lateral to the triceps tendon. They are used for debridement of anconeal process osteophytes as part of multiportal complete joint debridement combined with a caudal telescope portal. For this application, the operative portal is placed into the portal site not used by the telescope. A caudomedial operative portal is used for removal of UAP fragments combined with a medial telescope portal. The operative portal for UAP removal is more accurately a miniarthrotomy than a portal because it needs to be large enough for removal of the fragment in one piece.

### Egress Portals

The most common egress portal sites for the elbow joint are caudomedial and caudolateral portals with the egress cannula positioned into the olecranon fossa (see Figs. 14-49 and 14-50). The craniomedial operative portal site can be used as an egress portal site during caudal joint compartment debridement or during UAP removal. For these procedures, the craniomedial site is used as an operative portal and is converted into an egress portal simply by placing an egress cannula into the already established portal site. Any of the elbow joint operative portal sites can also be used for outflow, either with an egress cannula, with outflow around operative instruments, or through an operative cannula.

## Examination Protocol and Normal Arthroscopic Anatomy

When first entering the elbow through the standard medial telescope portal, anatomic structures are identified that allow orientation within the joint. The following are important and easily identifiable structures to use for orientation: medial coronoid process of the ulna, radial head, medial ridge of the humeral condyle, and medial collateral ligament (Fig. 14-52); concave ridge of the semilunar notch and convex surface of the humeral condyle with the articulation between the ulna and radial head (Fig. 14-53); and anconeal process (Fig. 14-54). Once orientation is established, the joint is examined in a systematic manner to ensure evaluation of all important structures of the joint. Starting in the craniomedial portion of the joint with the telescope oriented cranially the medial coronoid process, medial aspect of the radial head, medial collateral ligament, and the medial ridge of the humeral condyle are evaluated (see Fig. 14-52). The telescope is swept caudolaterally and the caudal portion of the radial head, the articulation of the radial head with the ulna, and the lateral ridge of the humeral condyle are examined (see Fig. 14-53). The lateral coronoid process can also be visualized (Fig. 14-55). Continued caudal angulation of the telescope exposes the anconeal process and caudal portion of the articular surface of the trochlea of the humerus (see Fig. 14-54). In some joints, the telescope can be passed into the caudal compartment of the joint from the medial portal.

Orientation when using the craniolateral telescope portal uses the dorsal aspect of the radial head, cranial

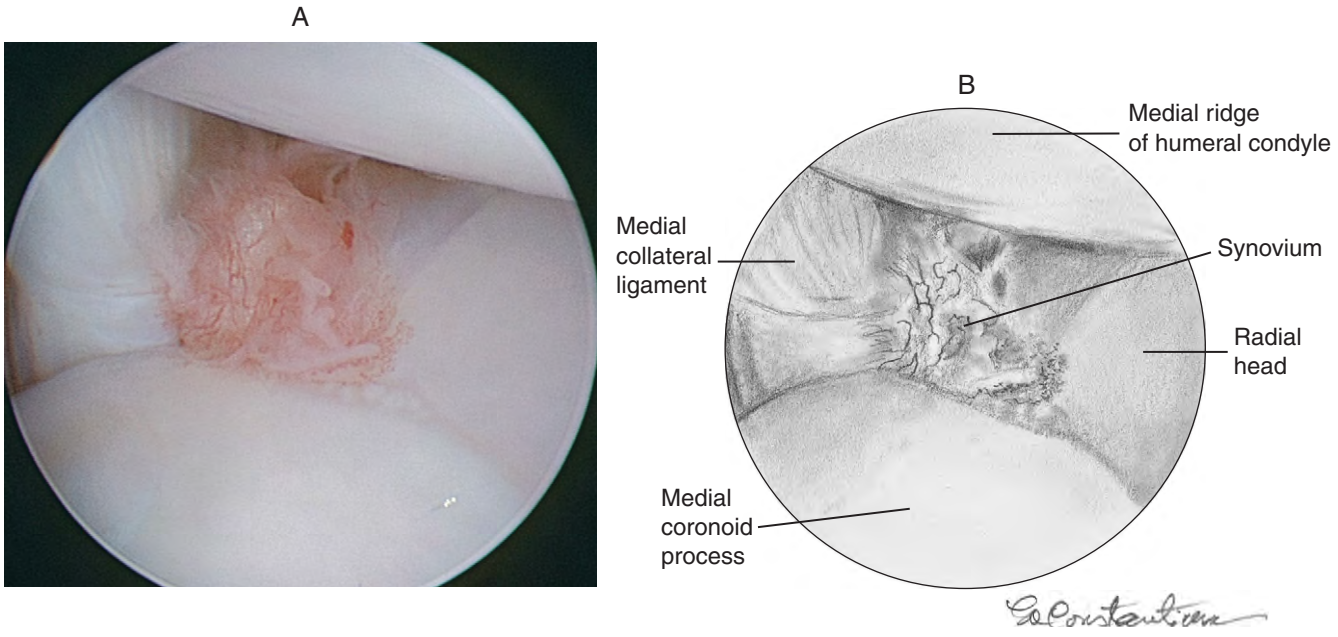



**Fig. 14–52**
Normal structures in the elbow joint used for orientation from the medial telescope portal with the telescope angled craniolaterally are the medial coronoid process, the radial head, the convex medial ridge of the humeral condyle, and the medial collateral ligament.

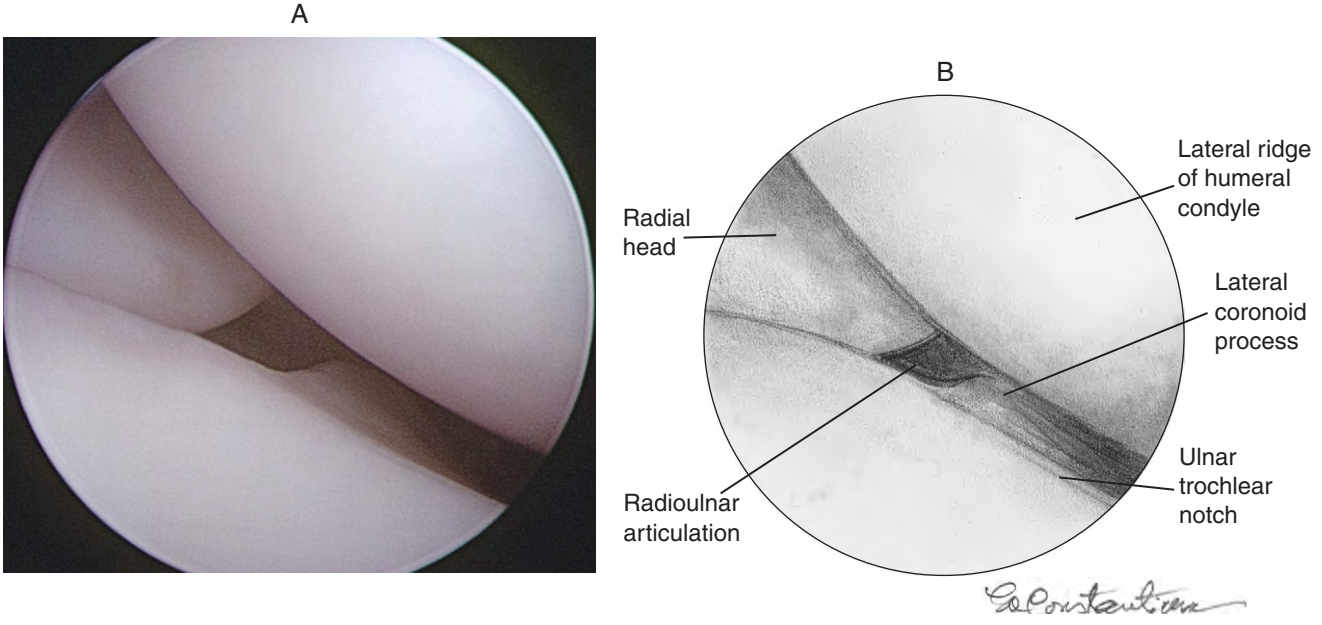



**Fig. 14–53**
Normal structures of the elbow joint from the craniomedial telescope portal with the telescope directed laterally with the convex surface of the lateral ridge of the humeral condyle, the concave ridge of the trochlear (semilunar) notch, the radial head, the radioulnar articulation between the radial head and the radial notch of the ulna, and the base of the lateral coronoid process.

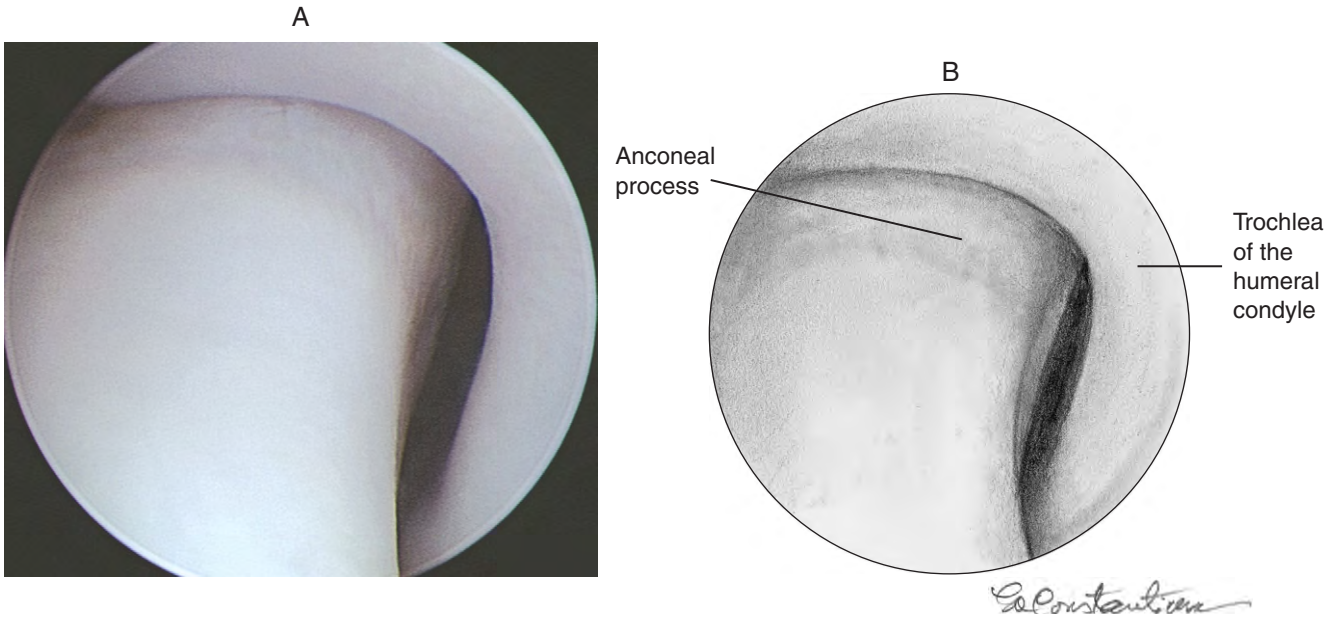



**Fig. 14-54**
The tip of the anconeal process articulating with the caudal humeral articular surface.

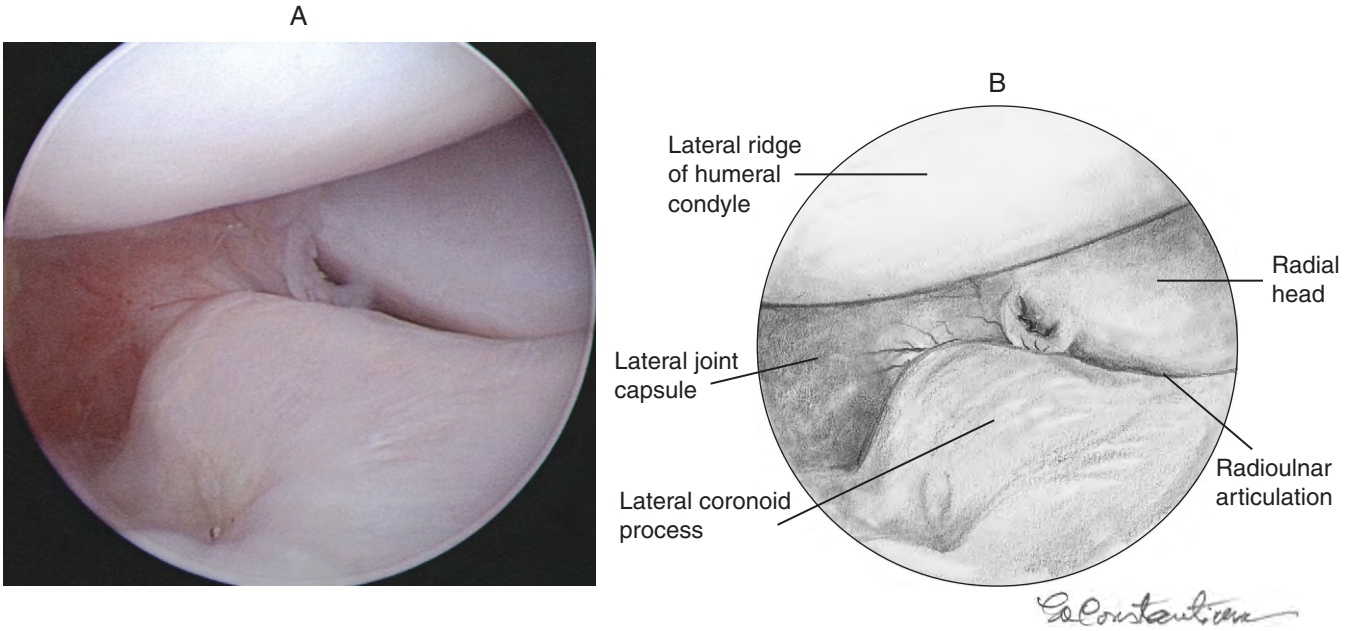



**Fig. 14-55**
The lateral coronoid process seen from the medial telescope portal.

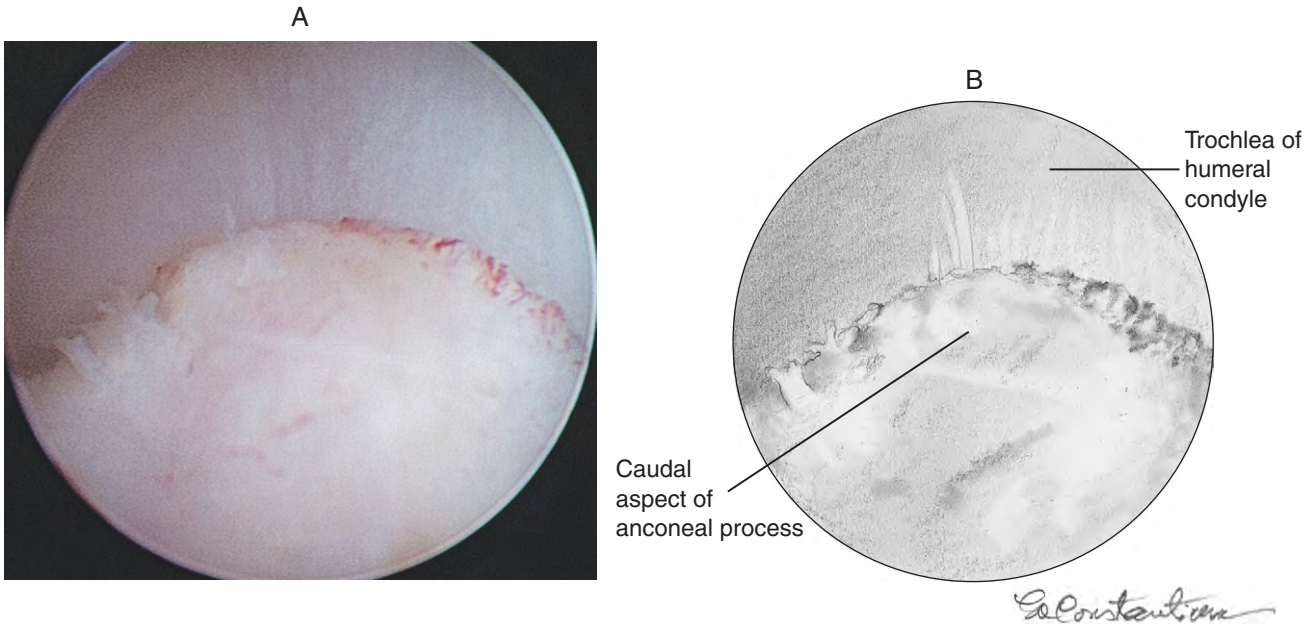



**Fig. 14-56**
The tip of the anconeal process and the caudal articular surface of the humeral trochlea visualized from a caudal telescope portal.

articular surface of the humeral condyle, and the cranial tip of the medial coronoid process. The cranial compartment of the joint can also be accessed for examination through the medial or craniomedial portals after revision of the medial coronoid process. The caudal portals use the tip of the anconeal process and the caudal articular surfaces of the humeral trochlea for orientation (Fig. 14-56). From the caudal portals, the telescope can be passed through the supratrochlear foramen to visualize the dorsal aspect of the radial head, cranial articular surface of the humeral condyle, and the cranial joint space (Fig. 14-57).

## Diseases of the Elbow Diagnosed and Managed with Arthroscopy

### Medial Coronoid Process Pathology

MCPP (FCP) is the most common diagnosis achieved with arthroscopy of the elbow joint. Arthroscopy of the elbow joint is indicated with front leg lameness in medium to large breed dogs when there is elbow joint pain or swelling, or when there are radiographic changes present in the elbow joint. MCPP (FCP) is diagnosed primarily in young dogs but has been seen as an acute-onset lameness in dogs as old as 9 years. Definitive differentiation of the etiology of radiographic change is not necessary before arthroscopy in that arthroscopy allows determination of the diagnosis and because the two most common conditions seen in the elbow joint, MCPP (FCP) and OCD, are approached through the same medial telescope and craniomedial operative portals. MCPP (FCP) is commonly a bilateral disease process, and bilateral elbow arthroscopy is routinely recommended, even in the presence of unilateral presentation. It is more economical and easier for the patient to undergo a bilateral procedure rather than two unilateral procedures.

Arthroscopy for MCPP (FCP) is performed through the medial telescope portal and the craniomedial operative portal (see Fig. 14-49). Egress is typically through the operative portal site. An egress portal can be placed in the caudal compartment of the joint if needed but is seldom required. MCPP (FCP) is typically easily visible but some lesions can be subtle and are not easily seen on initial examination of the joint. There is an extensive variety of pathology that can be present with a wide range of lesion severity. The wide variation of lesions indicates that this is not a single disease process but is a variety of different abnormalities producing distinctly different lesions. Small coronoid process fragments with no other pathology are seen in only a small percentage of cases. In these cases, normal cartilage is present on the free fragment, the fixed base of the coronoid process, and the medial ridge of the humeral condyle (Fig. 14-58). The classic larger free coronoid process fragments are typically seen with a variety of additional lesions. Loss of cartilage from the fixed base of the coronoid process can be minor (Fig. 14-59) to extensive (Fig. 14-60). Cartilage loss is also seen on the medial ridge of the humeral condyle, ranging from minor partial thickness erosions (see Fig. 14-59) and partial thickness wear lesions (Fig. 14-61) to extensive full thickness lesions with eburnation of exposed bone

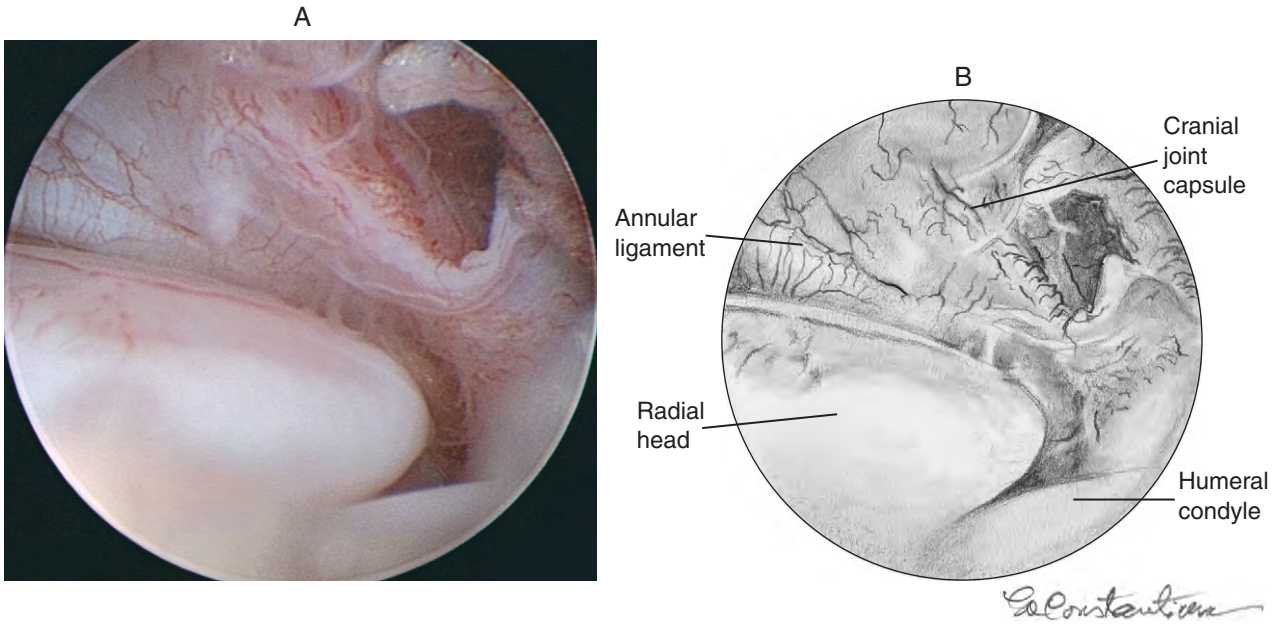



**Fig. 14–57**
The dorsal aspect of the radial head as seen with the telescope passed through the supratrochlear foramen from a caudal portal.

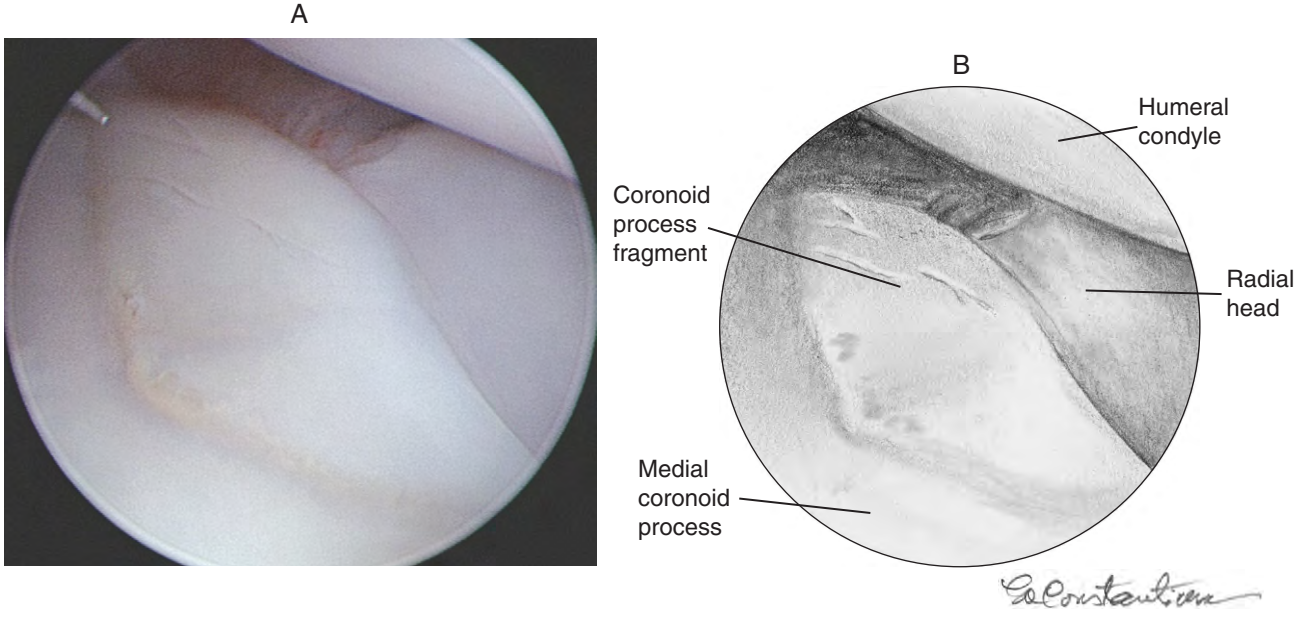



**Fig. 14–58**
A small, loose medial coronoid process fragment with normal cartilage on the fragment, coronoid process, and humeral condyle.

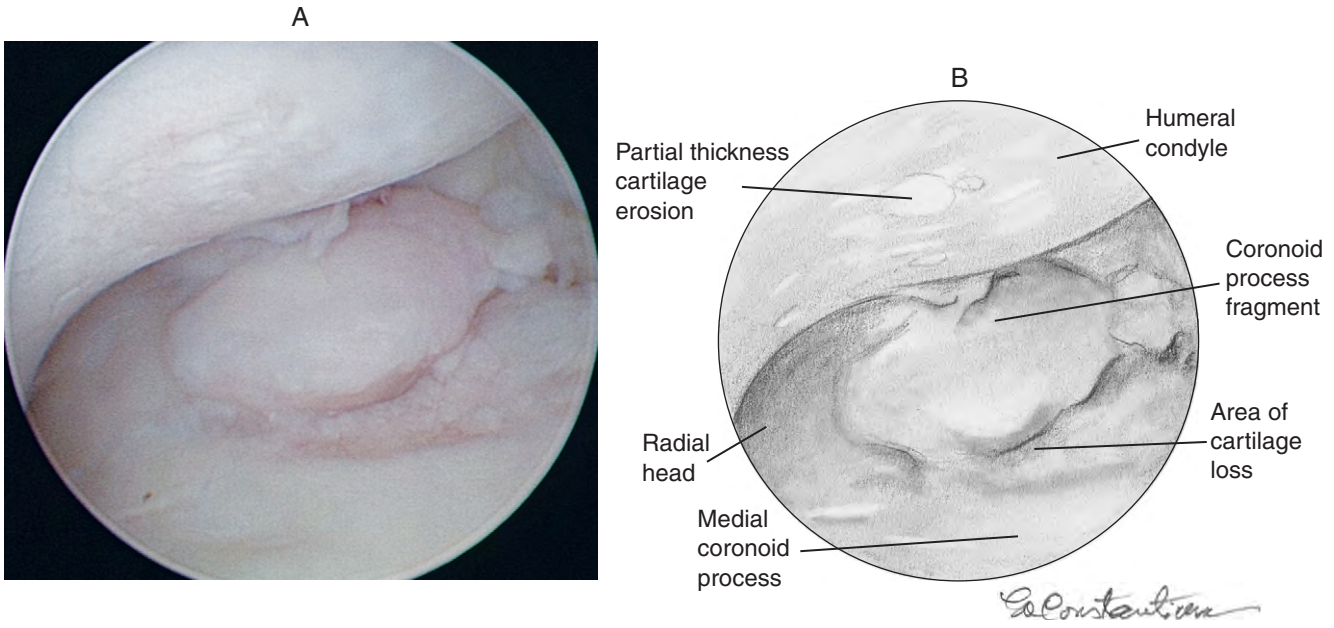



**Fig. 14-59**
A loose medial coronoid process fragment with normal cartilage on the fragment, a small area of cartilage loss from the fixed portion of the medial coronoid process, and an area of partial thickness cartilage erosion on the medial ridge of the humeral condyle.

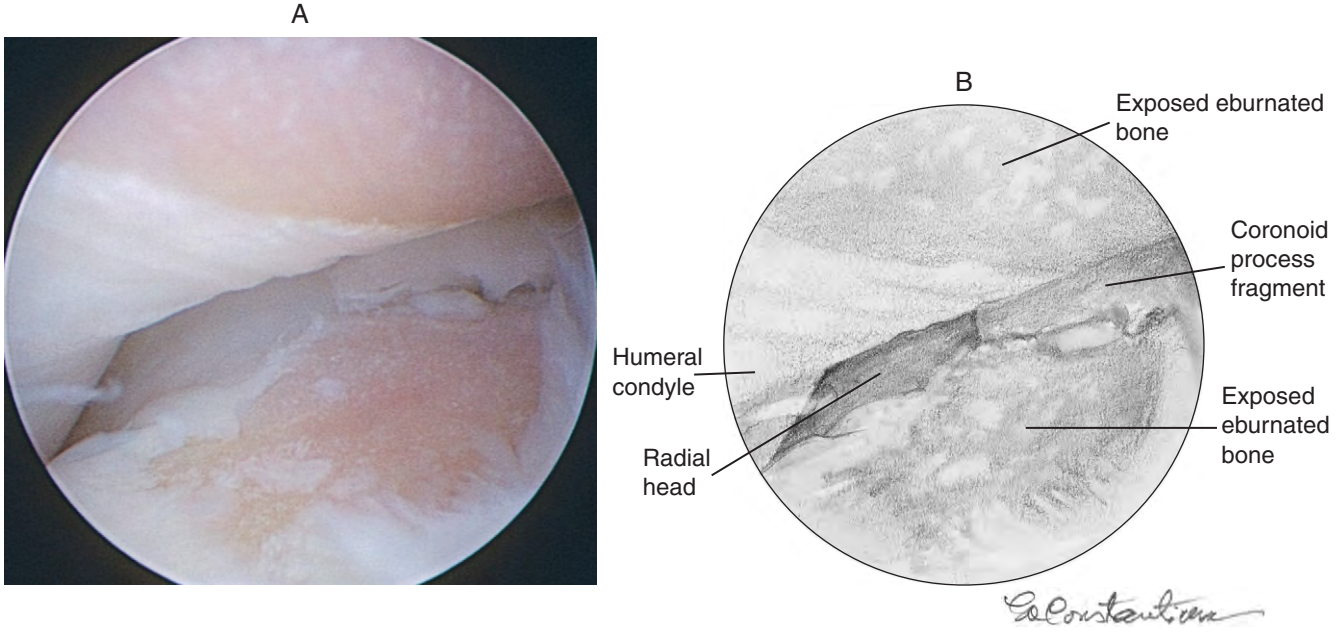



**Fig. 14-60**
A large, loose medial coronoid process fragment with extensive full thickness cartilage loss from the fixed portion of the medial coronoid process and the medial ridge of the humeral condyle with exposed eburnated bone.

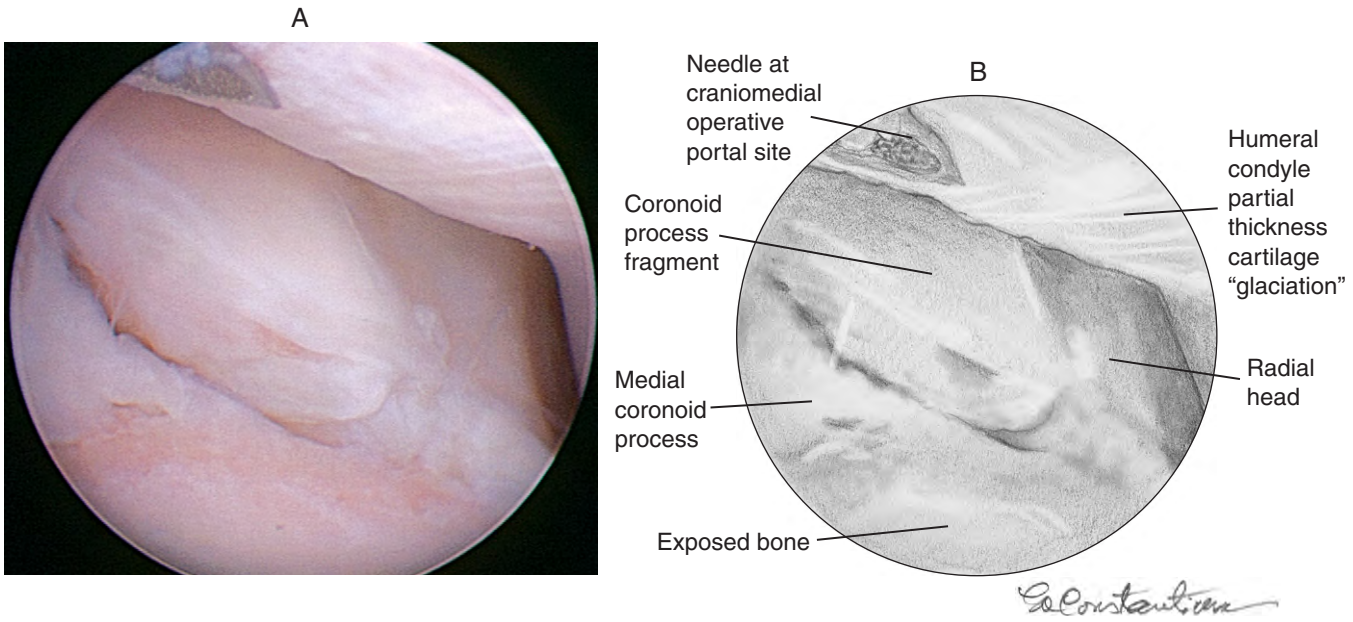



**Fig. 14-61**
A large, loose medial coronoid process fragment with normal cartilage on the fragment, an area of full thickness cartilage loss from the fixed portion of the medial coronoid process, and partial thickness wear lesions on the medial ridge of the humeral condyle. The grooves in the cartilage caused by wear appear similar to the grooves in rocks from glacier movement. The term *cartilage glaciation* provides an accurate visual picture for communication purposes.

(see Fig. 14-60). Humeral condyle wear lesions are more typically aligned with the fixed portion of the coronoid process than they are with the free fragment. Cartilage wear lesions can also be seen without free coronoid process fragments. Fixed coronoid process fragments also occur under normal (Fig. 14-62) or abnormal articular cartilage (Fig. 14-63). Removal of the cartilage over the fixed fragments commonly reveals fissure lines in the coronoid process with typically sclerotic bone in the fragment portion of the coronoid process (Fig. 14-64). Completely loose displaced free fragments are also seen in the cranial compartment of the joint. In these cases, the defect in the coronoid process where the fragment originated is typically filled with fibrous tissue and cartilage.

Which arthroscopic procedure is performed depends on the lesions that are seen and varies from simple removal of the free fragment to extensive revision of the coronoid process. Most coronoid process pathology can be managed with hand instruments, but revision procedures are facilitated with a power shaver. When the lesion has been identified, a needle is placed into the joint at the operative portal site to confirm the best location for the portal (Fig. 14-65) and the operative portal is established using a curved mosquito hemostat to bluntly dissect into the joint. Coronoid process procedures are typically performed without an operative portal cannula. Removal of small free fragments is performed with hand instruments by elevating the free fragment out of its bed with a curette (Fig. 14-66) or with the hemostat. The free fragment is grasped with the hemostat, with arthroscopic graspers, or most commonly with arthroscopic rongeurs (Fig. 14-67). The defect in the fixed portion of the coronoid process created by removal of the free fragment is examined and debrided to remove any residual fragments. For large, free fragments it may be necessary to remove the fragment in multiple pieces. Rongeurs work well for this technique because they achieve a better grip than grasping instruments, and if the fragment does not come out as one piece the rongeurs remove a piece of the fragment rather than shattering the fragment. Removal of large fragments can also be facilitated by removal of the fixed medial, abaxial, portion of the coronoid process between the operative portal and the free fragment to create a larger operating space. Most cases with large, free fragments have sufficient pathology of the fixed portion of the coronoid process to require revision and removal of a portion of the coronoid process, which is simply done before removal of the free fragment rather than after.

Cartilage wear lesions are caused by excessive pressure on the cartilage secondary to "incongruity." The pattern of the lesions defines the pattern of excessive pressure and where the bone is removed for coronoid process revision. Sufficient bone is removed from the involved portion of the coronoid process to eliminate contact with

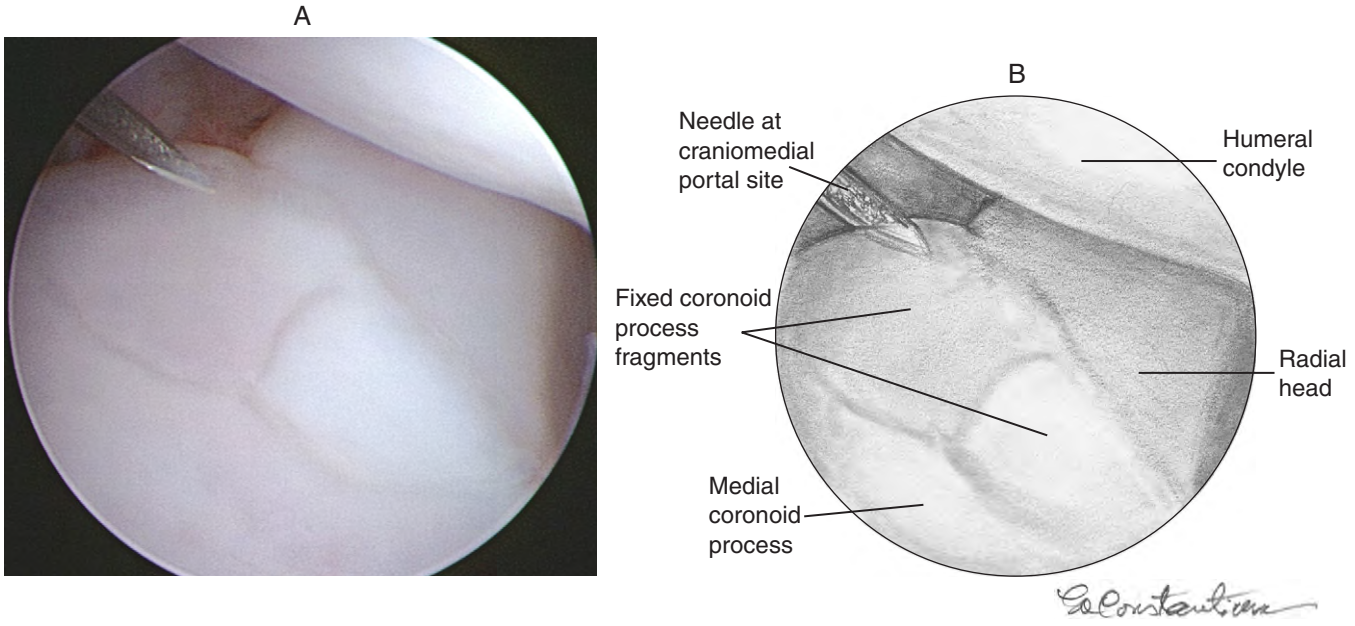



**Fig. 14–62**
Fixed medial coronoid process fragments covered with normal cartilage.

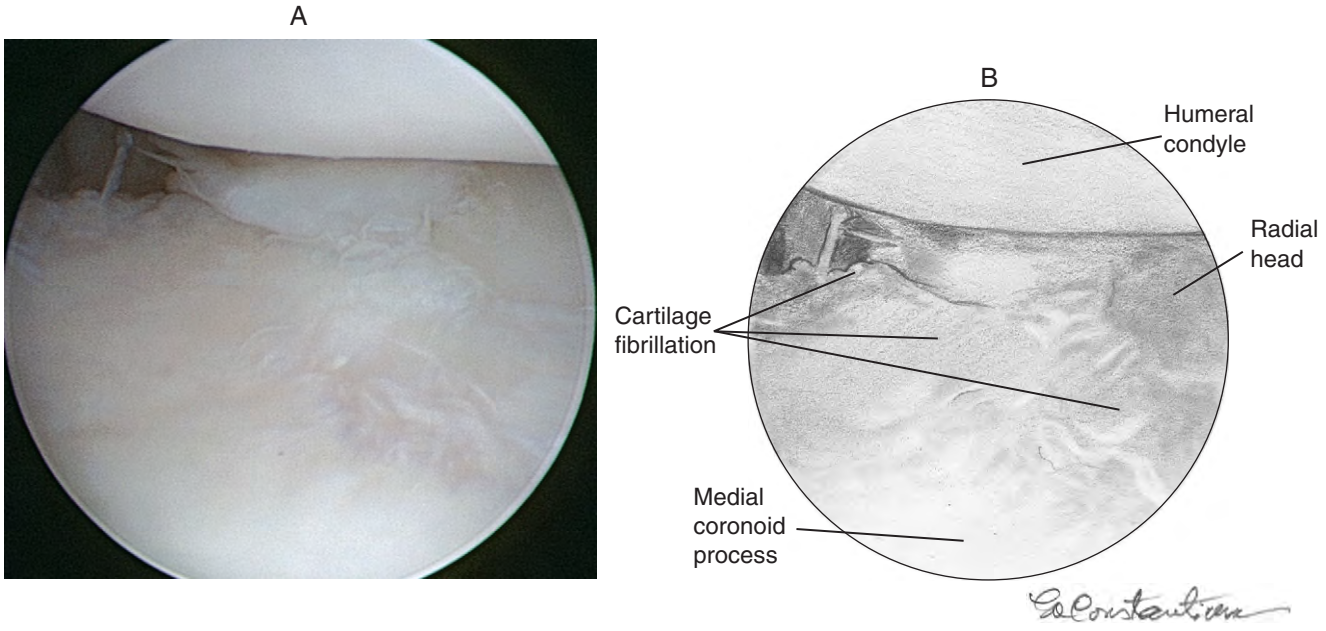



**Fig. 14–63**
Cartilage fibrillation over a fixed medial coronoid process fragment.

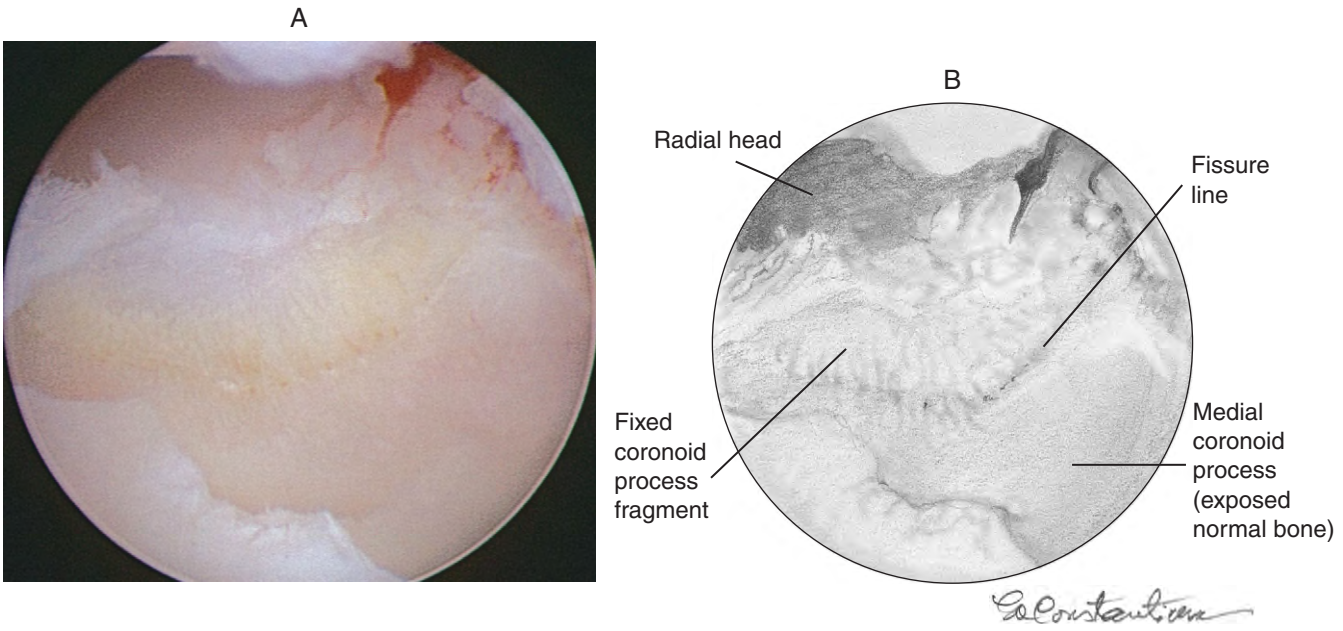



**Fig. 14-64**
A fissure line in the medial coronoid process delineating a fixed coronoid process fragment with sclerotic bone in the fragment above the fissure line and normal bone in the portion of the coronoid process below the fissure line. The medial coronoid process and this fixed fragment were covered with normal cartilage, and there was a visible demarcation line in the cartilage over the fissure line.

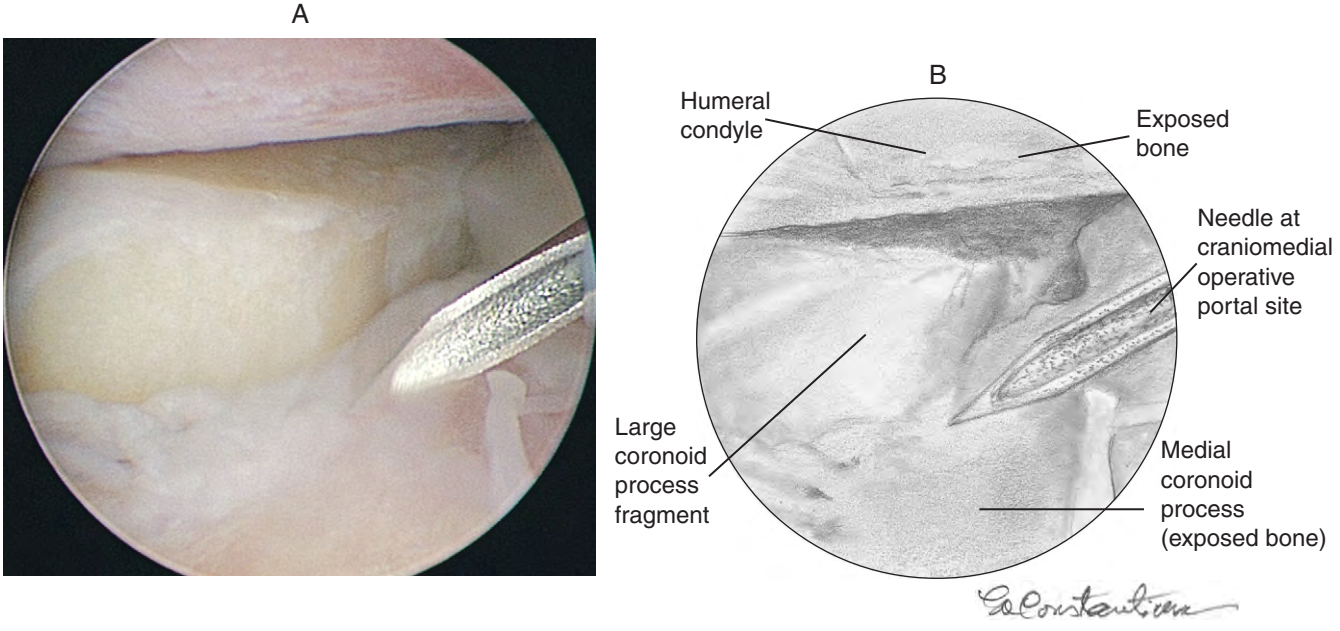



**Fig. 14-65**
A 20-gauge needle is placed into the joint at the craniomedial operative portal site to confirm the best location for the portal.

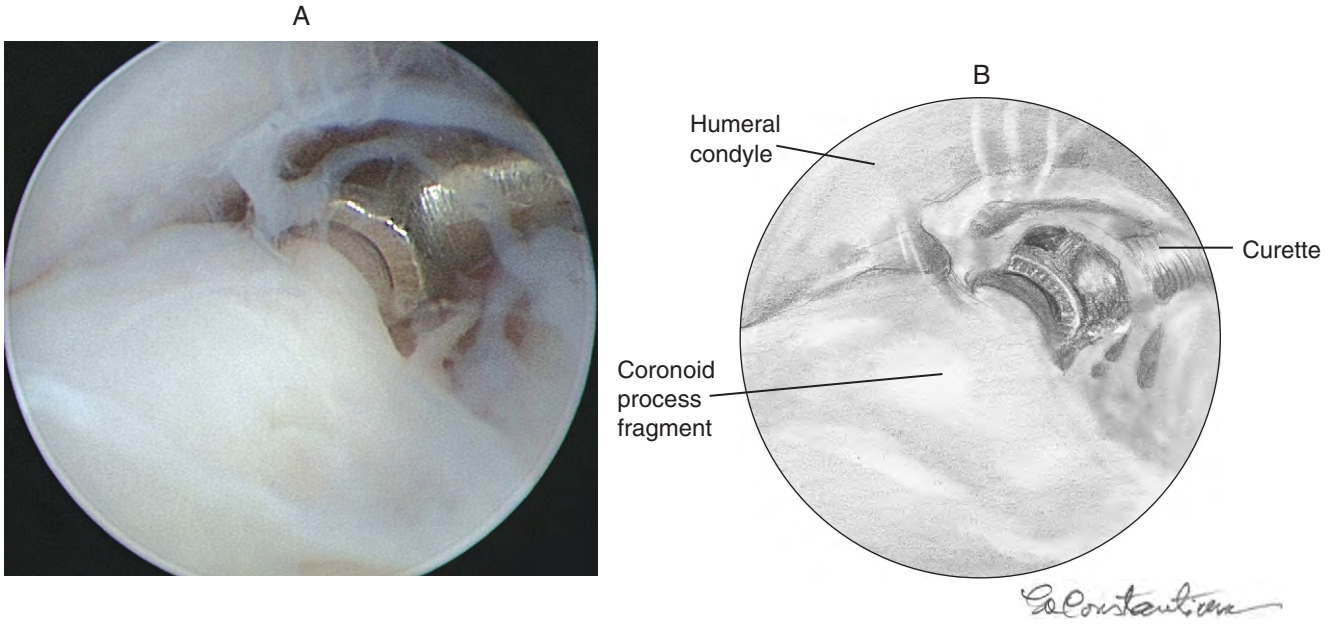



**Fig. 14-66**
Freeing the loose medial coronoid process fragment shown in Fig. 14-59 using a 5-0 curette.

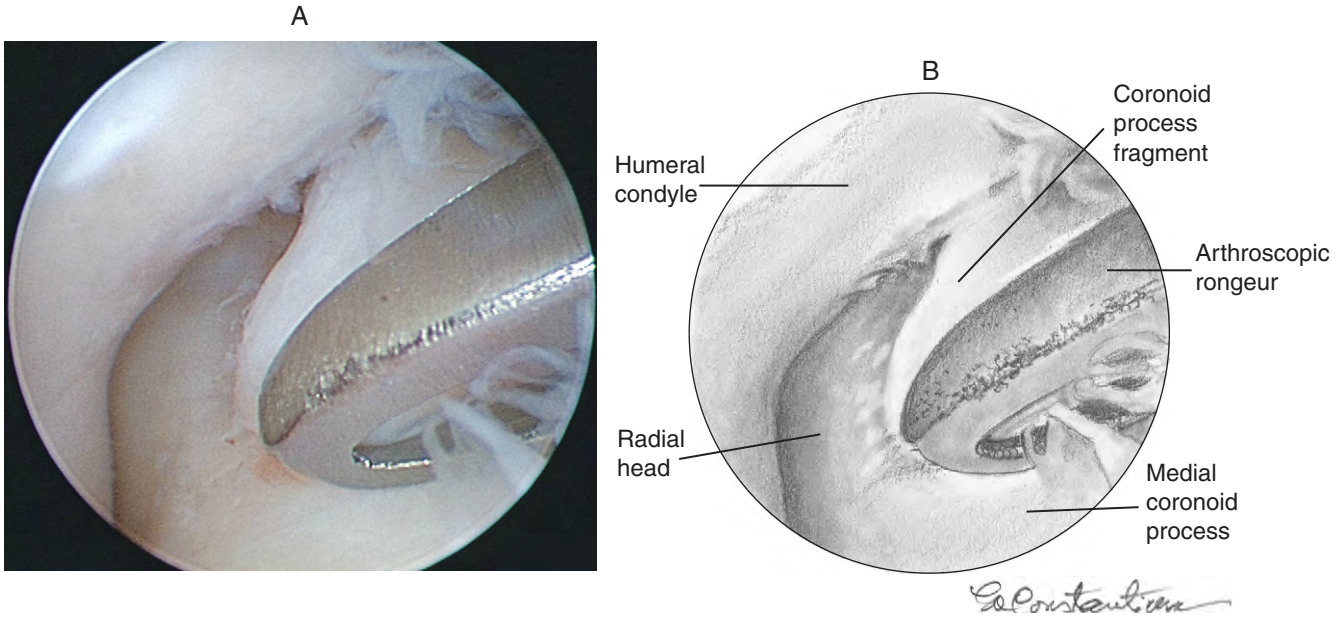



**Fig. 14-67**
Removing the freed medial coronoid process fragment shown in Figs. 14-59 and 14-66 using a 3.5-mm arthroscopic rongeur. Care is taken to avoid cutting into the cartilage of the medial ridge of the humeral condyle with the back side of the rongeur.

the humeral articular surface in the area where there was excessive pressure. The area of the coronoid process to be removed is defined by the wear pattern on the coronoid process and bone is removed from the area of exposed bone and worn cartilage. Coronoid process revision can be preformed with hand instruments using a curette to loosen pieces of the bone and then removing the loose pieces with rongeurs or graspers, but this procedure is greatly facilitated with a power shaver (Fig. 14-68). The revision is done on the coronoid process side of the joint and bone is not removed from the humeral condyle.

Coronoid process revision or removal is also performed for fixed coronoid process fragments that are seen as coronoid process fissure lines and sclerosis of the coronoid process. These lesions when first examined can appear as normal cartilage on the coronoid process (see Fig. 14-62) or as roughened cartilage (see Fig. 14-63). Any abnormal cartilage is removed for evaluation of the underlying bone. The bone medial to the fissure line is removed and any abnormal bone abaxial to the fissure lines is also removed. This is performed most easily with a power shaver but can be accomplished with hand instruments.

Free fragments that have migrated into the cranial compartment of the joint can usually be removed through the standard medial portals. Removal of part of the fixed portion of the medial coronoid process may be required to allow access into the cranial compartment from these portals. This approach can also be used for retrieving fragments that are lost into the cranial compartment during removal procedures. Care is used during removal of coronoid process fragments and revision of the coronoid process with hand instruments to prevent loss of fragments into the cranial compartment because this greatly increases the difficulty of the procedure and the operative time involved. If lost fragments cannot be accessed through the standard medial portals, additional portals are established until removal is achieved. The craniomedial operative portal can be used for a telescope portal to provide visualization of the cranial compartment and lost fragments with a cranial or craniolateral operative portal for fragment removal. Lateral coronoid process pathology is occasionally seen with abnormal cartilage and loose fragments being the most common findings (Fig. 14-69). These lesions are managed by removal of the loose fragments and abnormal cartilage. Access to the lateral coronoid process can be achieved through the standard medial portals in some cases, but typically a lateral operative portal is established and visualization is from the medial telescope portal (Fig. 14-70).

When all free fragments have been removed from the elbow joint, the bed of the defect has been adequately debrided, and any coronoid process revision has been completed, the joint is irrigated to remove debris by placing an instrument cannula or egress cannula through the operative portal and then moving the cannula around the joint to vacuum out any debris. In the elbow joint, debris

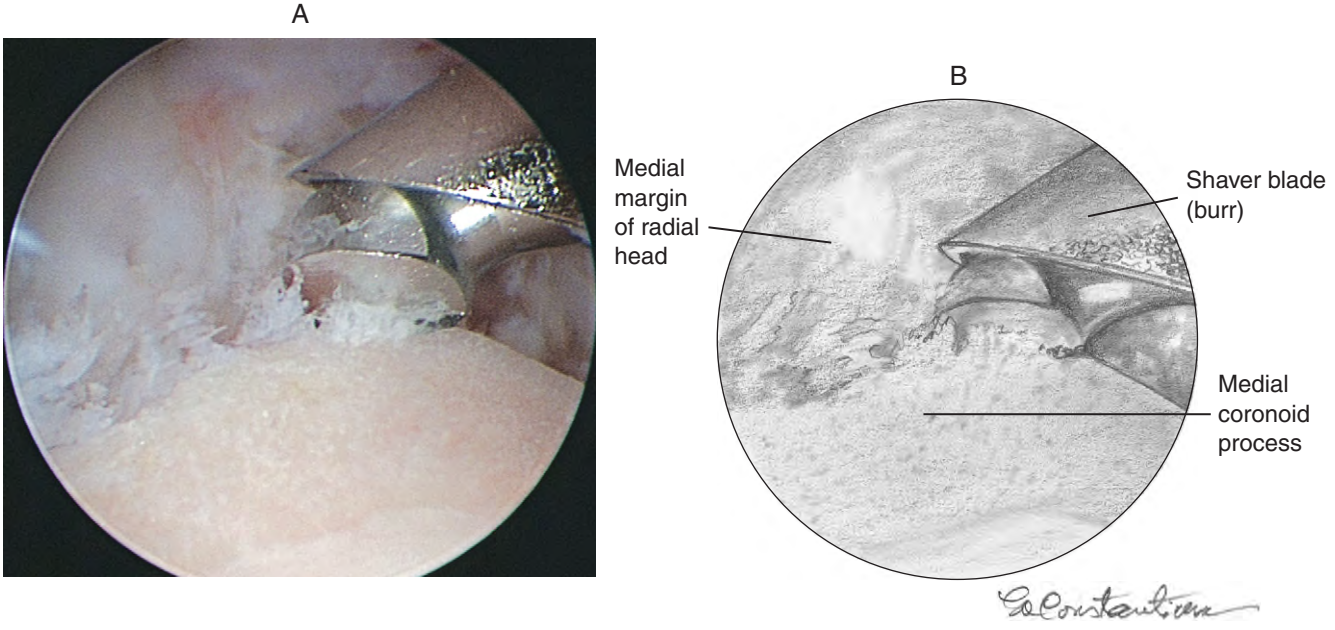



**Fig. 14-68**
The power shaver with a 3.5-mm burr is being used to remove the fixed portion of the medial coronoid process. The free coronoid process fragment and the margin of abnormal cartilage on the lateral aspect of the fixed portion of the medial coronoid process have already been removed.

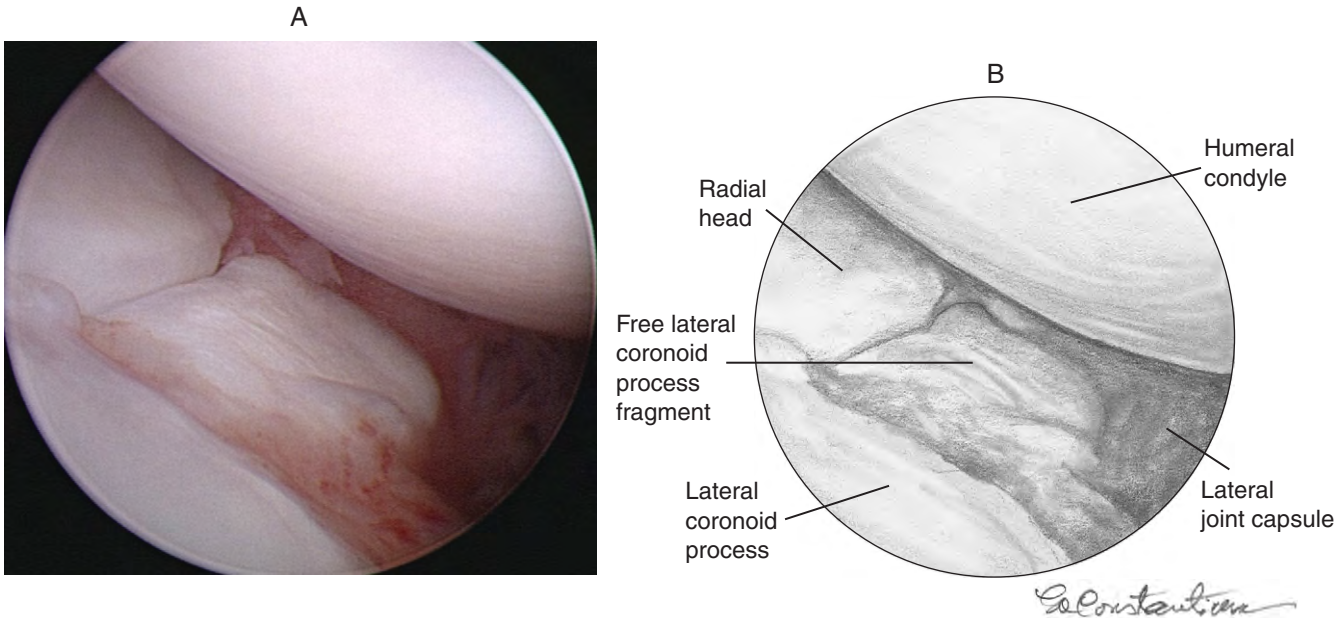



**Fig. 14–69**
Abnormal cartilage on a loose fragmented lateral coronoid process.

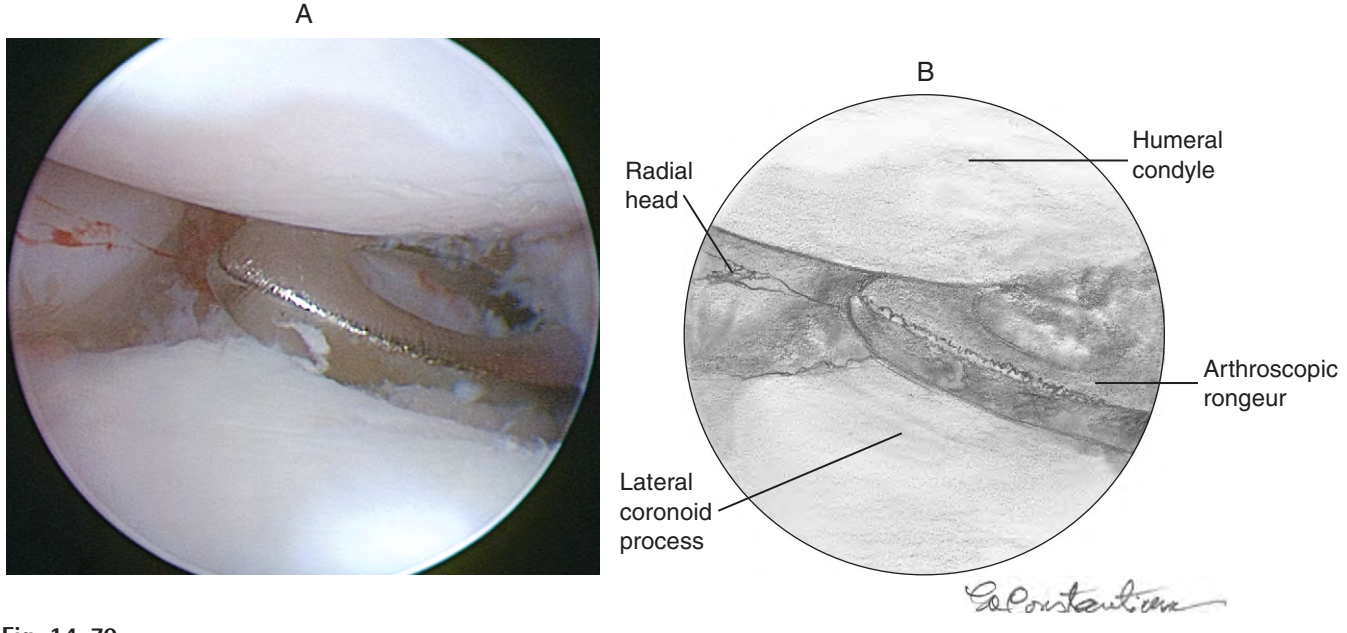



**Fig. 14–70**
Removing the fragmented lateral coronoid process fragment seen in Fig. 14-69 using a 3.5-mm arthroscopic rongeur placed through a lateral operative portal. The telescope is in the standard medial portal.

can be trapped between the cartilage surfaces; using a small hook probe that fits through the cannula facilitates removal of these pieces. This hook is used to tease these small fragments loose so that they exit through the cannula. Closure is with single interrupted skin sutures at each portal site.

## Osteochondritis Dissecans

The distal humeral condyle is a well-defined but uncommon site for OCD, with most lesions being seen on the medial ridge of the humeral condyle, but they are occasionally seen on the lateral ridge. Arthroscopy for removal and debridement of humeral condyle OCD lesions uses the medial telescope portal and craniomedial operative portal. Because of the location of the lesions on the humeral condyle, reversal of these portals sometimes facilitates the procedure. OCD lesions most commonly appear as a full thickness free flap of cartilage on the ventral or ventromedial aspect of the medial ridge of the humeral condyle, but they can also appear as a deep irregular cartilage defect with loose full thickness cartilage margins (Fig. 14-71) or as an area of loose cartilage with attached margins (Fig. 14-72). These lesions can be easily distinguished from the humeral condyle lesions seen with MCPP (FCP) because of the absence of the tapered feathering wear pattern and the presence of full thickness cartilage at the margins.

Removal of free flap lesions and areas of loose cartilage is performed in the same manner as for shoulder OCD lesions, although manipulation is restricted by the narrow joint space. Free flaps are elevated (Fig. 14-73) and removed with a curved mosquito hemostat or arthroscopic graspers. The margins and bed of the defect are evaluated for loose cartilage and bone and are debrided with hand instruments until all loose cartilage and bone are removed (Fig. 14-74). Removal of bone from the bed of the lesion is minimized and microfractures are created in the bed of the lesion if needed to increase vascular penetration. Hand instrumentation is used almost exclusively for management of OCD lesions in the elbow joint because power shavers are too aggressive, making it too easy to remove an excessive amount of bone and cartilage.

## Ununited Anconeal Process

Failure of the anconeal process ossification center to unite with the ulna is most commonly diagnosed in young German Shepherd dogs and presents as front leg lameness with unilateral or bilateral elbow pain, with or without crepitus, and with or without joint capsule distention or joint thickening. Diagnosis is confirmed with lateral radiographs obtained with the elbow in flexion. UAPs commonly occur bilaterally and arthroscopy is routinely performed bilaterally at the same procedure in these cases. A very high percentage (75% to 80%) of dogs with a UAP also have MCPP (FCP), and the coronoid process must be evaluated and managed to achieve adequate results. In cases with unilateral involvement of the anconeal process, bilateral arthroscopy is considered for assessment and management of MCPP (FCP). Evaluation of results of surgical management of UAP has not addressed coronoid

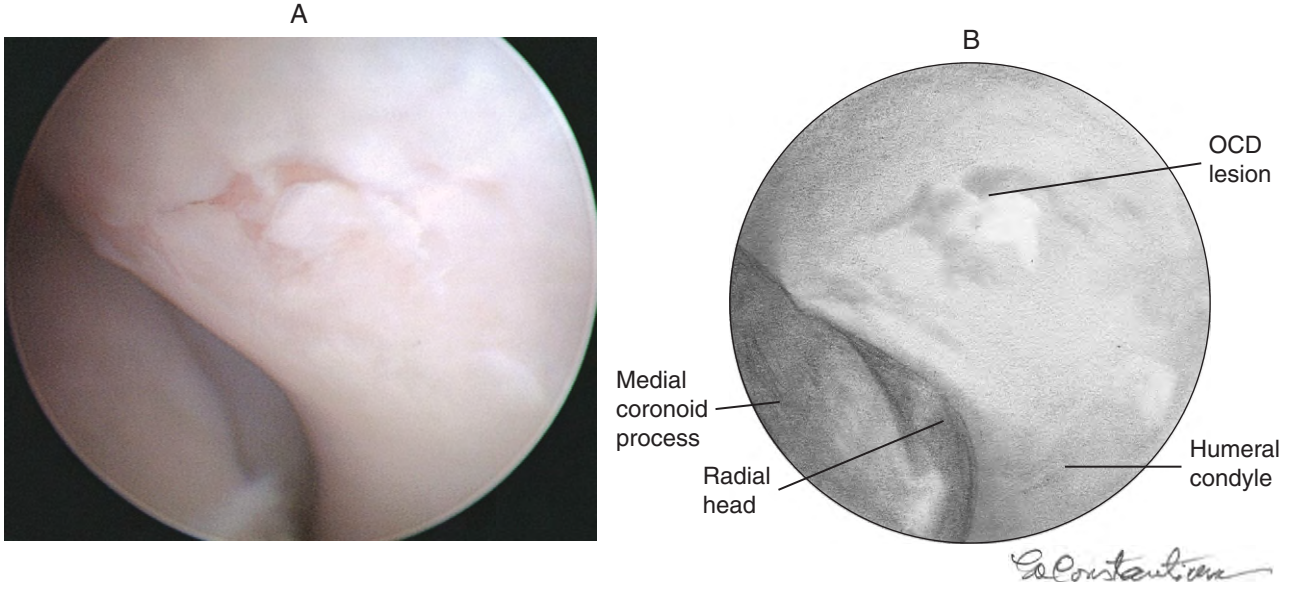



**Fig. 14–71**
An osteochondritis dissecans lesion on the medial ridge of the humeral condyle with a cartilage defect and full thickness loose cartilage margins.

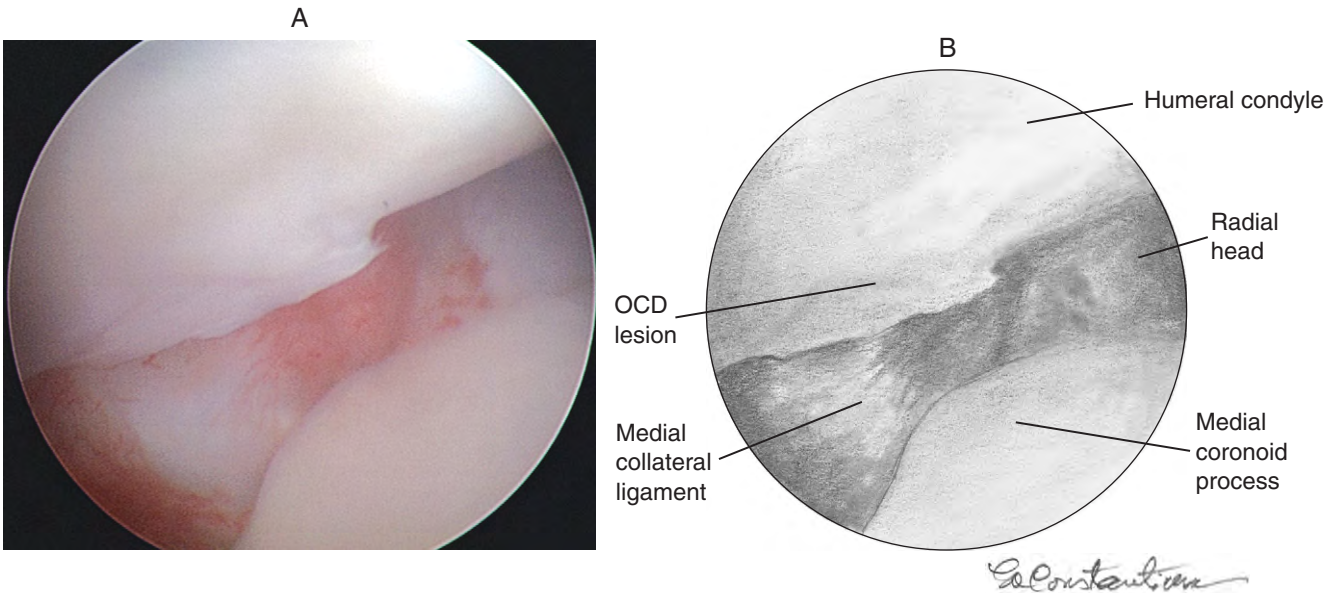



**Fig. 14–72**
An osteochondritis dissecans lesion on the medial ridge of the humeral condyle with an area of full thickness loose cartilage with attached margins.

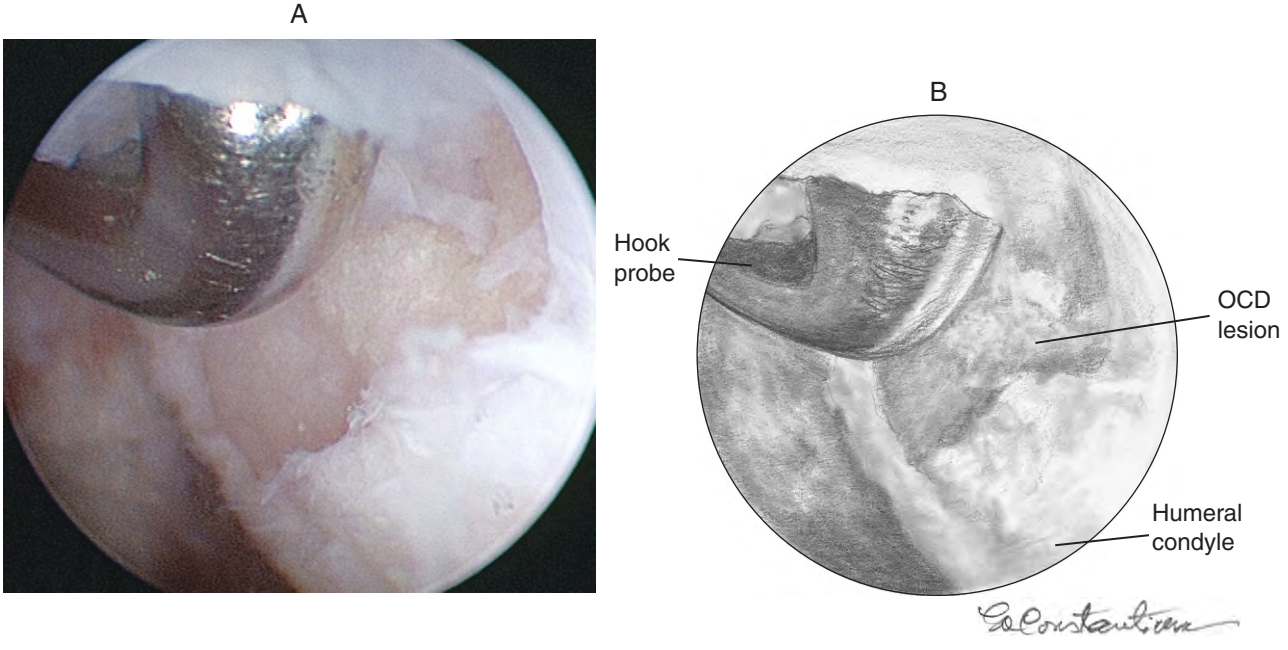



**Fig. 14–73**
Elevating an osteochondritis dissecans cartilage flap from the medial aspect of the medial ridge of the humeral condyle with the hook probe.

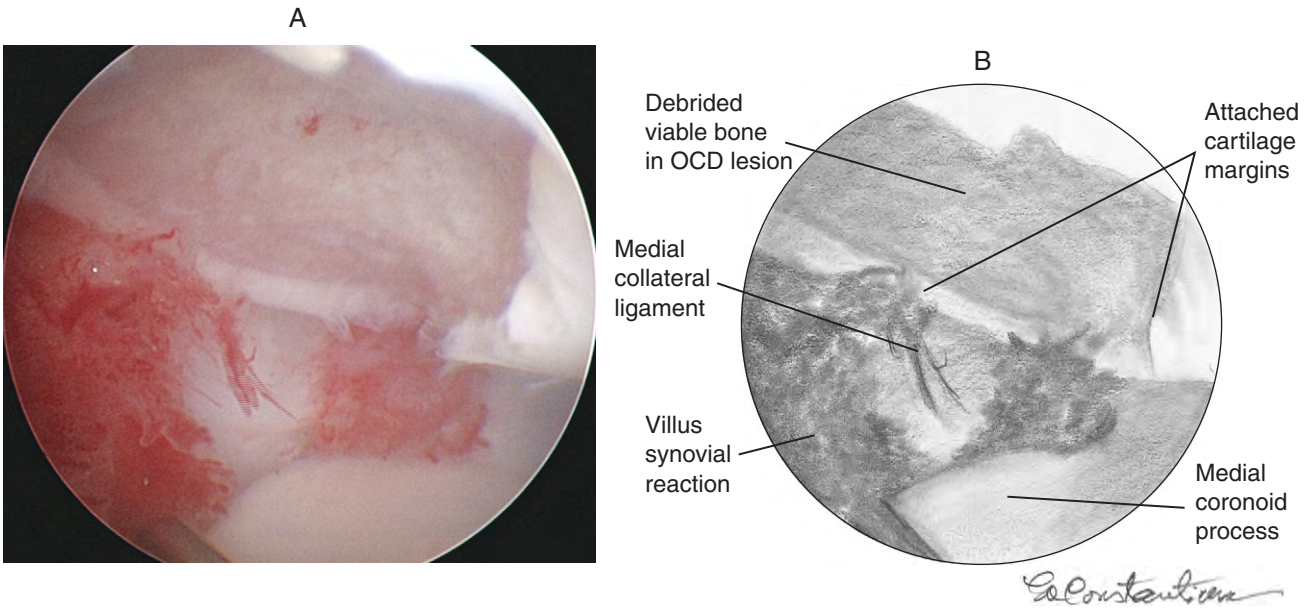



**Fig. 14-74**
An appropriately debrided humeral condyle osteochondritis dissecans lesion.

process pathology and lack of adequate postoperative results has been attributed to failure of the anconeal process treatment technique rather than the possible effects of other pathology. Results need to be reevaluated in case series that have had coronoid process pathology assessed and managed.

The arthroscopic approach to the UAP uses the medial telescope portal, the craniomedial operative portal for revision of MCPP (FCP) and a caudomedial operative portal for removal of the anconeal process fragment. The patient is positioned and prepared with the same protocol as for MCPP (FCP), which facilitates performing the procedure bilaterally. The telescope is placed in the medial portal and the joint is examined. After the coronoid process is assessed, the arthroscope is directed caudally for visualization of the anconeal process. The cleavage line at the separation of the free fragment from the ulna is usually easily visible (Fig. 14-75). A craniomedial operative portal is established and coronoid process pathology addressed before anconeal process removal. The caudomedial operative portal is established and is enlarged to allow removal of the free fragment in one piece if possible. This portal is more accurately a miniarthrotomy rather than a true arthroscopy portal. Removal of the free fragment in multiple small pieces or with a power shaver is excessively time-consuming and is avoided if possible. An arthroscopic or small surgical periosteal elevator is placed in the anconeal process cleavage plane (Fig. 14-76) and the fragment is elevated off of the ulna. Large arthroscopic graspers, large arthroscopic rongeurs (5 to 7.5 mm), or appropriate size orthopedic rongeurs are used for fragment removal (Fig. 14-77). Rongeurs are preferred over graspers because they get a better grip on the fragment and, if gripping is too aggressive, they remove a defined portion of the fragment rather than crushing the fragment. Following removal of the anconeal process fragment, the caudal joint compartment is evaluated for residual bone fragments and is irrigated thoroughly to remove debris. Closure is with single skin sutures in the medial and craniomedial portals and with layered surgical closure of the larger caudomedial portal.

## Degenerative Joint Disease

Chronic severe degenerative elbow joint disease in older dogs with lameness, limited range of elbow joint motion, and multiple intraarticular osteophytes can be managed by arthroscopic debridement of osteophytes to improve range of motion, joint function, joint pain, and lameness. The most significant osteophytes that typically interfere with joint motion are those on the caudal aspect of the anconeal process and those on the dorsal aspect of the radial head. A multiportal approach is used to access the medial joint space through the standard medial telescope and craniomedial operative portals, the caudal joint compartment through caudomedial and caudolateral joint portals, and the cranial joint space through medial, cranial, craniomedial, or craniolateral portals. A medial telescope portal and craniomedial operative portal are established first to assess the articular surfaces of the joint and the medial coronoid process, to remove coronoid process fragments, and to revise the coronoid process. Most cases of chronic DJD have their origin in

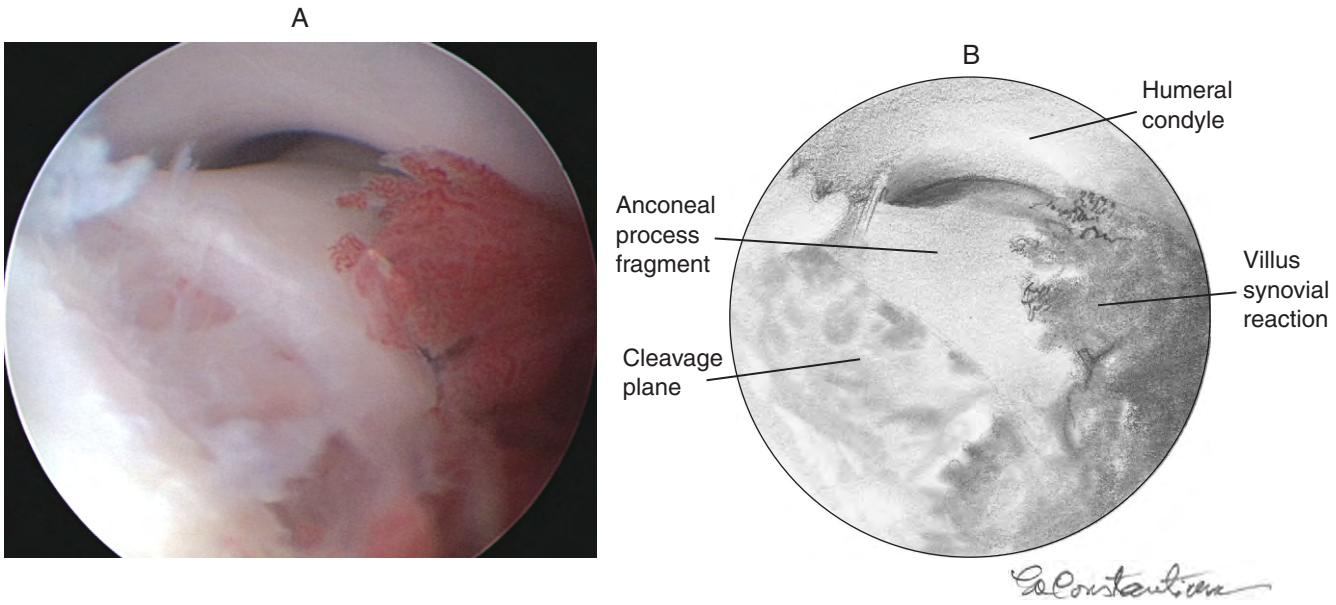



**Fig. 14–75**
The cleavage plane of an ununited anconeal process.

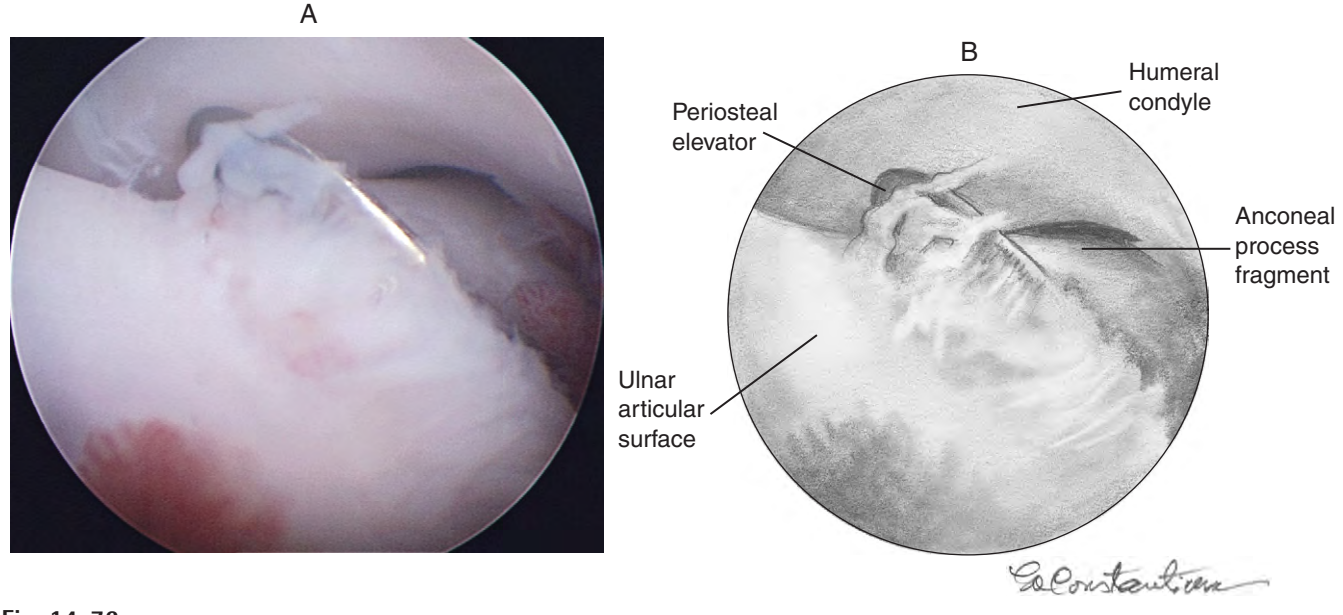



**Fig. 14–76**
Elevating the ununited anconeal process fragment off of the ulna using a periosteal elevator.

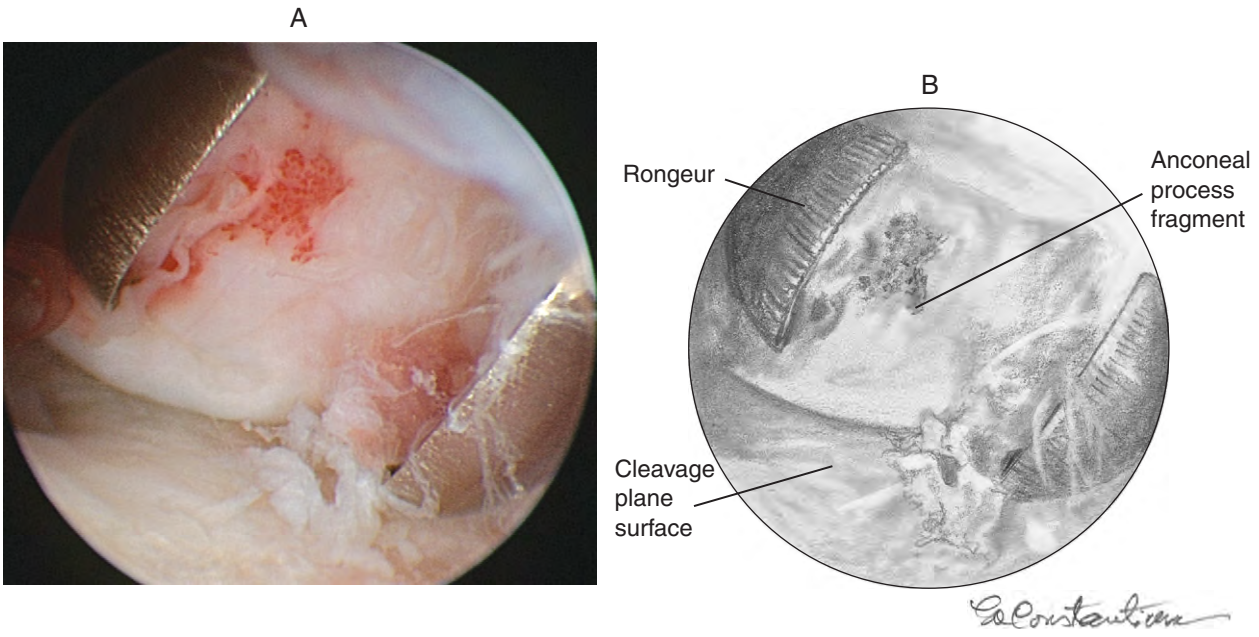



**Fig. 14–77**
The freed ununited anconeal process fragment is grasped with a rongeur and removed through an enlarged caudomedial operative portal.

MCPP (FCP), which is evaluated and addressed as part of the procedure.

Access to the osteophyte on the dorsal aspect of the radial head can sometimes be achieved through the medial telescope and craniomedial operative portals after the medial coronoid process has been revised. This is attempted to facilitate the procedure by decreasing the number of portals required and eliminating the need for establishing the more difficult cranial portals. A power shaver with a burr is used to remove the dorsal radial head osteophyte and the cranial joint compartment is evaluated for any loose bodies or debris created by the procedure. Visualization of the lateral portion of the cranial joint compartment can be improved by moving the telescope to the craniomedial operative portal. If access from the medial portals is not adequate, a proximal craniolateral telescope portal and craniolateral operative portal can be established.

Access to osteophytes on the caudal aspect of the anconeal process is through caudomedial and caudolateral portals. Synovial villus reaction in the caudal compartment commonly interferes with visualization and is removed using a radiofrequency probe before osteophyte removal. Hand instruments can be used for osteophyte removal, but a power shaver with a burr is preferred. When all areas of the joint have been treated, the joint is irrigated thoroughly through all portals to ensure removal of debris and that there are no significant remaining osteophytes.

Results with this technique are variable, from dramatic improvement to little or no improvement. Improved range of motion may be detected at the time of completion of the procedure, or it may not be seen for several weeks. In some cases, optimum function may not be achieved without a program of postoperative physical therapy. Multiportal elbow joint debridement is a difficult and time-consuming procedure and should not be attempted by the beginning arthroscopist.

## Arthroscopic Intraarticular Fracture Repair

Surgical repair of intracondylar fractures of the distal humerus can be facilitated using arthroscopy or arthroscopic-assisted technique. Closed fracture reduction and screw placement with arthroscopic guidance is the ideal concept, but more practically a limited open approach and arthroscopic-assisted fracture reduction and screw placement is used.

## Arthroscopic Biopsy of Intraarticular Neoplasia

Intraarticular neoplastic masses can be found with arthroscopy during elbow exploration in cases of lameness and elbow pain that do not have radiographic changes. Arthroscopy can also be used to obtain biopsy specimens of epiphyseal bone lesions seen on radiographs and in many cases is the least traumatic approach for conducting biopsies.

### Arthroscopic Diagnosis of Immune-Mediated Erosive Arthritis

Immune-mediated erosive arthritis is commonly discussed as occurring most frequently in the carpus and tarsus. After conducting arthroscopy in more than 1000 joints, I have seen only one confirmed case of immune-mediated erosive arthritis, and that was seen in an elbow.

## ARTHROSCOPY OF THE RADIOCARPAL JOINT

### Indications

Arthroscopy of the radiocarpal joint is indicated in the presence of front leg lameness with carpal pain, crepitus, swelling, or instability or in cases of radiographic evidence of intraarticular fractures or DJD. The carpal joint is a commonly recommended site for synovial biopsies to diagnose immune-mediated polyarthric disease. Carpal joint disease is commonly accompanied by significant joint swelling or thickening, making localization of the involved joint easier than with more proximal joints.

### Patient Preparation, Positioning, and Operating Room Setup

Radiocarpal joint arthroscopy is typically performed as a unilateral procedure. The patient is placed in dorsal recumbency with the involved leg extended caudally beside the body, or the patient is placed in lateral recumbency with the leg to be evaluated on the upper side. The leg is suspended for preparation and draping. The monitor is placed across the table from the surgeon when the lateral position is used and at the head of the table when the dorsally recumbent position is used. The assistant stands caudal to the surgeon between the surgeon and the monitor when lateral recumbency is used and cranial to the surgeon when the dorsal position is used. Dorsal recumbency is used for the occasional bilateral procedure: the patient's legs are extended caudally, the monitor is placed at the foot of the table, and the assistant stands caudal to the surgeon between the surgeon and the monitor. When carpal fusion or other open surgical procedure is being considered following the arthroscopy, this is taken into account in positioning the patient to allow a smooth transition without repositioning or redraping.

### Portal Sites and Portal Placement

All portals for the radiocarpal joint are on the cranial or dorsal aspect of the joint. Portals are placed either medial or lateral to the common digital extensor tendon with the telescope portal placed on the side of the tendon away from the area of interest (Fig. 14-78). This allows placement of an operative portal directly over the lesion. The radiocarpal joint is small and there is frequently not enough room for three portals, so an egress portal is not placed and egress is allowed through the operative portal. If an egress portal is needed, it can be established medial or lateral to either of the other two portals. The portal sites are established by flexing the carpus and palpating the indentation of the radiocarpal joint space medial and lateral to the common digital extensor, a 20-gauge, 1-inch needle is placed into the joint, joint fluid is aspirated, the joint is distended with saline, a stab incision is made with a number 15 scalpel blade, and the telescope cannula is placed into the joint using the blunt obturator. Initial egress is allowed through a 20-gauge needle until an operative portal is established.

The portal site on the dorsal aspect of the joint not used for the telescope portal is used for an operative portal. A 20-gauge, 1-inch needle is placed in the joint to accurately confirm portal site placement and a stab incision is made into the joint with a number 15 scalpel blade. Instrumentation is passed directly into the joint without an instrument cannula.

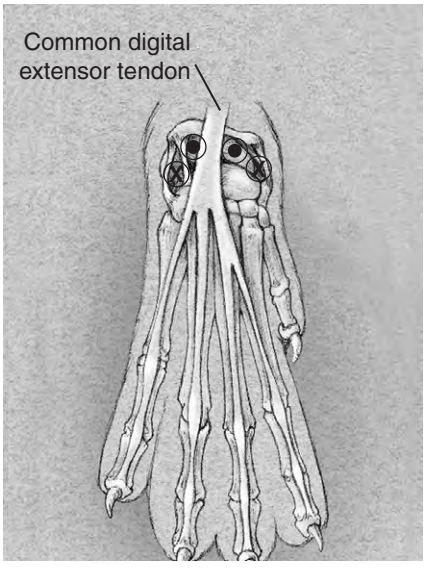



**Fig. 14–78**
Portal sites on the dorsal aspect of the radiocarpal joint. The portals that are shown are the two sites for the telescope portal medial and lateral to the common digital extensor tendon (*circles*) and the two sites for operative or egress portals (*X*'s). The radiocarpal joint is flexed and the portals are placed directly over the palpable indentation of the joint medial or lateral to the common digital extensor tendon. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

## Examination Protocol and Normal Arthroscopic Anatomy

Upon entering the radiocarpal joint, orientation is established using the distal articular surface of the radius, proximal articular surface of the radial or ulnar carpal bones, and the joint space (Fig. 14-79). Space within the radiocarpal joint is limited and examination requires careful manipulation of the joint through flexion and extension, with small movements of the telescope in depth, angle, and rotation. The distal articular surfaces of the radius and ulna (see Fig. 14-79), the proximal surface of the radial carpal bone (see Fig. 14-79), the ulnar carpal bone, accessory carpal bone (Fig. 14-80), the dorsal joint space (Fig. 14-81), and palmar ligaments of the joint (Fig. 14-82) are examined. Transposing the telescope between the two dorsal portal locations facilitates complete examination of the joint.

## Diseases of the Radiocarpal Joint Diagnosed and Managed with Arthroscopy

### Fractures

Evaluation and management of radial carpal bone fractures can be assisted with arthroscopy primarily from a diagnostic standpoint to facilitate decision making for treatment selection. Assessment of fracture pattern and evaluation of articular cartilage damage (Fig. 14-83) is more accurate and less invasive than open exploration. Dorsal slab fractures of the radial carpal bone and chip fractures from the dorsal margin of the distal articular surface of the radius (Fig. 14-84) can be diagnosed and removed with arthroscopy.

### Soft Tissue Injuries

All soft tissue structures in and around the radiocarpal joint can be injured. Arthroscopy provides a minimally invasive approach for diagnosis, for selecting and planning open operative procedures, and, occasionally, for treatment. Extensive ligament injuries require open surgical stabilization with either ligament reconstruction or carpal fusion and are not managed with arthroscopy. Dorsal joint capsule injuries have been treated with thermal modification and external splint support.

### Arthroscopic Diagnosis of Immune-Mediated Erosive Arthritis

Arthroscopy is an effective method for joint examination and biopsy specimen collection in cases of suspected immune-mediated arthritis.

# ARTHROSCOPY OF THE HIP JOINT

## Indications

The most common indication for arthroscopy of the hip joint is hip dysplasia for assessment of articular cartilage condition in a young dog before performing corrective

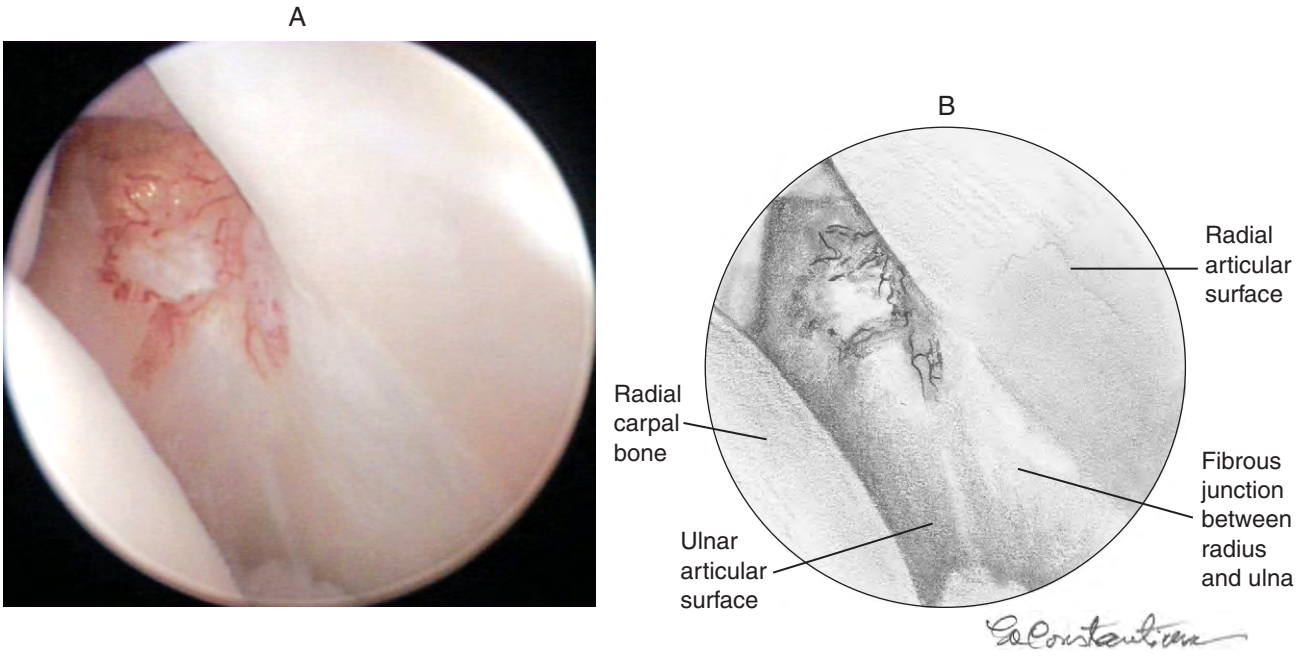



**Fig. 14-79**
The radiocarpal joint space with the distal articular surface of the radius and ulna with the articular surface of the radial carpal bone.

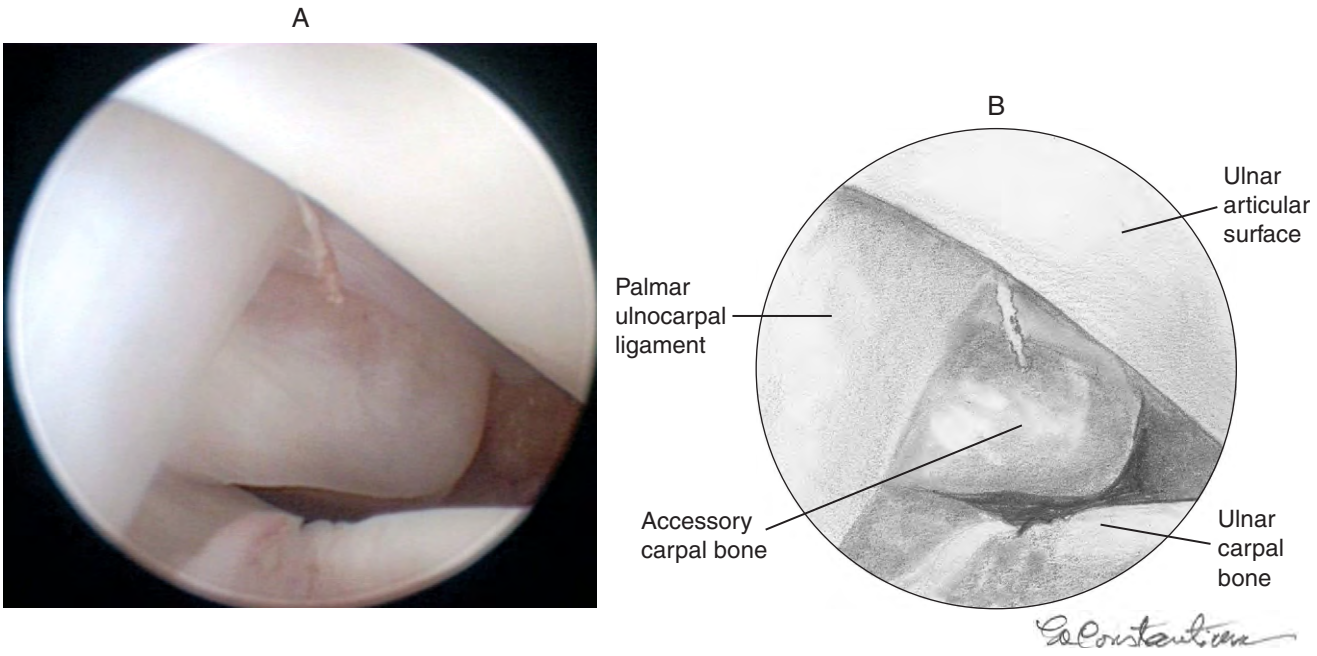



**Fig. 14–80**
The accessory carpal bone visible in the palmar portion of the radiocarpal joint.

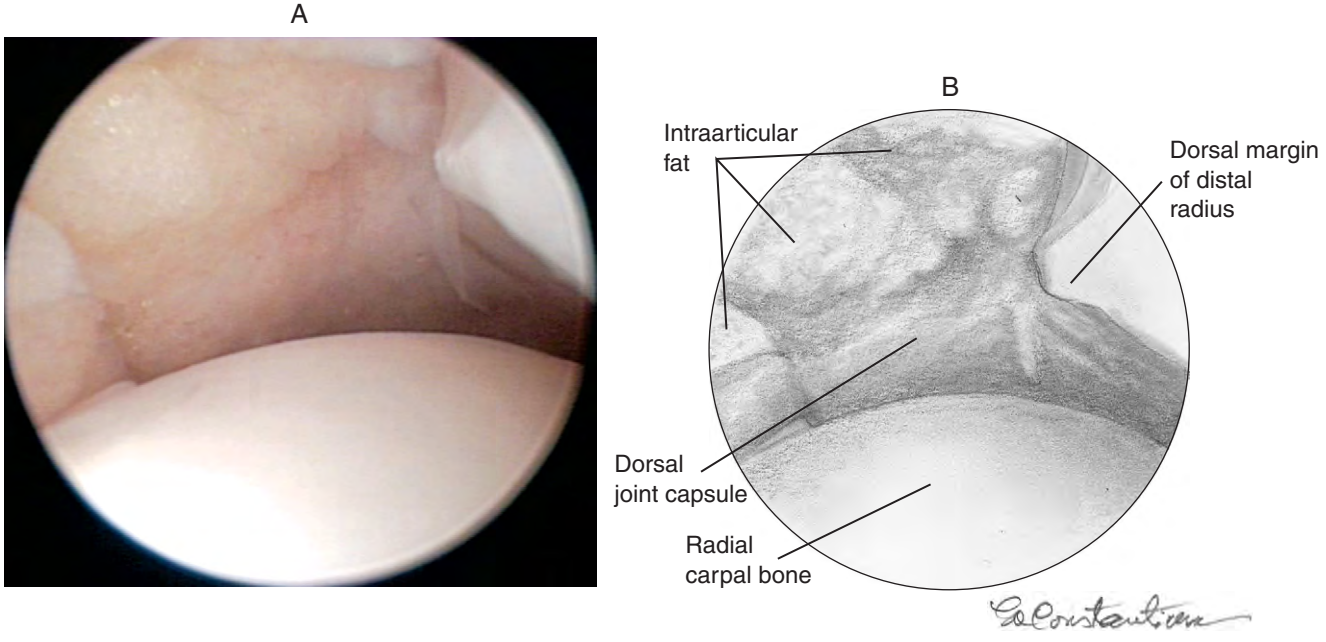



**Fig. 14–81**
The dorsal carpal joint space with the telescope directed medially.

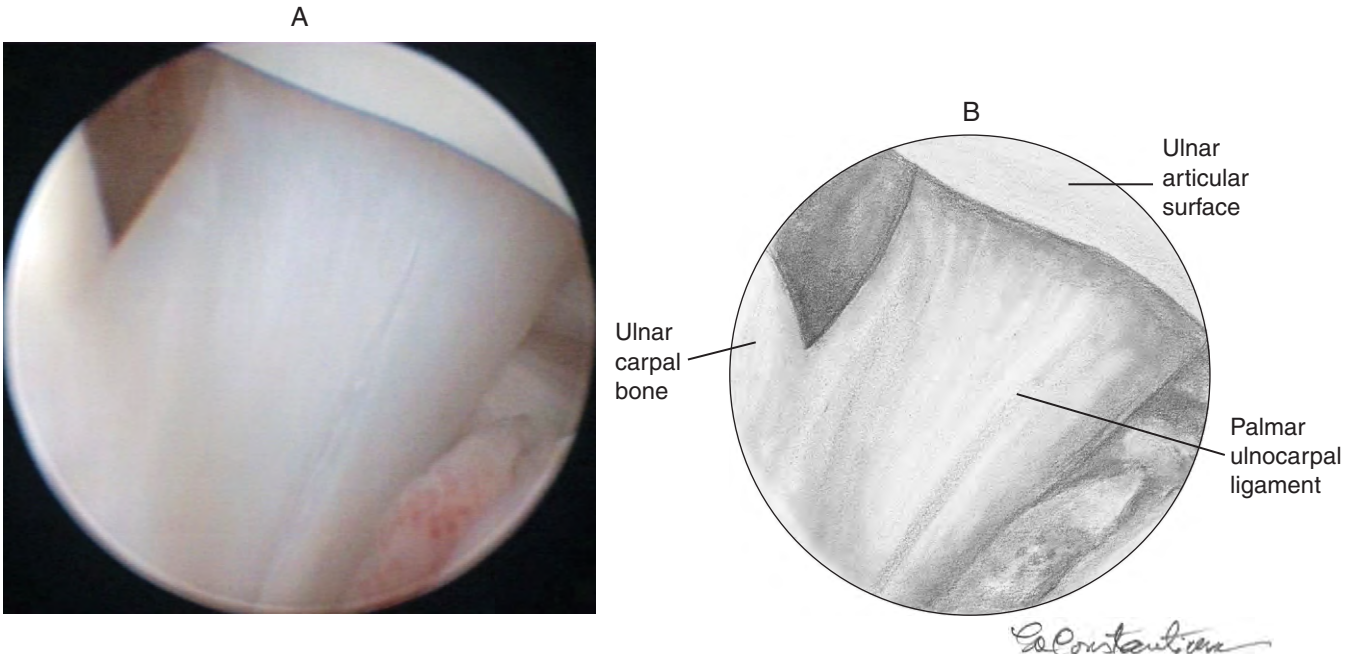



**Fig. 14–82**
The palmar ulnocarpal ligament in the palmar portion of the joint.

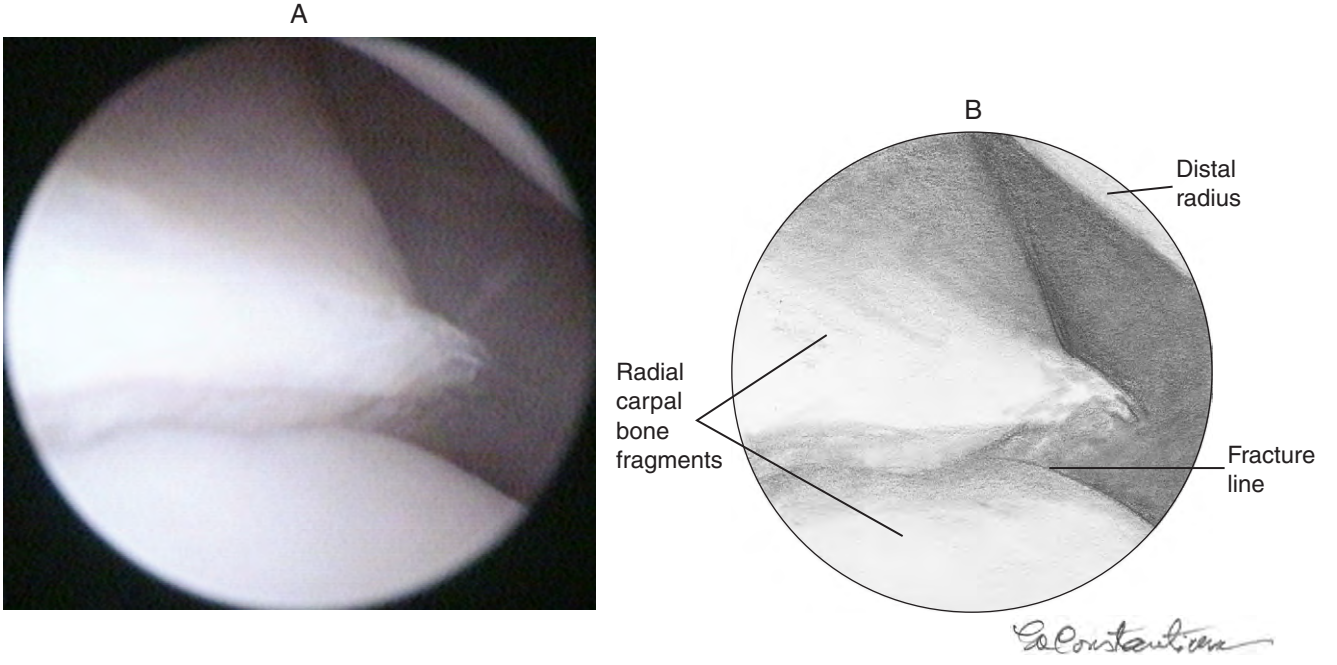



**Fig. 14–83**
A radial carpal bone fracture line that was more than 6 months old. The joint was examined with arthroscopy before surgery to evaluate the condition of the cartilage.

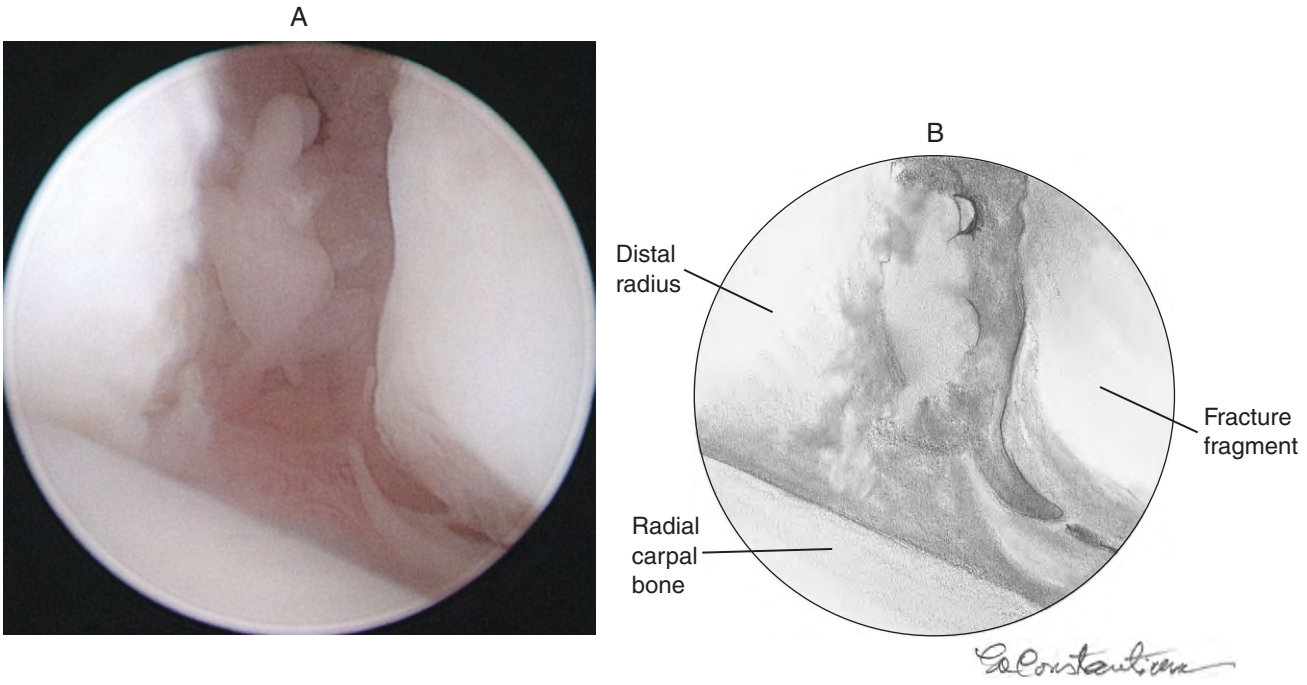



**Fig. 14-84**
A fracture fragment from the distal radius visible in the dorsal joint space of the radiocarpal joint. The chip fragment was removed with arthroscopy.

triple pelvic osteotomy (TPO) surgery. Arthroscopy provides more information for case selection and for improving results with TPO surgery than can be obtained with other less invasive techniques. The patient is prepared for the TPO surgery and arthroscopy is performed as the first step of the procedure. If the patient is found to be a good candidate for TPO with arthroscopy, then the surgery is performed. If the patient is not a good candidate for TPO based on the arthroscopic findings, then the procedure is terminated and the patient is recovered. Other indications for hip joint arthroscopy are hip joint pain or crepitus not associated with hip dysplasia, radiographic evidence of intraarticular fractures, degenerative changes not typical of hip dysplasia, and lytic lesions in the femoral head.

## Patient Preparation, Positioning, and Operating Room Setup

Because the most common indication for hip joint arthroscopy is in dysplastic dogs immediately before TPO surgery, the patient is clipped, positioned on the table with the leg suspended, prepared, and draped for the TPO surgery. The monitor is placed dorsal to the patient and far enough cranially to be out of the way of the sterile field for the TPO surgery and the surgeon stands at the caudal end of the table with the assistant on the ventral side of the patient. An alternative is for the surgeon to stand on the dorsal side of the patient with the assistant ventral to the patient and monitor ventral to the patient far enough cranially to be out of the way of the sterile field.

## Portal Sites and Portal Placement

All portals for the hip joint are on the dorsal aspect of the joint (Fig. 14-85). The telescope portal is placed directly dorsal to the greater trochanter, and an egress needle or portal is placed either cranial or caudal to the telescope portal. Access to the hip joint is easy in young dysplastic dogs because of their hip laxity. To establish the telescope portal site, ventral traction is applied to the limb and the proximal femur is pushed down or medially. A 2- to 3-inch, 20-gauge spinal needle is inserted into the joint in a medial direction immediately dorsal to the greater trochanter, joint fluid is aspirated, the joint is distended with saline, a stab incision is made in the skin, fascia, and muscle at the portal site with a number 10 scalpel blade, the portal tract is deepened with blunt dissection using a curved mosquito hemostat, and the telescope cannula is placed into the joint with the blunt obturator. For joint exploration before TPO surgery, egress through the initial arthrocentesis needle or a second needle is usually adequate and establishing an egress portal is not required. Operative procedures are not commonly performed in the hip joint and an operative portal is not typically placed but, if needed, can be placed either cranial or caudal to the telescope portal.

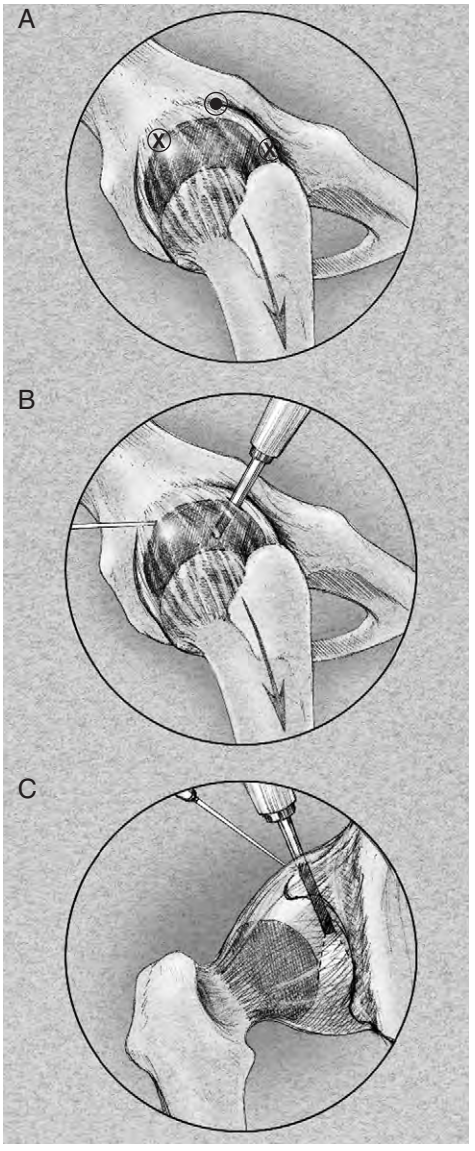



**Fig. 14-85**
Portal sites on the dorsal aspect of the hip joint. **A,** The three portal sites shown are the dorsal telescope portal (*circle*) and craniodorsal or caudodorsal egress portal sites (*X*'s). **B,** The telescope is positioned vertically and directed medially for initial examination of the joint. **C,** An anteroposterior projection of the hip joint demonstrates positioning of the telescope. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

## Examination Protocol and Normal Arthroscopic Anatomy

Orientation in the hip joint uses the round ligament, the acetabular fossa, the concave articular surface of the acetabulum, and the convex articular surface of the femoral head. A common tendency is to insert the arthroscope too deeply so that the tip is in the tissues of the acetabular fossa, obscuring identification of structures needed for orientation. Retraction of the telescope brings the anatomy into view. The joint is examined in a systematic manner to assess the entire articular surface of the acetabulum, including the cranial extent (Fig. 14-86), central portion (Fig. 14-87), caudal tip (Fig. 14-88), and dorsal rim (Fig. 14-89). The articular surface of the femoral head is examined with particular attention being given to the dorsal surface (see Fig. 14-87). The medial surface immediately dorsal to the fovea capitis and the dorsal margin of the articular surface are also examined. Soft tissue structures that are evaluated include the dorsal labrum of the acetabulum and dorsal joint capsule (see Fig. 14-89), round ligament (Fig. 14-90), transverse articular ligament (see Fig. 14-88), and the joint capsule of the craniocaudal and ventral compartments of the joint.

## Diseases of the Hip Diagnosed and Managed with Arthroscopy

### Hip Dysplasia

Areas of primary interest with arthroscopy of the hip in young dysplastic dogs before performing pelvic osteotomy surgery are the joint surfaces that will come into use with repositioning of the acetabular cup. These areas include the dorsal surface of the femoral head, the dorsal margin of the femoral articular surface, and the central portion of the acetabular articular surface. The cartilage wear pattern on the femoral head from subluxation is evaluated for extent, severity, and position. The typical wear pattern is on the medial aspect of the femoral head immediately dorsal to the fovea capitis and can appear as fibrillation (Fig. 14-91), partial thickness cartilage erosions (Fig. 14-92), and full thickness cartilage loss with eburnation of exposed bone (Fig. 14-93). Small lesions in this area, on the medial aspect of the femoral head, do not interfere with joint function following acetabular repositioning, but large lesions in this area (see Fig. 14-93) and similar lesions on the dorsal or dorsomedial area of the femoral head decrease the prognosis for good function following surgery. Significant osteophytes on the dorsal rim of the femoral head (Fig. 14-94) can interfere with range of joint abduction following acetabular repositioning. Changes in the acetabular articular surface secondary to hip subluxation are seen as a roughened surface (Fig. 14-95), and dorsal acetabular rim cartilage and bone loss secondary to wear from subluxation of the femoral head (Fig. 14-96). Minor loss does not preclude surgery but extensive loss decreases femoral head support after acetabular repositioning. Dorsal soft tissue damage is typical of chronic hip subluxation with joint capsule changes and avulsion of the dorsal labrum (see Fig. 14-96). The round ligament is typically partially

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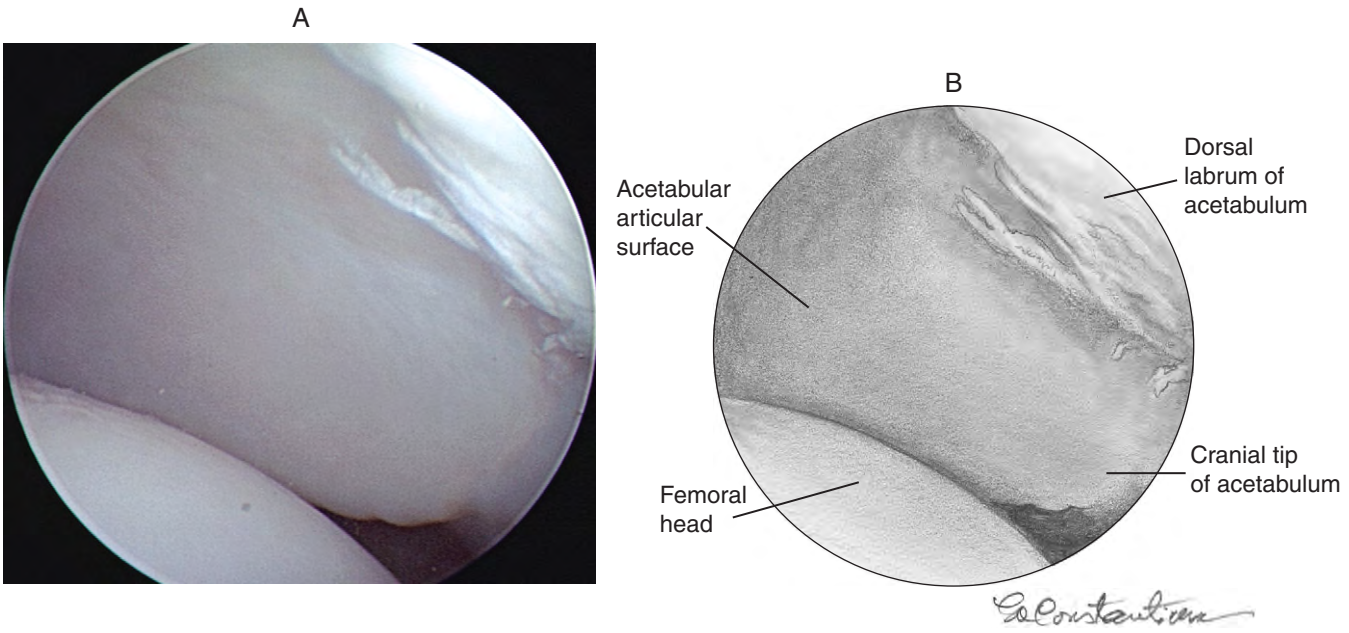



**Fig. 14–86**
The cranial aspect of the acetabular articular surface and the cranial aspect of the femoral head articular surface. The dorsal labrum, visible in the upper right margin of the image, is mildly damaged.

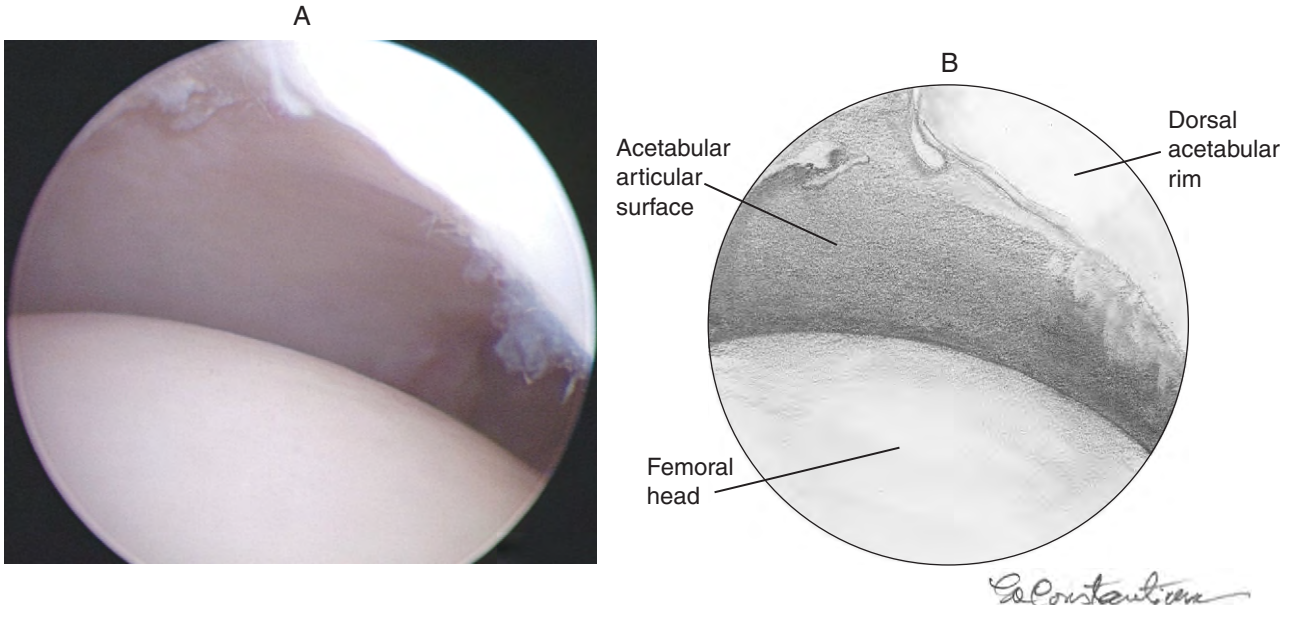



**Fig. 14–87**
The central or dorsal portion of the acetabular articular surface and the dorsal aspect of the femoral head articular surface.

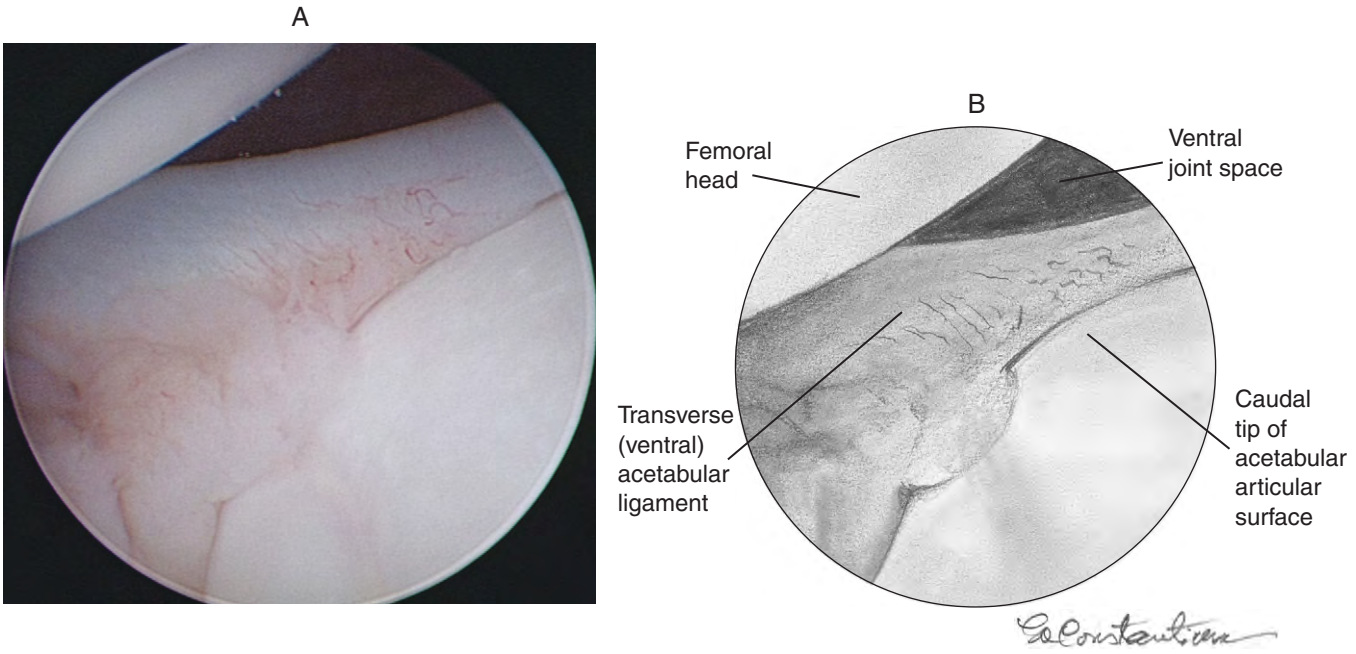



**Fig. 14–88**
The caudal tip of the acetabular articular surface, caudal aspect of the femoral head articular surface, and the caudal end of the ventral or transverse acetabular ligament.

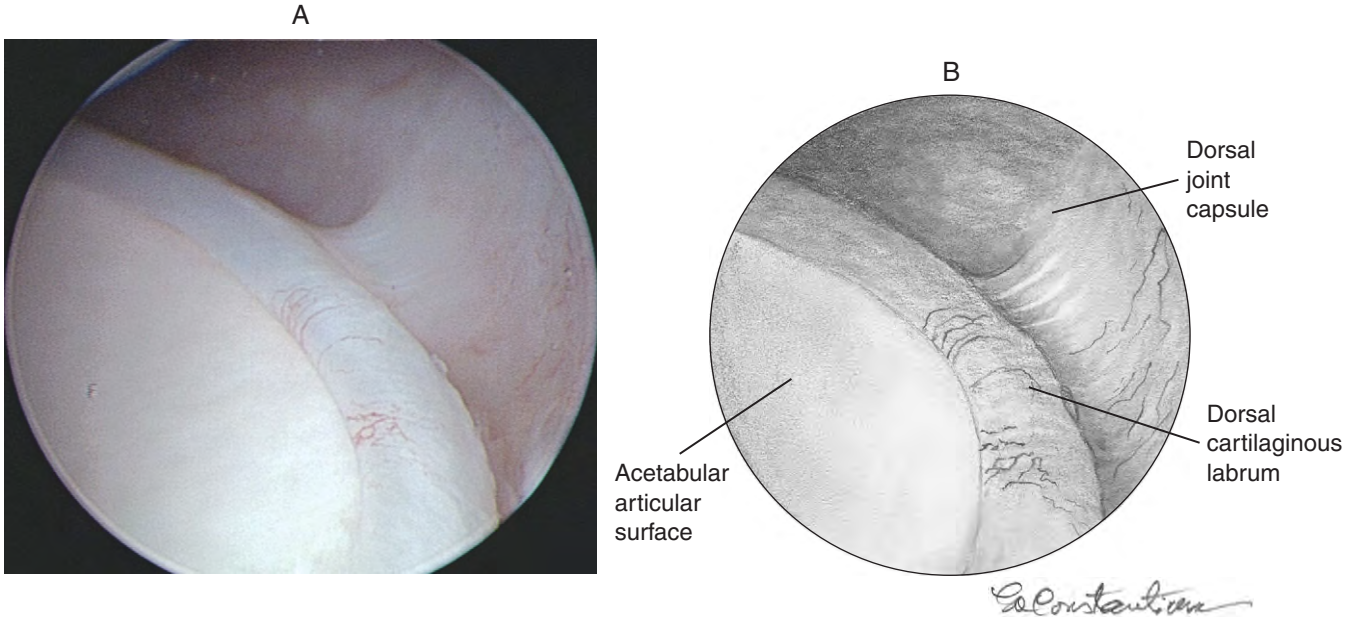



**Fig. 14–89**
The dorsal rim of the acetabular articular surface with the dorsal cartilaginous labrum.

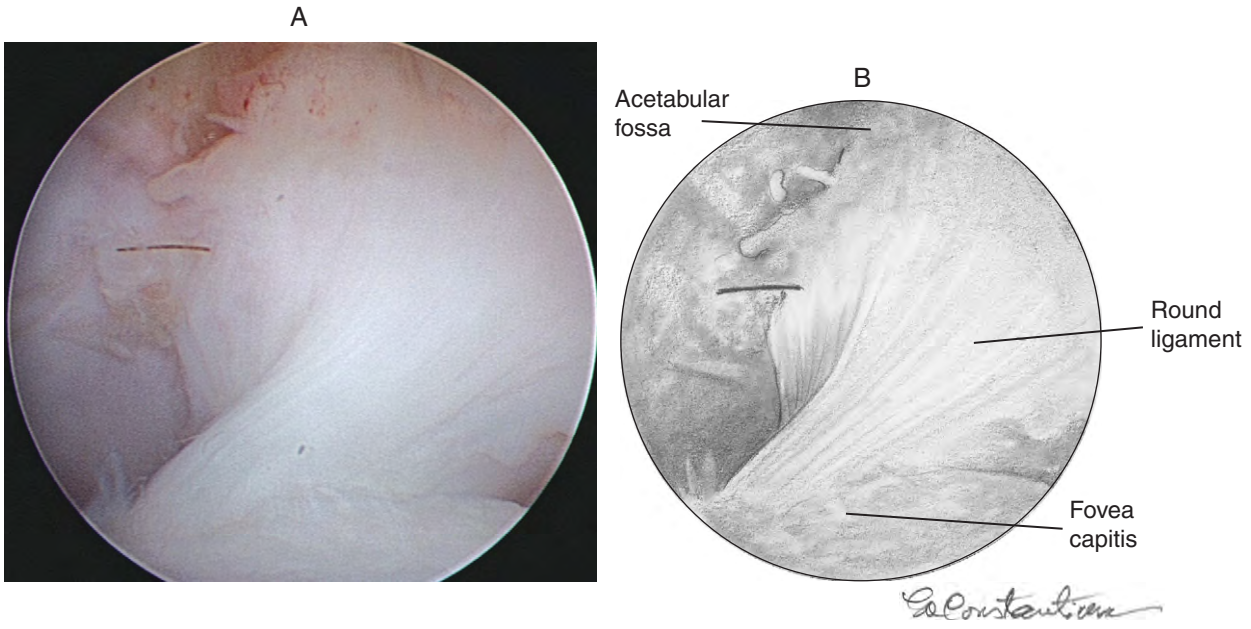



**Fig. 14–90**
The round ligament originating in the acetabular fossa and inserting on the fovea capitis of the femoral head.

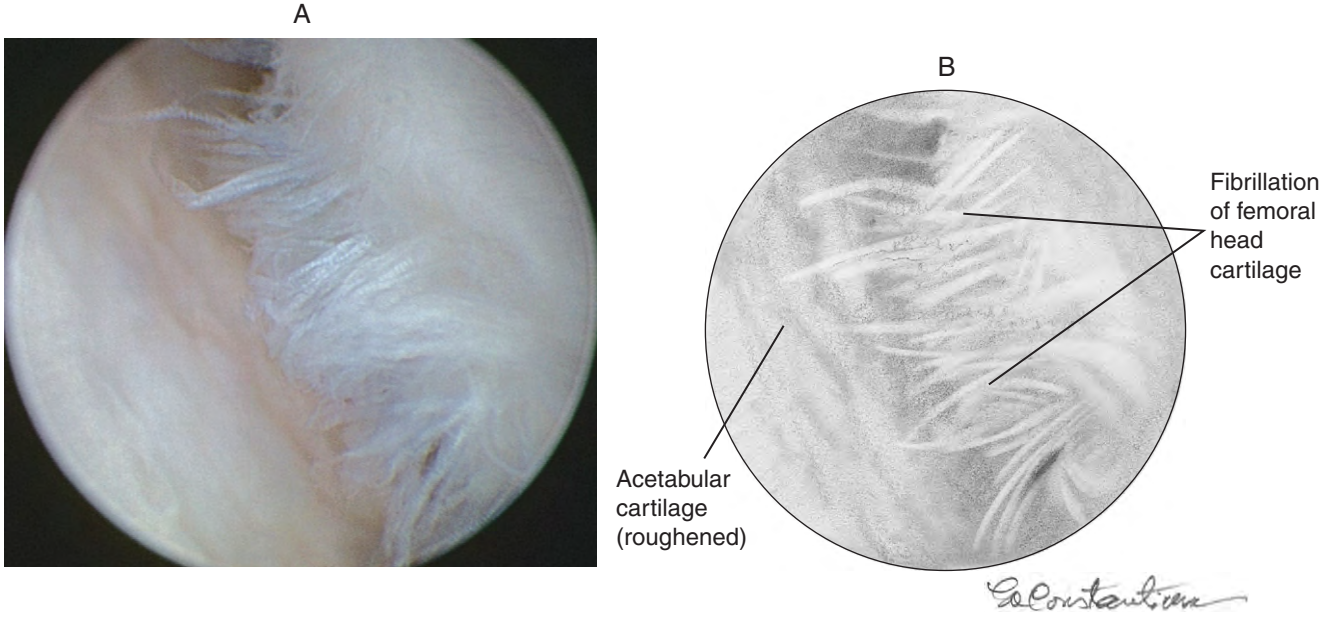



**Fig. 14–91**
Fibrillation of the medial aspect of the femoral head articular cartilage in a young dog with hip dysplasia.

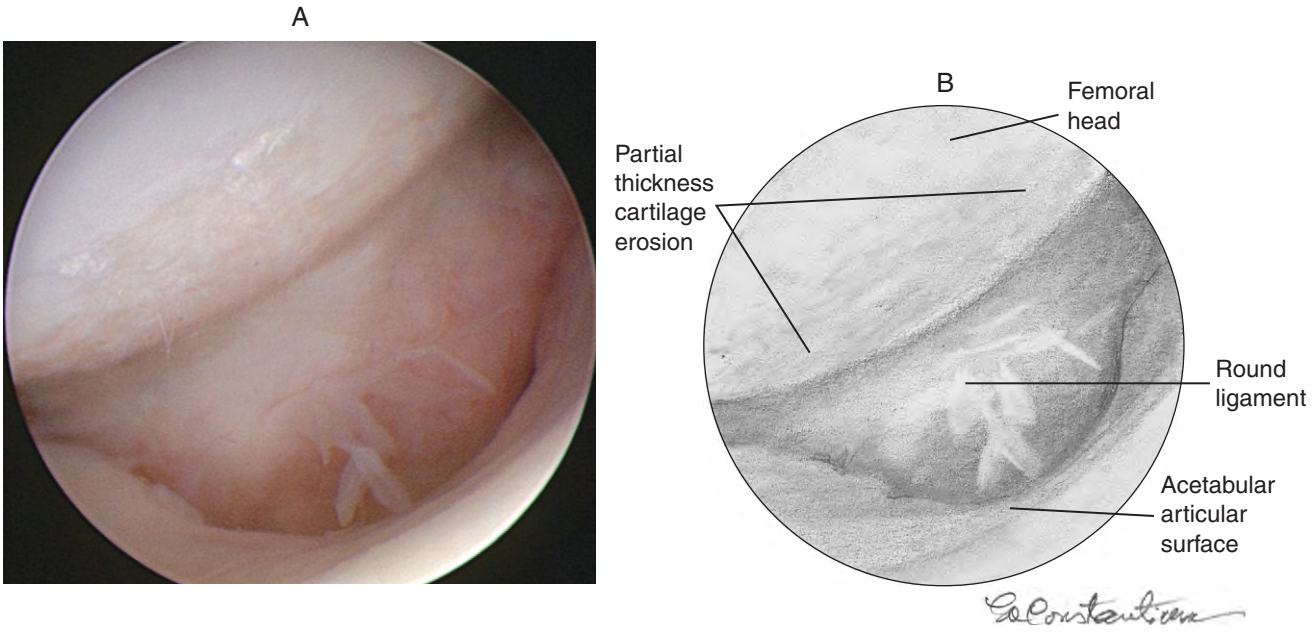



**Fig. 14-92**
A partial thickness erosion of the femoral head articular cartilage resulting from hip dysplasia.

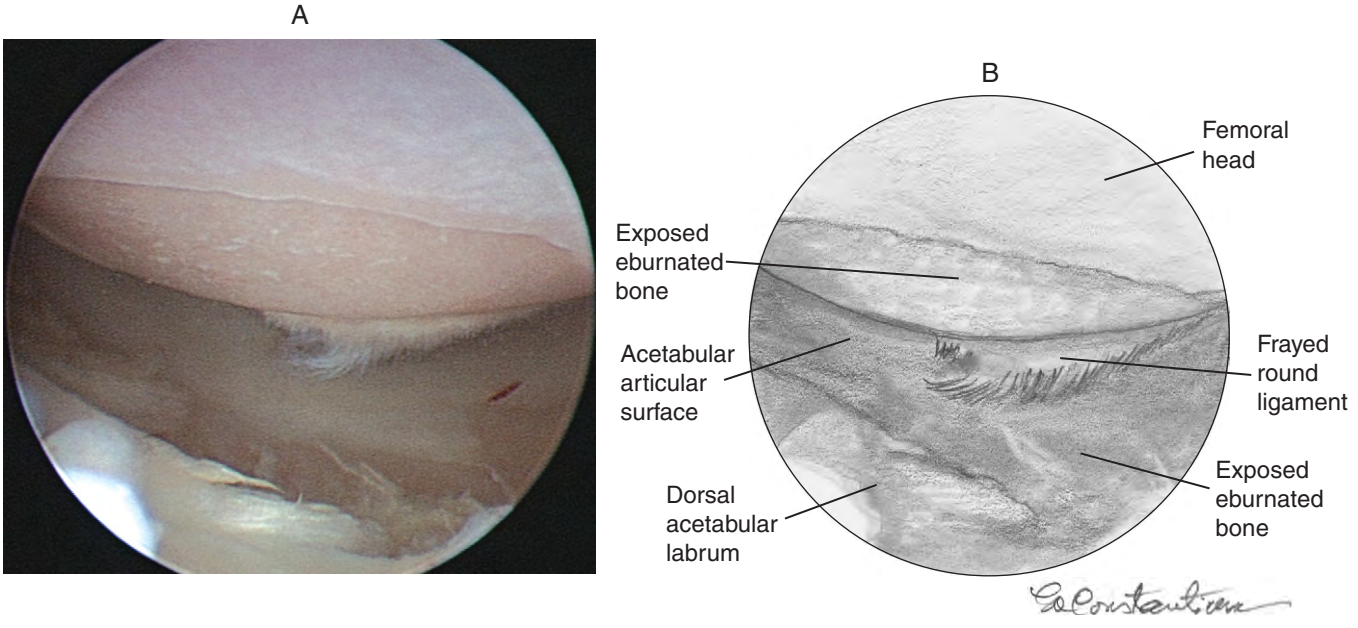



**Fig. 14-93**
A large, full thickness cartilage wear lesion on the medial aspect of the femoral head secondary to subluxation from hip dysplasia.

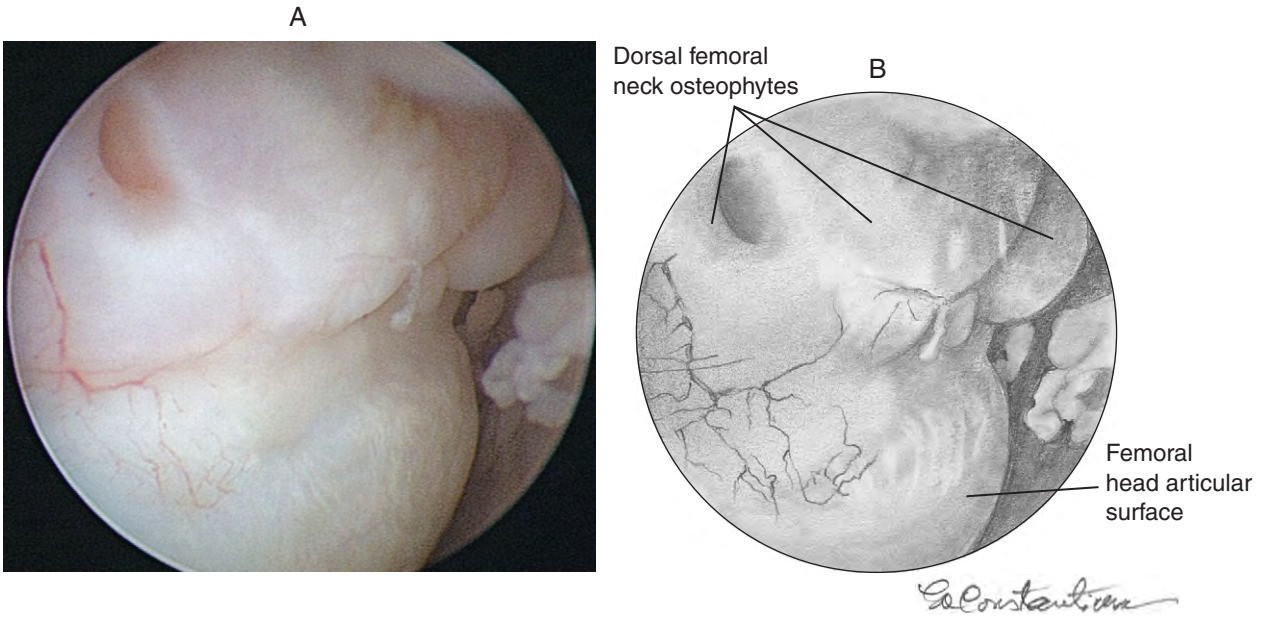



**Fig. 14–94**
A large ridge of osteophytes on the dorsal aspect of the femoral neck lateral to the margin of the articular cartilage in a dog with severe hip dysplasia.

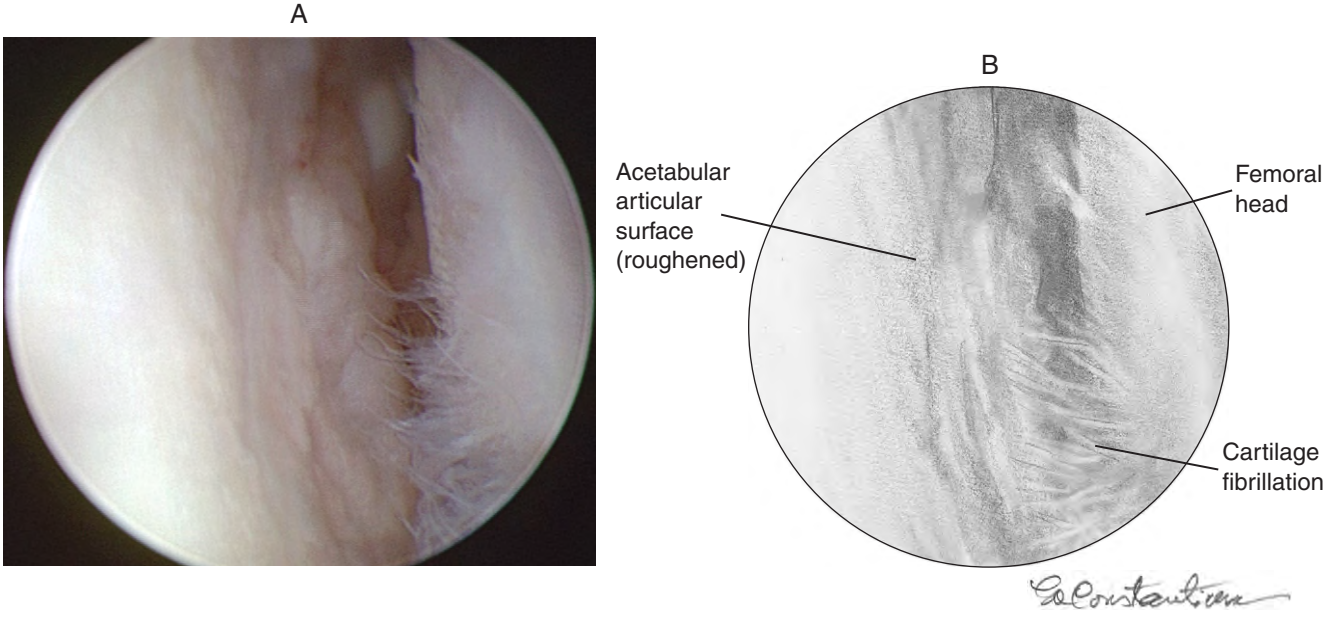



**Fig. 14–95**
Acetabular articular surface roughening and femoral head cartilage fibrillation in a young dog with hip dysplasia.

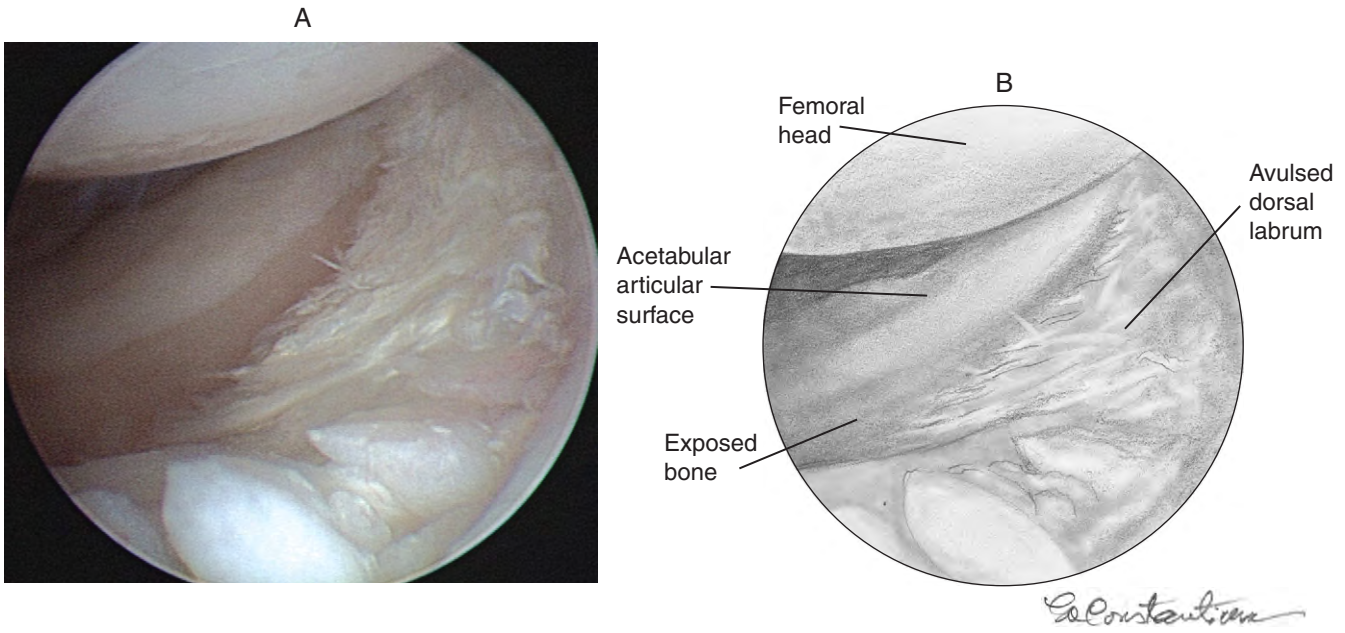



**Fig. 14-96**
Avulsion of the dorsal labrum of the acetabulum and loss of cartilage and bone from the dorsal acetabulum in a young dog with hip dysplasia.

ruptured (Fig. 14-97) or completely destroyed by the subluxation process. Villus synovial proliferation is common, osteophytes are frequently seen in the acetabular fossa, and pannus is occasionally seen. In older dogs with chronic degenerative changes from hip dysplasia, free joint bodies can be seen and are removed with arthroscopy.

### Soft Tissues Injuries of the Hip Joint

Acute soft tissue injuries can occur to the hip joint secondary to traumatic subluxation in the otherwise anatomically normal hip joint. These cases typically present as an acute onset of hind leg lameness with variable hip pain and no other orthopedic findings. These cases can present a diagnostic challenge and arthroscopy is usually required to define the injury. Findings in these cases are typically an acute tear in the dorsal joint capsule or granulation tissue filling the dorsal joint capsule injury (Fig. 14-98). With the common incidence of partial cruciate ligament injuries that cause hind leg lameness, hip arthroscopy is usually combined with stifle arthroscopy to rule out stifle involvement as the cause of the lameness.

### Arthroscopic-Assisted Intraarticular Fracture Repair

Visualization of the acetabular articular surface to assist fracture reductions facilitates acetabular fracture repair. The technique is typically performed through the open approach to the joint for fracture reduction and implant placement. The joint capsule is commonly sufficiently damaged to preclude closed arthroscopy, but additional joint capsule incision can be avoided with better visualization than can be achieved by open technique.

### Arthroscopic Biopsy of Intraarticular Neoplasia

Intraarticular neoplastic masses can be found with arthroscopy during hip exploration in cases of hind leg lameness and hip pain that do not have radiographic changes (Fig. 14-99). Arthroscopy can also be used to obtain biopsy specimens of femoral head lesions seen on radiographs and in many cases is the least traumatic approach for conducting biopsies.

### Aseptic Necrosis of the Femoral Head

The extent of femoral head pathology can be assessed with arthroscopy, even in small dogs, before performing femoral head and neck excision.

## ARTHROSCOPY OF THE STIFLE JOINT

### Indications

Arthroscopy of the stifle joint is indicated when there is hind leg lameness in the presence of stifle pain, crepitus, swelling, or thickening, with or without drawer instability, or when there is radiographic evidence of increased joint fluid, OCD lesions, degenerative changes, or intraarticular fractures. The most common condition of the stifle joint is injury to the cranial cruciate ligament, and arthroscopy is ideally suited for diagnosing and managing cruciate ligament injuries. Increased joint fluid on a

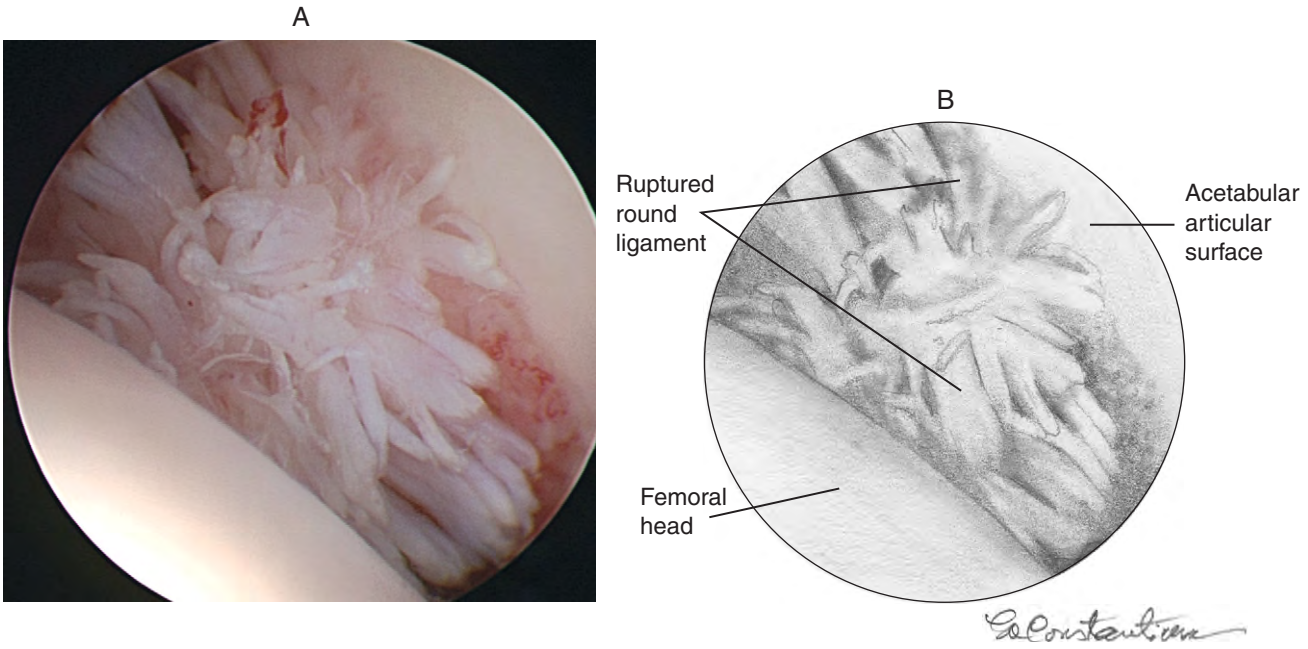



**Fig. 14–97**
Partial rupture of the round ligament with the appearance of a frayed rope.

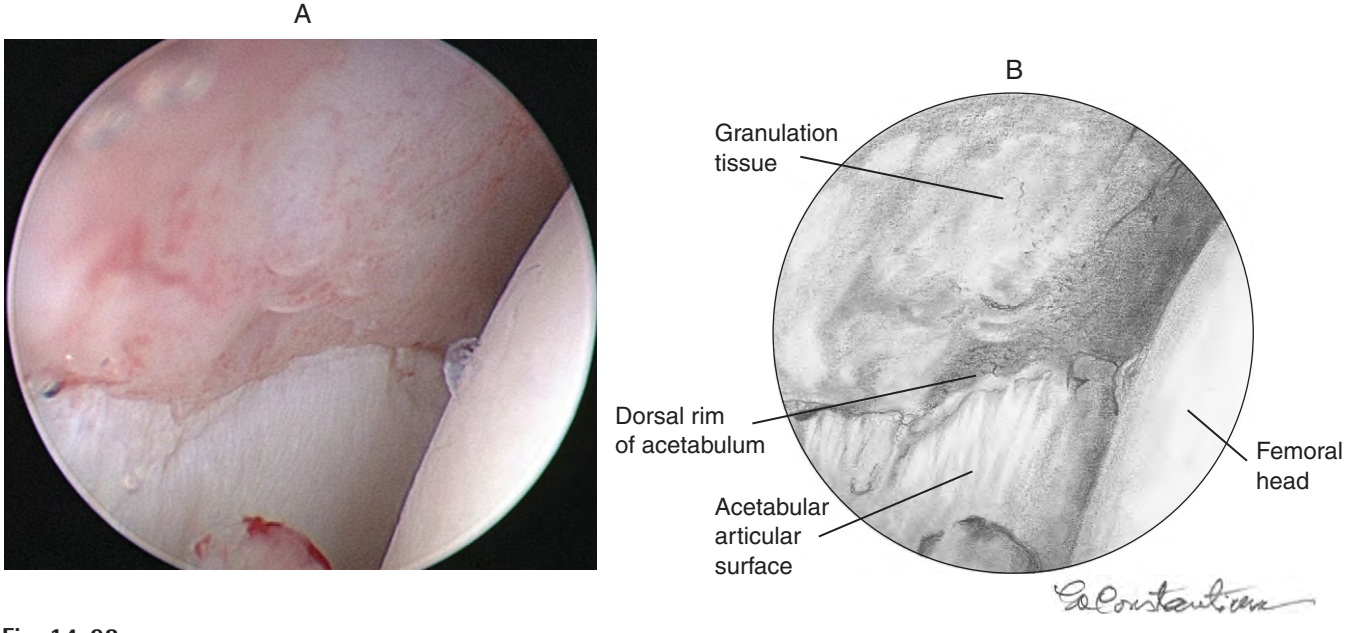



**Fig. 14–98**
Granulation tissue filling a dorsal hip joint capsule injury in a dog with lameness, hip joint pain, and normal radiographs.

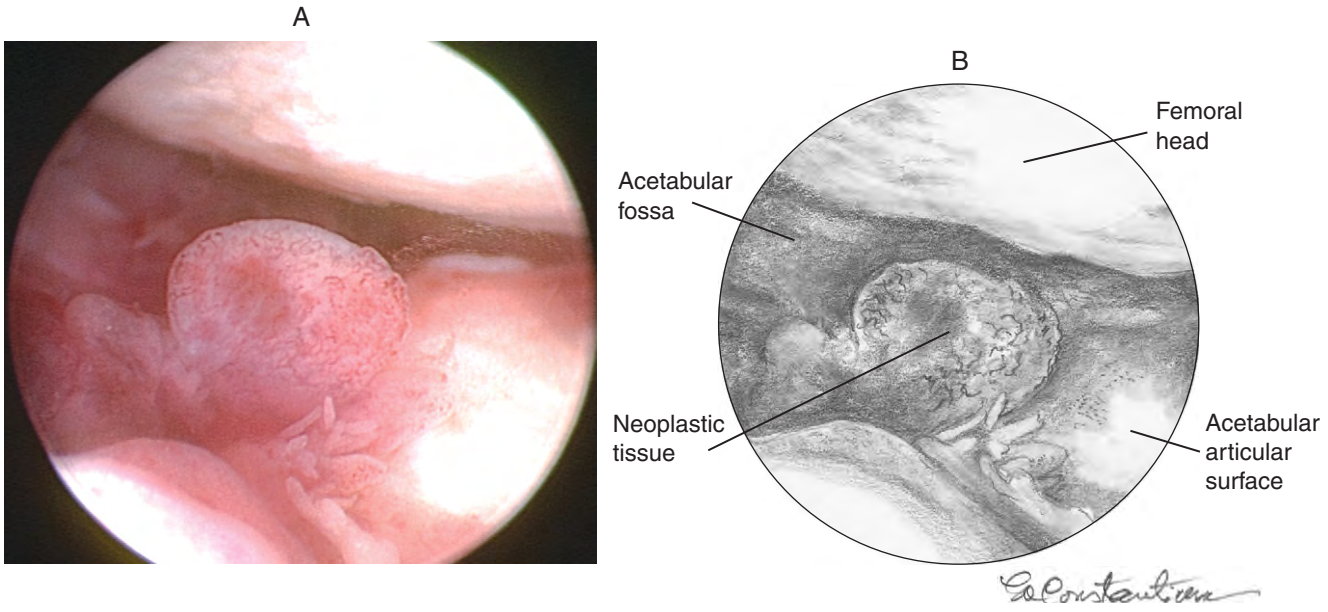



**Fig. 14–99**
Neoplastic tissue in the acetabular fossa of a dog with lameness, hip joint pain, and normal radiographs.

lateral radiograph of the stifle joint, even in the absence of any other physical or radiographic findings, is sufficient indication for stifle joint arthroscopy. A large percentage of these cases have partial tears of the cranial cruciate ligament. Drawer instability is diagnostically significant but the absence of drawer instability is not sufficient to rule out cranial cruciate ligament injury in that many dogs with hind leg lameness without drawer instability have partial tears of the cranial cruciate ligament. Cruciate ligament disease is a chronic, insidious process; true acute cranial cruciate ligament injuries are unusual in most "acute" presentations. Changes seen on physical examination, on radiographs, and with arthroscopy usually indicate chronicity of months or years of duration. Cranial cruciate ligament injuries are being seen more commonly as a bilateral condition, and assessment of the contralateral stifle is indicated in dogs undergoing evaluation, arthroscopy, and surgery for the symptomatic stifle.

Injuries to other soft tissue structures in the stifle joint are uncommon. Meniscal injuries are commonly seen with cranial cruciate ligament ruptures but are rare in the presence of normal cruciate ligaments. Damage to the caudal pole of the medial meniscus is the classic presentation of meniscal damage with bucket handle tears, cranial folding and entrapment, and crushing that is commonly described. Arthroscopy has revealed multiple types of injuries encompassing all classifications of meniscal damage and involving both the medial and lateral menisci. Injuries to the caudal cruciate ligament are uncommon and are difficult to differentiate from cranial cruciate ligament injuries without arthroscopy or open exploration of the joint. The frequency of caudal cruciate ligament injury diagnosis is also decreasing with improved arthroscopic technique, allowing earlier diagnosis of minimally damaged cranial cruciate ligament injuries and the recognition of variations in normal surface appearance of the caudal cruciate ligament. Long digital tendon ruptures and avulsions are also seen as a source of lameness originating from the stifle joint, but these are uncommon.

Specific radiographic changes allowing diagnosis of OCD, patellar luxation, intraarticular fractures, and periarticular or intraarticular neoplasia can provide a definitive diagnosis before arthroscopy. Radiographic changes indicating DJD are nonspecific but statistically are more commonly associated with cranial cruciate ligament injuries than with any other diagnosis. Definitive diagnosis based on radiographs is not possible or necessary, but these changes are an indication for arthroscopy. MRI or CT may be beneficial in some cases but do not provide as much information as can be achieved with arthroscopy.

In cases referred to my practice, cranial cruciate ligament injuries constitute the most undiagnosed and underdiagnosed disease seen, and corrective cruciate ligament surgery is the most common procedure performed. Arthroscopy makes possible the earlier diagnosis of more subtle cruciate ligament injuries, sometimes because clients are more willing to allow arthroscopy to confirm

a diagnosis than they are to allow open surgery, so joint examination can be performed at an earlier time before the condition progresses and chronic changes can be seen with less sophisticated techniques. Application of the information gained with arthroscopy to evaluation of history, physical findings, and radiographs has improved interpretation of findings, allowing suspicion of cruciate ligament injuries with more subtle changes. The most important conclusion from this process is that increased joint fluid (or soft tissue swelling or displacement of the fat pad) on a lateral radiograph of the stifle is the earliest consistent indication of cruciate ligament injury with greater than 90% correlation. This is consistently seen before bony changes on radiographs, before palpable joint thickening, before medial buttress formation, without detectable drawer instability, and when there is no pain response to joint manipulation.

Stifle arthroscopy was initially used as a diagnostic technique but currently is the mainstay of stifle surgery, and the intraarticular portion of all cruciate ligament surgeries are performed with arthroscopy. The ends of completely ruptured cranial cruciate ligaments are removed or the damaged portion of partial tears are debrided with arthroscopy. Arthroscopy is used to release the medial meniscus by transection of the caudal meniscotibial ligament or by radial meniscotomy. Any meniscal injuries are addressed with partial meniscectomy under arthroscopic guidance. After completion of arthroscopic management of the intraarticular structures, a tibial plateau leveling osteotomy (TPLO) is performed as an open procedure without arthrotomy and with open exposure limited to the proximal tibia. This approach improves intraarticular assessment of the joint, improves joint debridement, and decreases postoperative pain. Arthroscopic stifle debridement can also be performed as the sole treatment for complete cruciate ligament ruptures. The remnants of the cranial cruciate ligament are removed, the caudal pole of the medial meniscus is released, and the joint is left unstable. This approach is only applied with complete ruptures of the cranial cruciate ligament and is primarily indicated in geriatric patients in which the 6-month recovery from a TPLO is a major portion of the animal's remaining life expectancy or when owners cannot enforce the postoperative activity restriction required for a TPLO or other cruciate repair procedures.

## Patient Preparation, Positioning, and Operating Room Setup

Because cranial cruciate ligament injuries are the most common finding in the stifle joint, the patient is typically positioned with the leg suspended, prepared, and draped for the surgeon's preferred cruciate ligament surgery. If there is a specific preoperative diagnosis other than cruciate ligament disease, then this protocol does not need to be followed. For unilateral stifle arthroscopy, the patient is placed in either lateral or dorsal recumbency, although dorsal recumbency with the leg extended caudally provides more flexibility for manipulation needed to perform a complete arthroscopic examination of the stifle. If the patient is placed in dorsal recumbency, the monitor is placed lateral and cranial to the joint being evaluated, the surgeon stands at the foot of the table at the distal end of the limb, and the assistant stands lateral to the joint being evaluated. If the patient is placed in lateral recumbency, the monitor is placed dorsal to the patient, the surgeon stands ventral to the patient at the distal end of the leg being evaluated, and the assistant stands at the foot of the table. Stifle arthroscopy is most commonly performed as a unilateral procedure but bilateral stifle arthroscopy can be performed and is indicated for bilateral OCD and for bilateral complete cranial cruciate ligament ruptures when arthroscopic stifle debridement is performed without a stabilization procedure. Bilateral stifle arthroscopy is performed with the patient in dorsal recumbency with the monitor, surgeon, and assistant positioned as for unilateral stifle arthroscopy

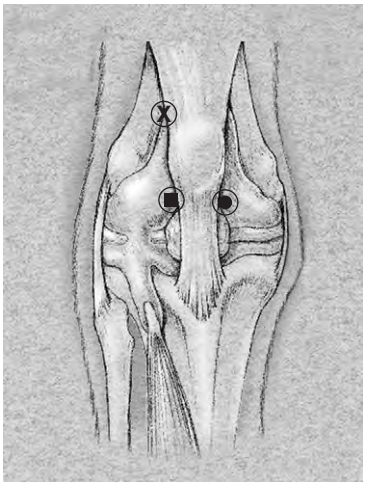
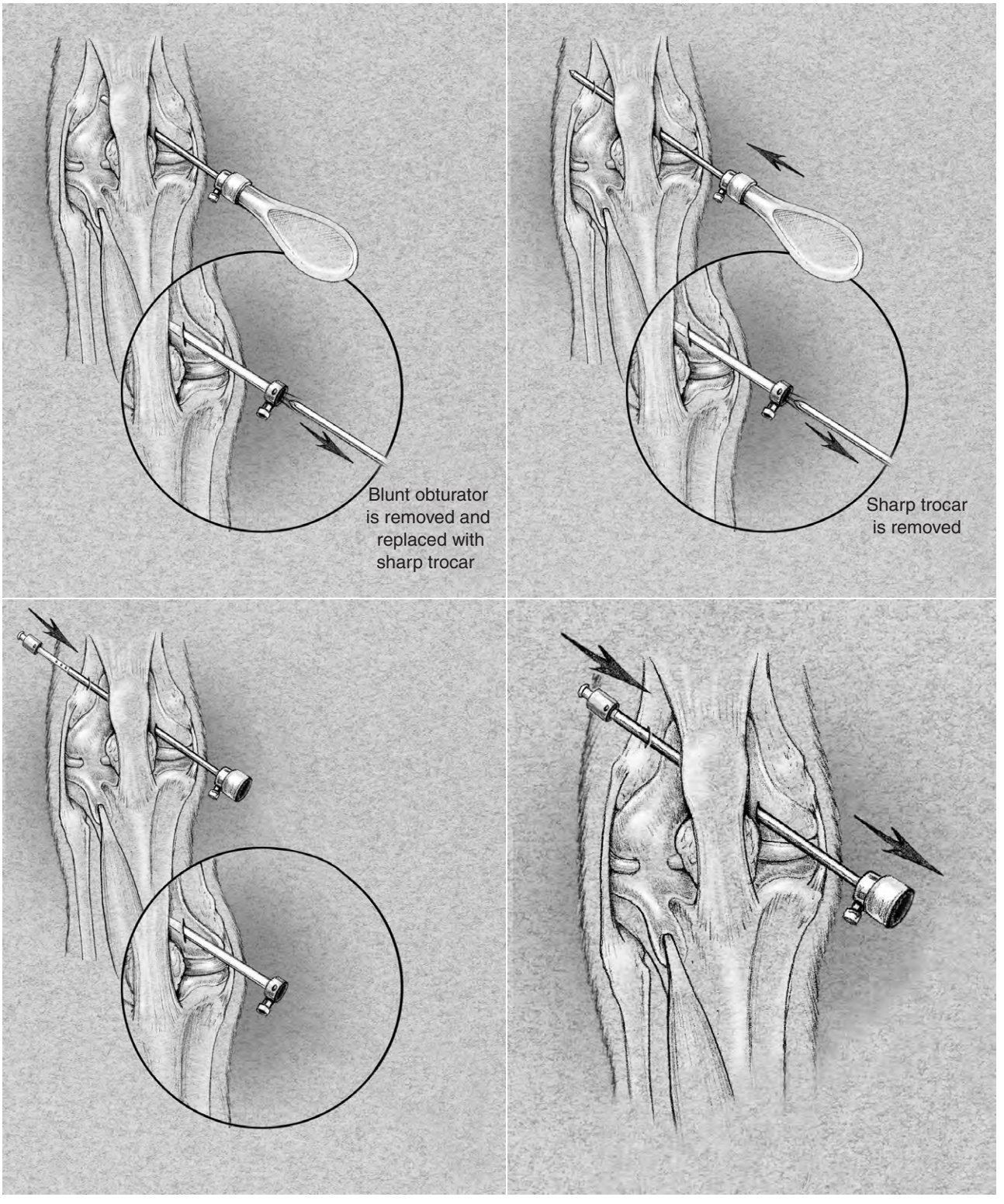


**Fig. 14–100**
Portal sites on the cranial aspect of the stifle joint. The three portals shown are the craniomedial telescope portal (*circle*), the craniolateral operative portal (*square*), and the suprapatellar egress portal (*X*). The telescope portal is placed halfway between the distal end of the patella and the proximal extent of the tibial crest just medial to the patellar tendon. The operative portal is placed at the same level and just lateral to the patellar tendon. The egress portal is placed in the lateral aspect of the suprapatellar pouch of the joint. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*


A
Blunt obturator is removed and replaced with sharp trocar
B
Sharp trocar is removed
C
D

with the patient in dorsal recumbency. Bilateral procedures are well tolerated by the patient.

## Portal Sites and Portal Placement

### Telescope Portals

Standard telescope portals for the stifle joint are on the cranial aspect of the joint, either medial or lateral to the patellar tendon, and can be placed anywhere between the distal end of the patella and the tibial plateau. My preference for diagnostic joint examination and for operative procedures involving the cranial cruciate ligament, menisci, and femoral OCD lesions is medial to the patellar tendon and halfway between the distal end of the patella and the tibial crest (Fig. 14-100). This puts the portal at the top of the fat pad and greatly facilitates examination of the joint. Another commonly used telescope portal is placed lateral to the insertion of the patellar tendon just above the tibial plateau between the tendon and "Gerdy's" tubercle.[8] This location is reported to provide superior visualization of the menisci and facilitate operative procedures. The disadvantage of this portal site is that the telescope is placed into the fat pad and part of the fat pad must be removed to allow examination of the joint. The telescope portal can also be placed immediately distal to the patella. This site keeps the telescope away from the fat pad and facilitates examination of the cranial compartment of the joint, including the cruciate ligaments, but access to the menisci is limited. To place the telescope portal, a 20-gauge, 1-inch needle is placed into the joint at the operative portal site (see Fig. 14-9), joint fluid is aspirated, the joint is distended with saline, a stab incision is made into the joint with a number 10 scalpel blade at the telescope portal site, and the telescope cannula with the blunt obturator is inserted into the joint (see Fig. 14-10) directed caudally initially and then proximally into the lateral aspect of the suprapatellar pouch (Fig. 14-101, *A*). The telescope portal can also be placed lateral to the patellar tendon at any of these levels.

### Operative Portals

The operative portal is placed on the side of the patellar tendon not used for the telescope portal and typically at the same level as the telescope portal (see Fig. 14-100). The technique for placing the operative portal using visualization of a needle inside the joint with the telescope may or may not be effective in the stifle joint because the extensive villus proliferation of the synovium that occurs with cruciate ligament injuries obscures visualization. To place the operative portal, a stab incision is made into the joint at the portal site with a number 10 scalpel blade. A curved mosquito hemostat or the initial operative instrument is worked into the joint with blunt dissection until it is visualized with the telescope.

### Egress Portal

An egress cannula is routinely used for both diagnostic and operative stifle arthroscopy. Minor diagnostic procedures can be performed without an egress cannula, but with the extent of villus reaction seen with cruciate ligament injuries and with the need for its removal to allow adequate joint examination, effective egress is needed. The suprapatellar pouch is the most practical site for an egress portal in stifle joint arthroscopy (see Fig. 14-100). This location is out of the way of diagnostic examination and operative procedures, and it is easier to maintain a cannula at this site during operative procedures. The egress portal is placed with the telescope cannula. The tip of the telescope cannula is positioned in the lateral aspect of the suprapatellar pouch and the blunt obturator is removed (see Fig. 14-101, *A*). The blunt obturator is replaced with the sharp trocar, and the sharp trocar with the cannula is pushed out through the joint capsule and skin (see Fig. 14-101, *B*). The sharp trocar is removed and the egress cannula is inserted into the tip of the telescope cannula (see Fig. 14-101, *C*). The telescope cannula is retracted back into the joint with the egress cannula (see Fig. 14-101, *D*); inside the joint, the egress cannula is backed out of the telescope cannula until the two cannulae are separated. The egress cannula is positioned in

**Fig. 14–101**

A, The telescope cannula is inserted at the medial portal site using the blunt obturator and the tip is placed into the lateral aspect of the proximal extent of the suprapatellar pouch. The blunt obturator is then removed. B, The sharp trocar is inserted into the telescope cannula and locked in place. The trocar and cannula are pushed out through the joint capsule of the suprapatellar pouch and through the skin. The sharp trocar is removed. C, The egress cannula is inserted into the tip of the telescope cannula. D, The tip of the telescope cannula is retracted back into the joint with the egress cannula, and inside the joint the egress cannula is backed out of the telescope cannula until they are separated. The egress cannula is positioned in the lateral joint. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

the lateral joint space and then is inserted as far as possible. This is a fast, easy, and trouble-free method of egress cannula placement.

When the egress cannula does not fit within the telescope cannula, a similar technique for egress cannula placement uses an exchange rod or a switching stick. The tip of the telescope cannula is positioned in the lateral aspect of the suprapatellar pouch and is pushed out through the skin as before. A switching stick is placed into the distal end of the telescope cannula, the telescope cannula is retracted back into the joint, and the egress cannula is inserted over the switching stick. The egress cannula is positioned in the lateral joint space and is inserted as far as possible. This is also a fast, easy, and trouble-free method of egress cannula placement.

## Examination Protocol and Normal Arthroscopic Anatomy

The stifle joint is the most difficult of all the joints to examine effectively. This difficulty is due to the complex anatomy of the stifle, the presence of the fat pad in the cranial compartment of the joint, and the extensive villus synovial reaction that occurs with cruciate ligament injuries, which is the most common indication for stifle examination. Stifle joint examination is facilitated by using a consistent, systematic approach to visualizing the joint, having adequate fluid pressure and flow, and using radiofrequency or a power shaver to remove part of the fat pad and villus synovial tissue to improve the visual field.

Examination of the stifle is begun with the tip of the telescope in the suprapatellar pouch. The telescope is retracted distally until the suprapatellar joint space can be visualized and fluid egress is closed to distend the joint for identification of the joint capsule, plica of the suprapatellar pouch, quadriceps tendon, caudal articular surface of the proximal end of the patella, and the proximal articular surface of the trochlear groove (Figs. 14-102 and 14-103). Once orientation is achieved, continued retraction of the telescope allows visualization of the caudal articular surface of the patella, the cartilage of the trochlear groove, and the medial and lateral trochlear ridges (Fig. 14-104). The telescope is directed into both the medial and lateral compartments for evaluation of the abaxial surfaces of the trochlear ridges and the joint capsule (Fig. 14-105). These areas are examined with the joint in extension. As the tip of the telescope moves distally around the cranial aspect of the femoral condyle, either medial or lateral, the joint is flexed. The fat pad is encountered during this portion of the examination and in normal joints can be swept out of the visual field with the tip of the telescope, allowing visualization of the cranial surface of the femoral condyles and the abaxial margin of the medial or lateral meniscus, depending on orientation of the telescope. The visual field is commonly lost during this maneuver. If the visual field is lost, the telescope is repositioned in the medial or lateral joint

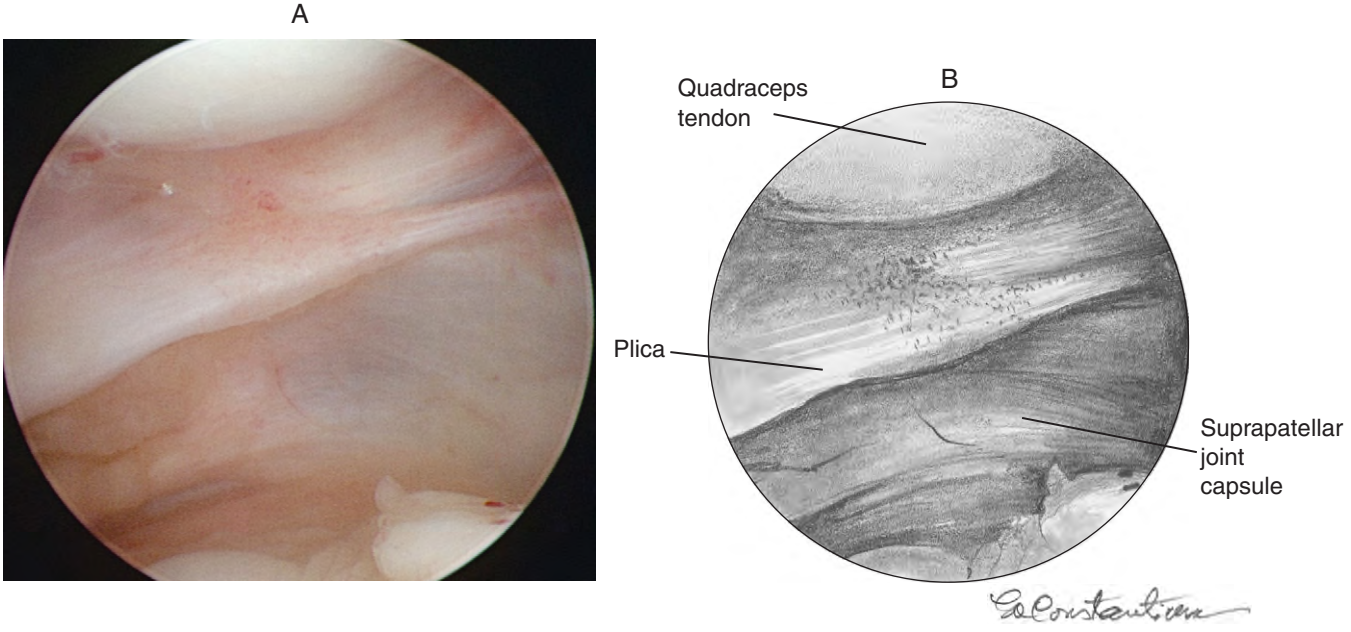



**Fig. 14–102**
Orientation in the stifle joint with the tip of the telescope in the suprapatellar pouch with visualization of the joint capsule, plica, and caudal surface of the quadriceps tendon.

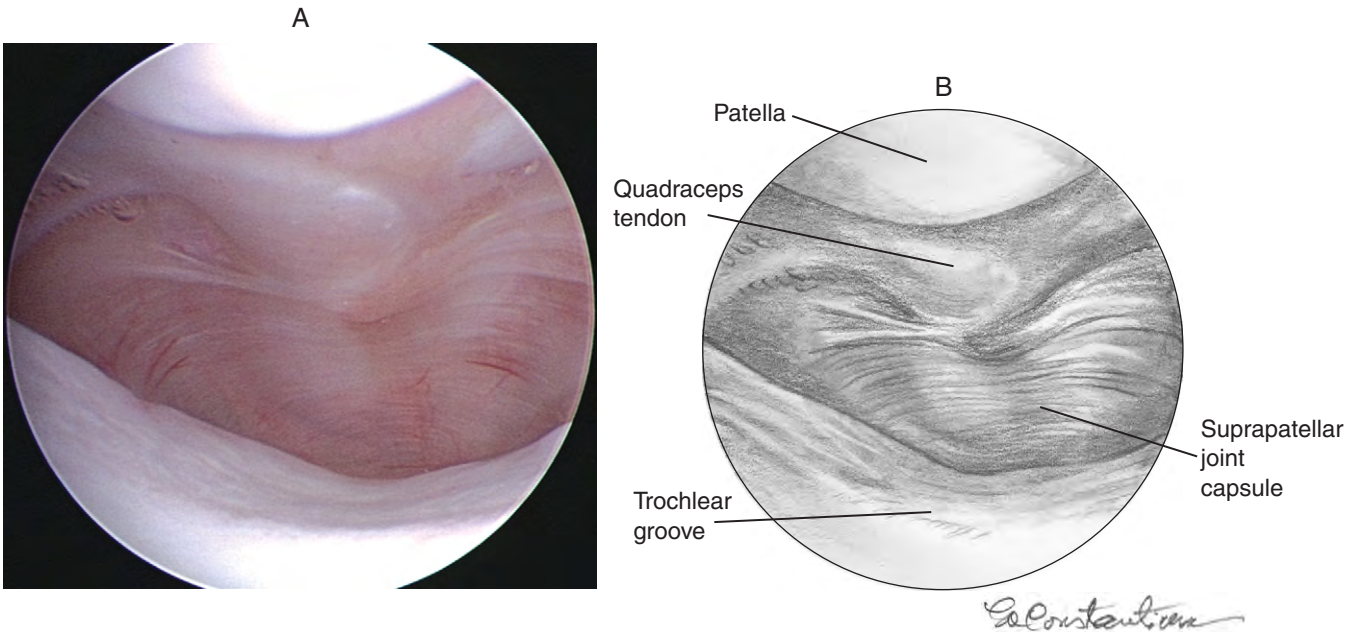



**Fig. 14–103**
Orientation in the stifle joint with the tip of the telescope in the proximal trochlear groove with visualization of the suprapatellar pouch, quadriceps tendon, proximal patella, and proximal trochlear groove.

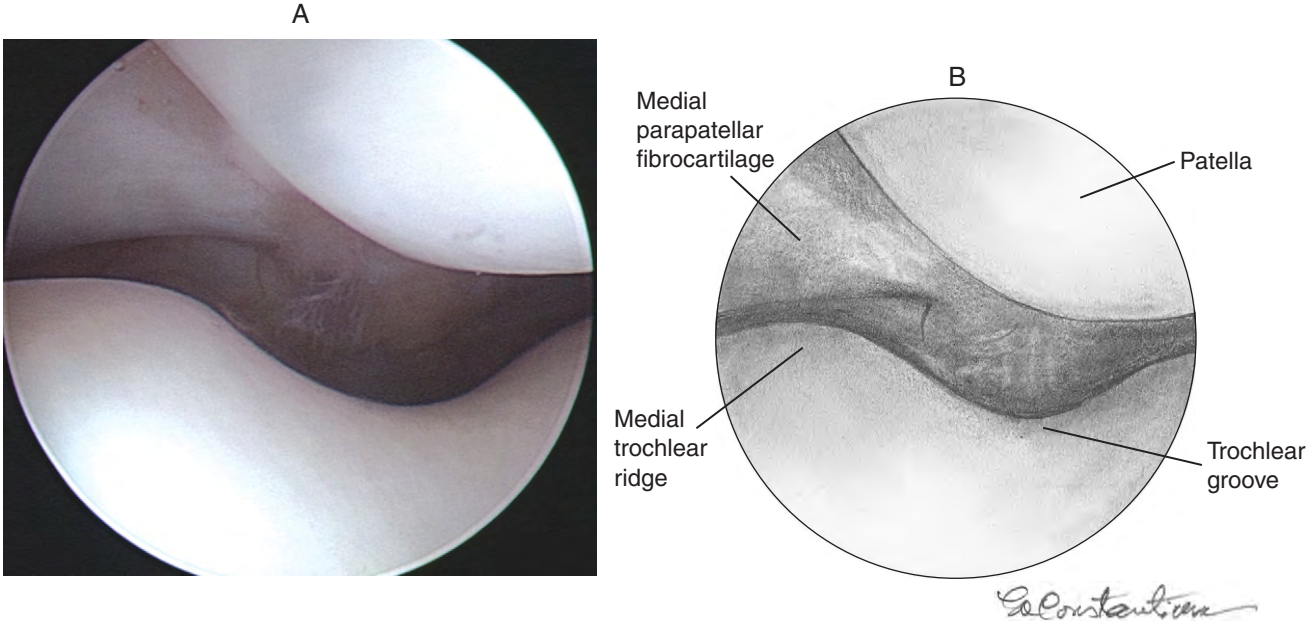



**Fig. 14–104**
The trochlear groove, caudal articular surface of the patella, medial trochlear ridge, and medial parapatellar fibrocartilage.

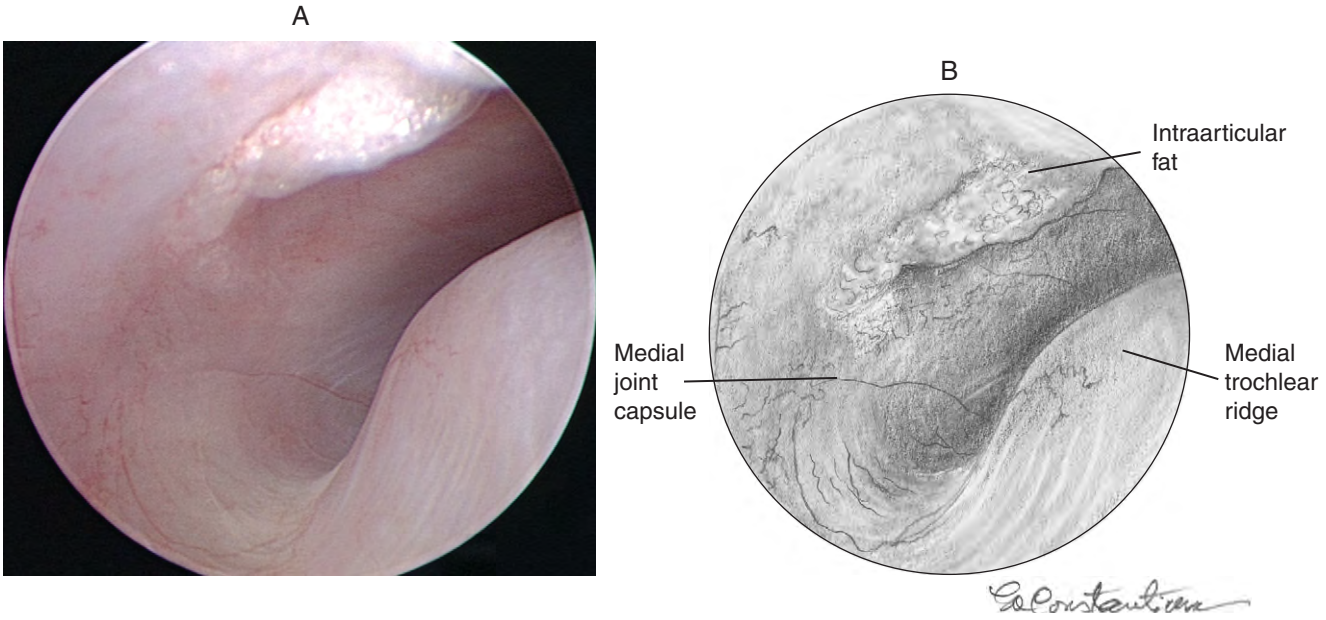



**Fig. 14–105**
Medial joint space and medial aspect of the medial trochlear ridge.

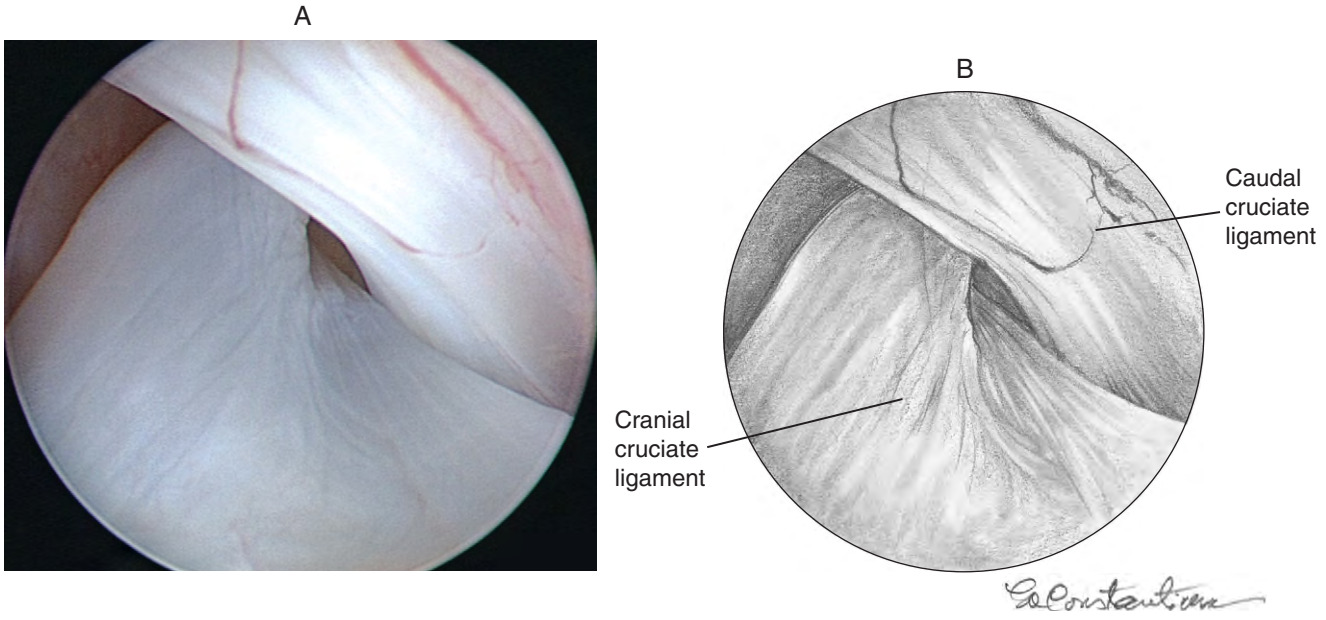



**Fig. 14–106**
Normal cranial and caudal cruciate ligaments. Note that the strands of the normal ligaments are straight and tight.

space and the maneuver is repeated. This procedure is repeated for both the medial and lateral condyles and menisci. The telescope is positioned in the intercondylar fossa for evaluation of the cranial and caudal cruciate ligaments (Fig. 14-106). Visualization of the medial meniscus is achieved by external rotation of the tibia with valgus stress to the stifle to open the medial joint space. The axial margin (Fig. 14-107), caudal pole (Fig. 14-108), and caudal meniscotibial ligament (Fig. 14-109) are visualized, and the integrity of the body of the medial meniscus is assessed. The lateral meniscus is exposed by varus stress, with or without internal rotation, to the stifle for examination of axial margin (Fig. 14-110), caudal pole (Fig. 14-111), the caudal meniscofemoral ligament, and

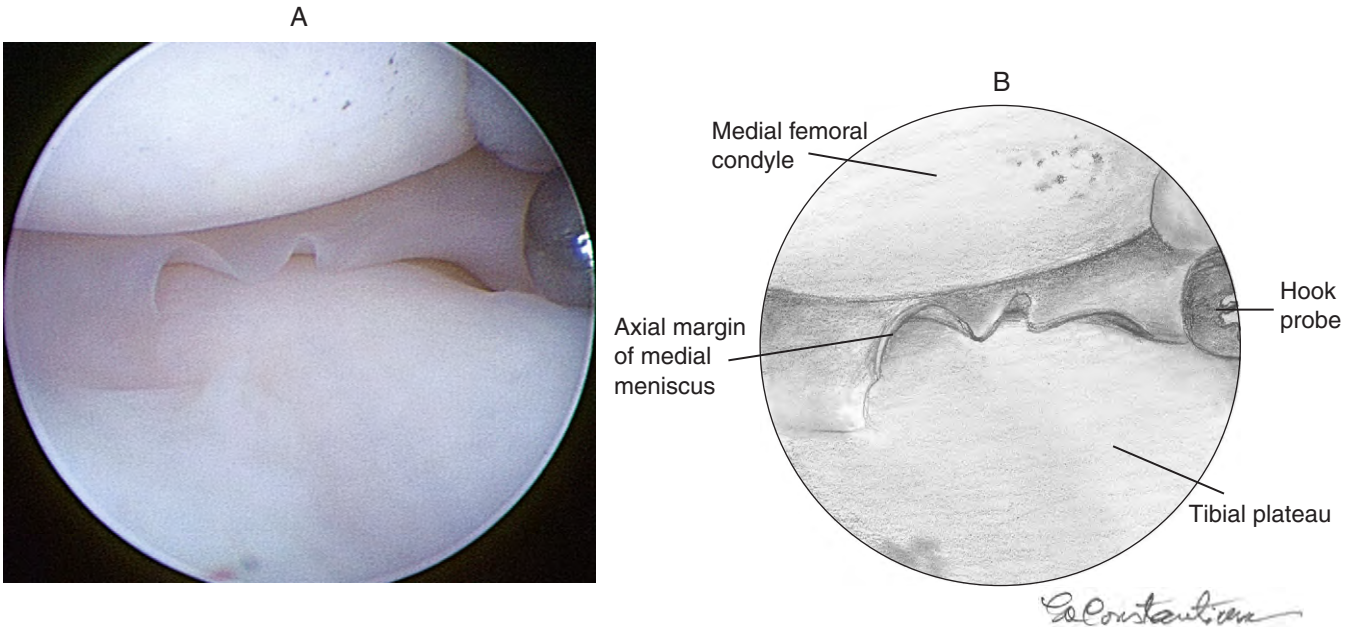



**Fig. 14–107**
The axial margin of a normal medial meniscus. The undulations in the free margin are normal and are positional artifacts commonly called *flounce*.

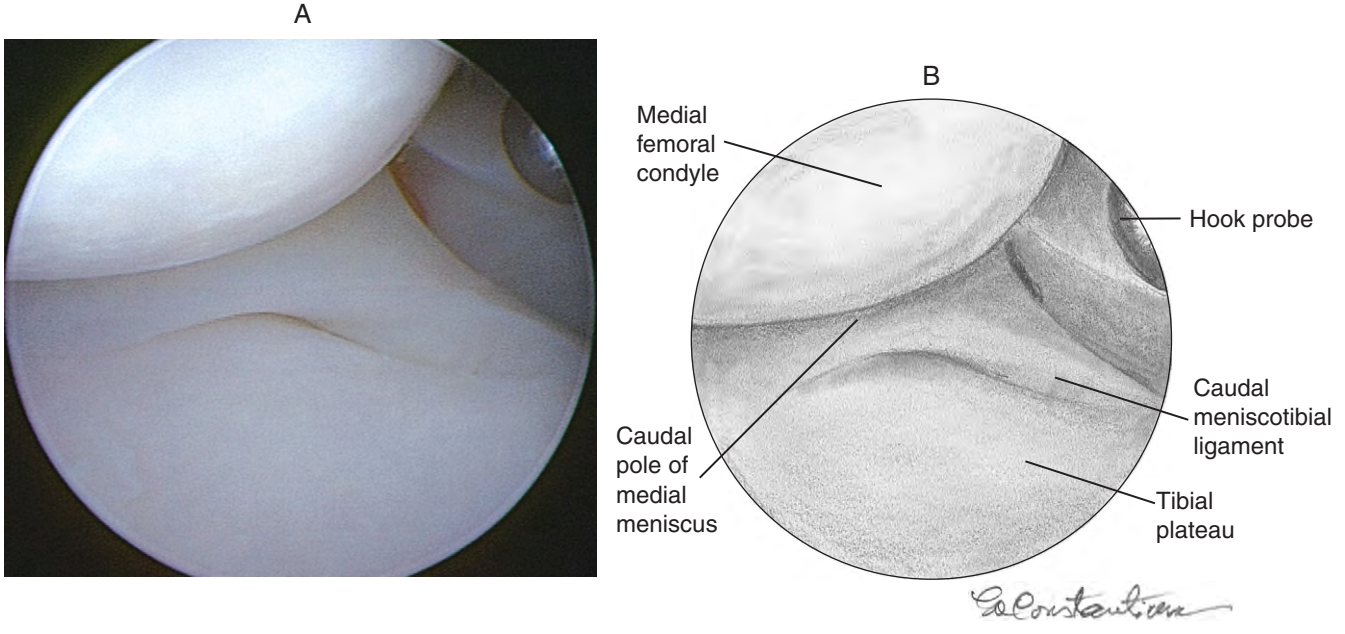



**Fig. 14–108**
The caudal pole of the medial meniscus.

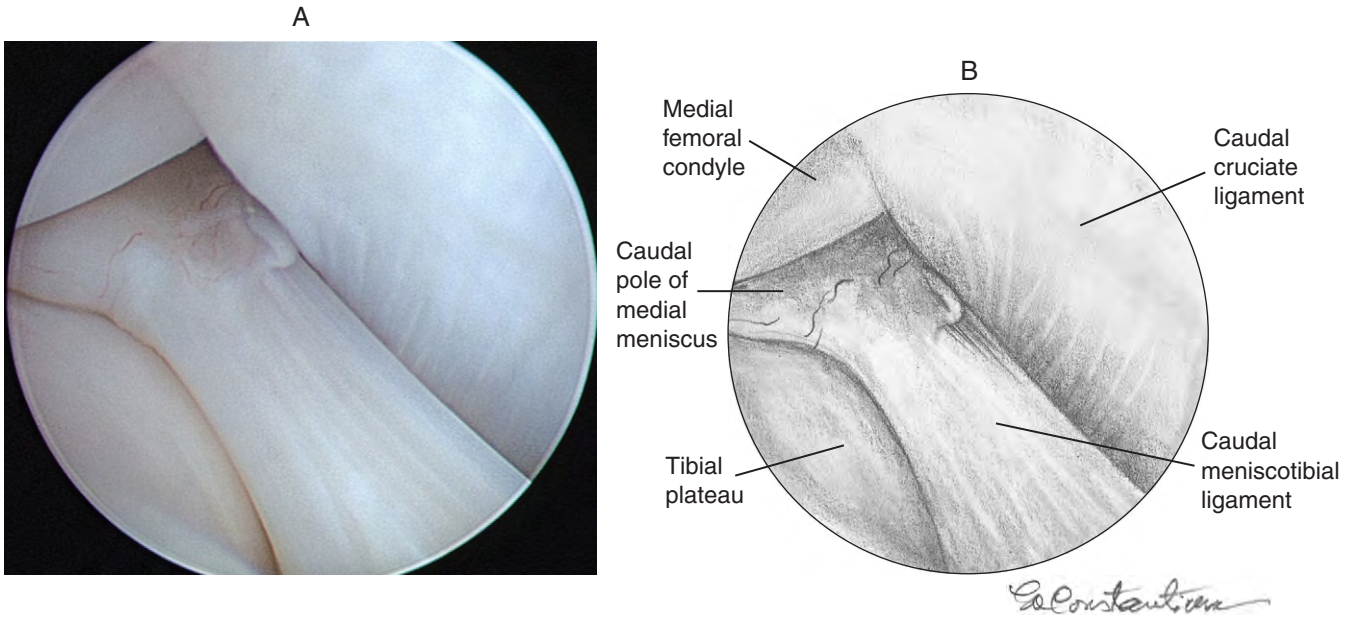



**Fig. 14–109**
The caudal meniscotibial ligament of the medial meniscus.

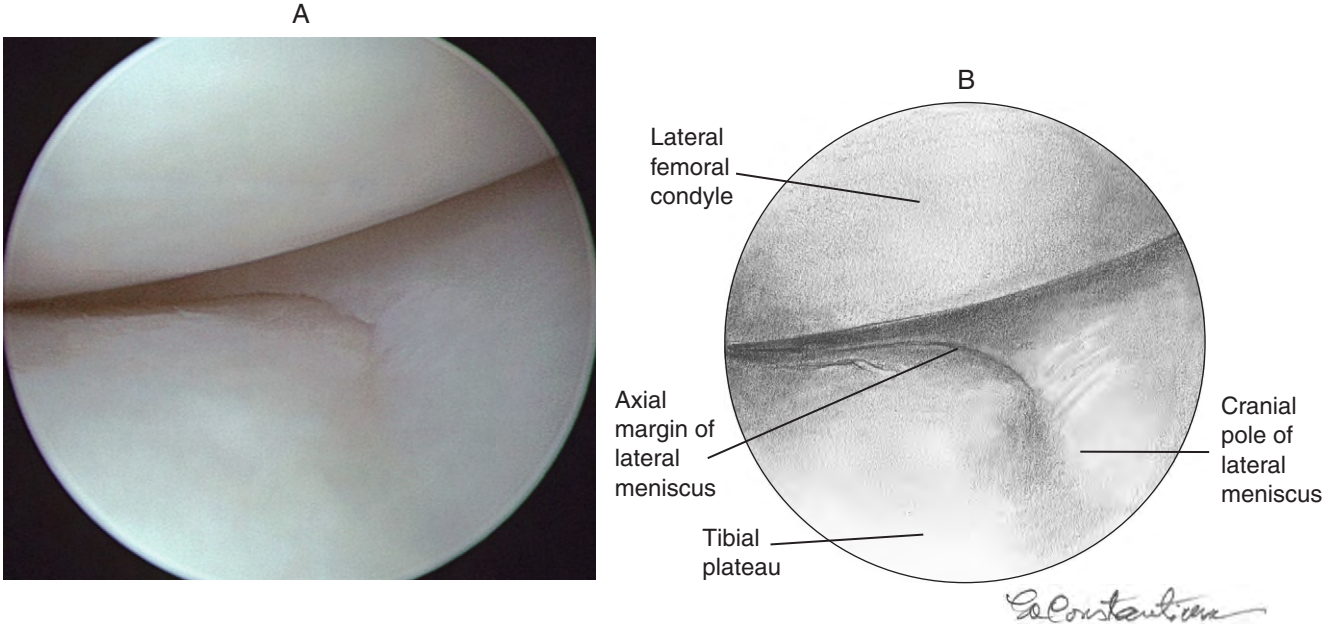



**Fig. 14–110**
The cranial pole of the lateral meniscus.

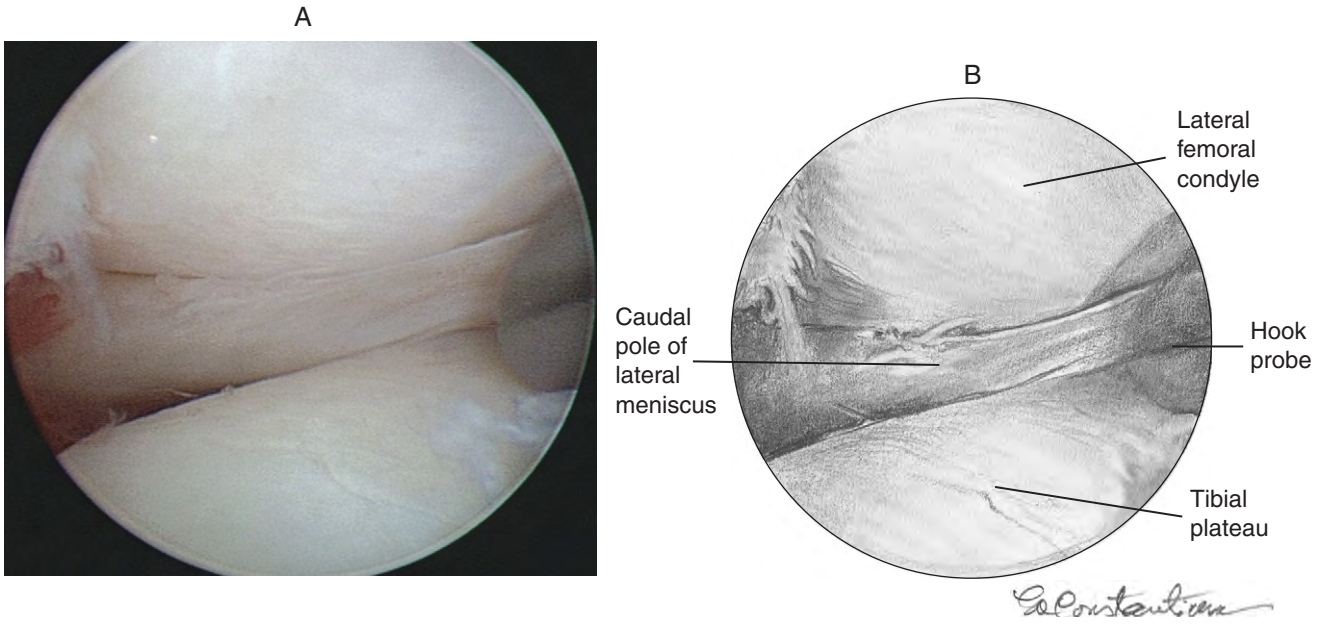



**Fig. 14–111**
The caudal pole of the lateral meniscus. The meniscus is elevated with the hook probe to assess the ventral surface for horizontal tears.

the integrity of the body of the meniscus. If there is significant drawer instability because of a cranial cruciate ligament injury, visualization of the menisci is improved by cranial displacement of the proximal tibia. The long digital extensor tendon is identified in the craniolateral aspect of the joint and is visualized from its origin on the abaxial surface of the lateral epicondyle of the femur to where it exits the joint distally (Fig. 14-112). The proximal tendon of the popliteal muscle is also identified in the lateral compartment of the joint and can be seen from its origin on the lateral aspect of the lateral femoral condyle as it angles caudally and distally (Fig. 14-113). The caudal compartment of the stifle joint can also be accessed by passing the telescope through the intercondylar fossa, either between the cranial and caudal cruciate ligaments or through the space created by removal of a ruptured cranial cruciate ligament. In the presence of significant stifle pathology with typical villus synovial reaction, examination of the stifle is greatly facilitated by partial cranial compartment synovectomy and fat pad removal with radiofrequency or a power shaver before examination of the cruciate ligaments or menisci.

## Diseases of the Stifle Joint Diagnosed and Managed with Arthroscopy

### Cranial Cruciate Ligament Injuries

Partial or complete rupture of the cranial cruciate ligament is the most common pathology found with arthroscopy in the stifle joint of dogs. The initial finding on entering a stifle joint with cruciate ligament pathology is the extensive villus reaction throughout the joint. Typically the villus reaction is as great in the suprapatellar pouch (Fig. 14-114), in the medial and lateral joint spaces, and in the caudal joint compartment (Fig. 14-115) as it is in the cranial joint compartment (Fig. 14-116). Cartilage lesions including multiple presentations of chondromalacia are also typically seen throughout the joint, with lesions varying from mild fissures or roughening (Fig. 14-117), fine fibrillation (Fig. 14-118), coarse fibrillation (Fig. 14-119), and neovascularization or pannus (Fig. 14-120). These lesions occur in the trochlear groove (see Fig. 14-119), on the caudal surface of the patella (see Fig. 14-120), on the femoral condyles (see Fig. 14-117), and on the tibial plateau (see Fig. 14-118). Osteophytes are typically seen on the abaxial surfaces of the medial and lateral trochlear ridges (Fig. 14-121), at the proximal end of the trochlear groove in the suprapatellar area (Fig. 14-122), and on the patella (Fig. 14-123). Osteophytes are also found on the axial surface of the intercondylar notch and on the tibial plateau.

Examination of structures in the intercondylar notch is greatly facilitated by partial fat pad resection and partial synovectomy of the villus reaction in the cranial joint compartment. Evaluation of the cruciate ligament and menisci can be attempted before or without tissue resection; this is possible in normal joints, joints with true acute cruciate ligament ruptures, or with other pathology that causes mild villus synovial reaction. The typical

*Text continued on p. 532.*

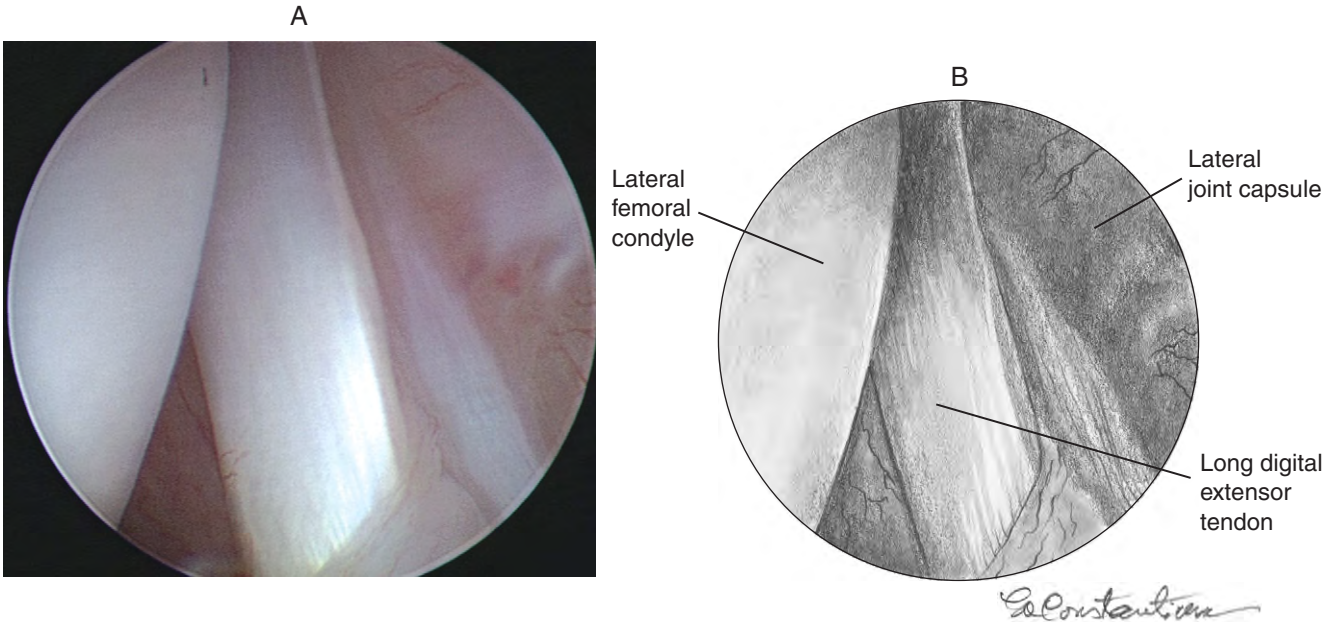



**Fig. 14–112**
The tendon of the long digital extensor muscle is seen originating from the abaxial surface of the lateral femoral condyle in the craniolateral corner of the joint.

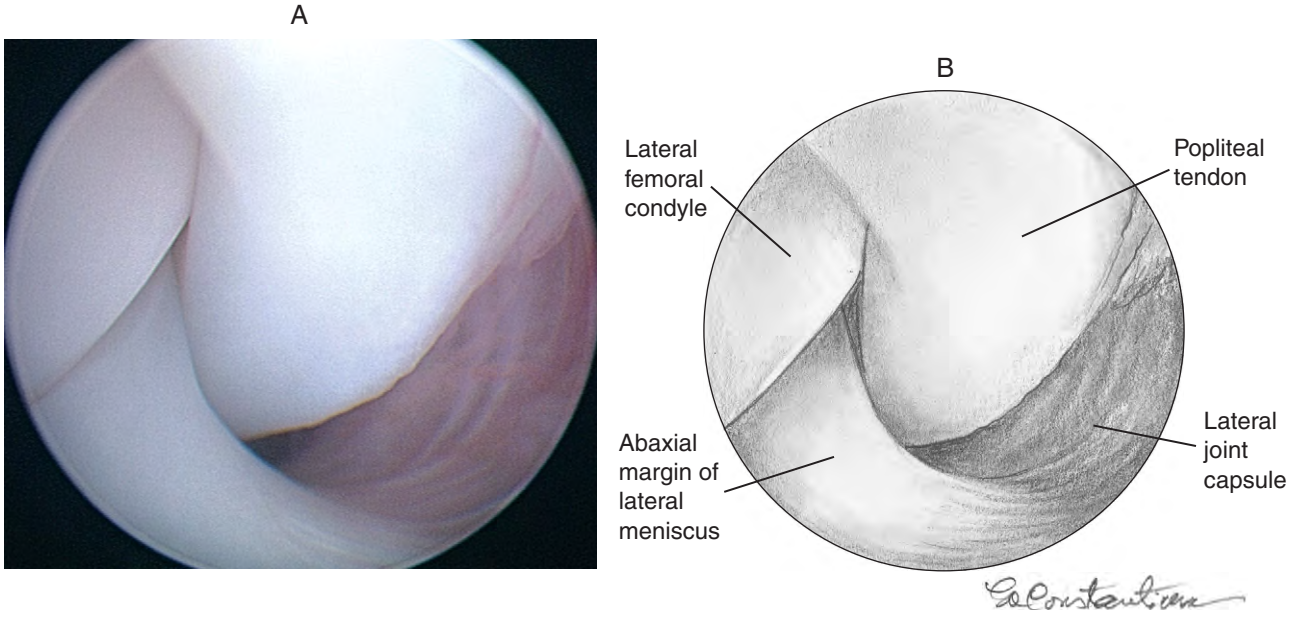



**Fig. 14–113**
The proximal tendon of the popliteal muscle is seen in the lateral joint space originating from the abaxial surface of the lateral femoral condyle and running caudally and distally within the joint.

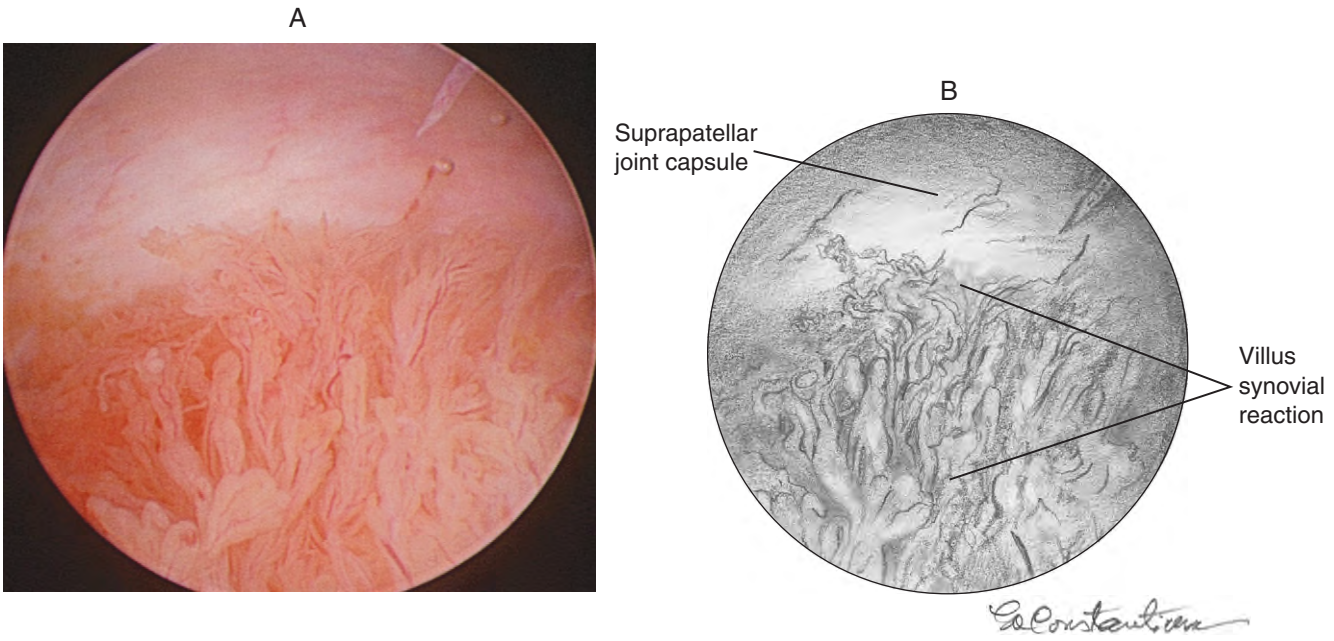



**Fig. 14–114**
Villus synovial reaction in the suprapatellar pouch of a dog with a cranial cruciate ligament rupture.

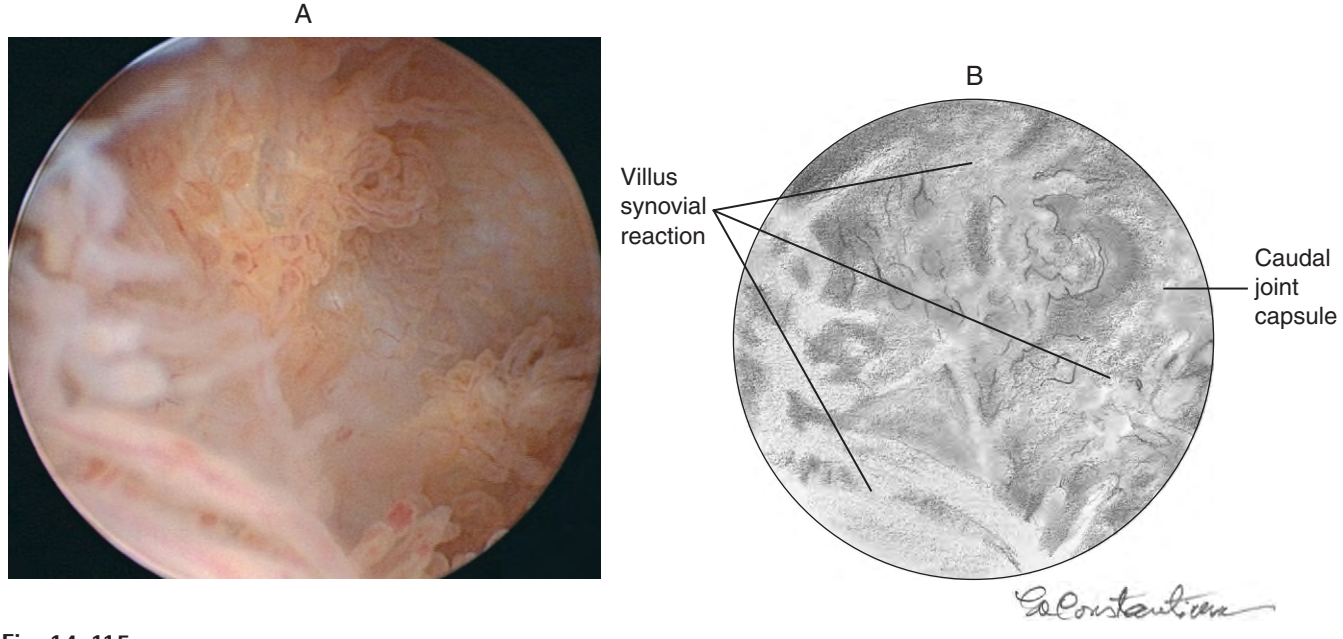



**Fig. 14–115**
Villus synovial reaction in the caudal joint compartment of a dog with a cranial cruciate ligament rupture.

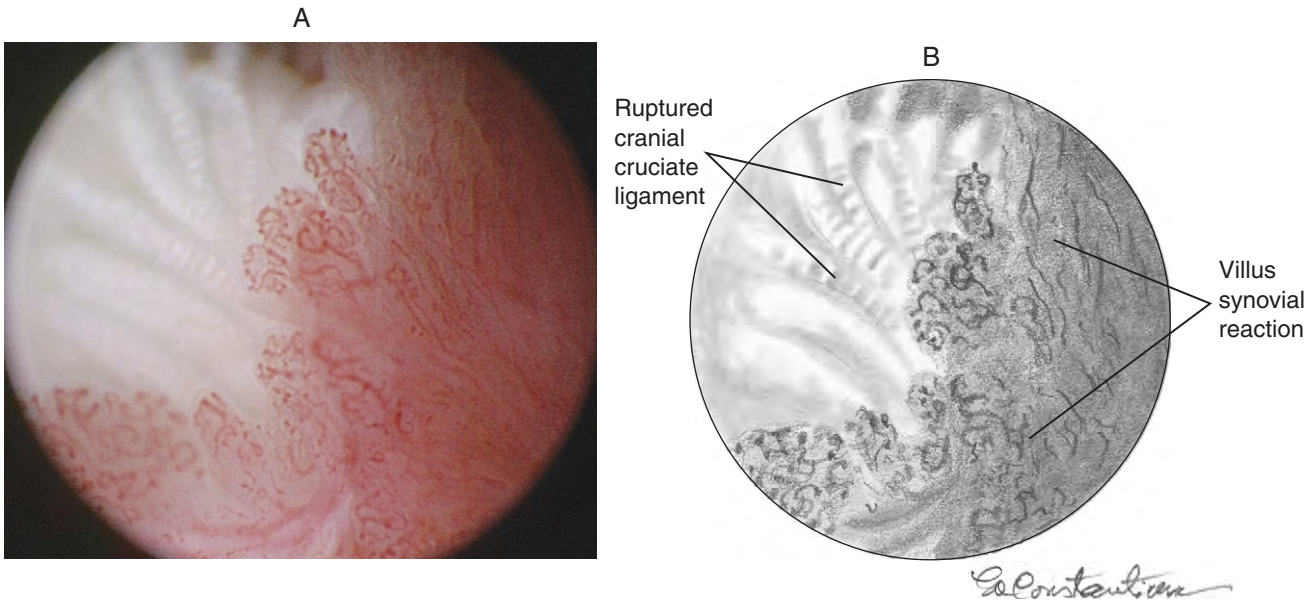



**Fig. 14–116**
Villus synovial reaction in the cranial joint compartment of a dog with a cranial cruciate ligament rupture.

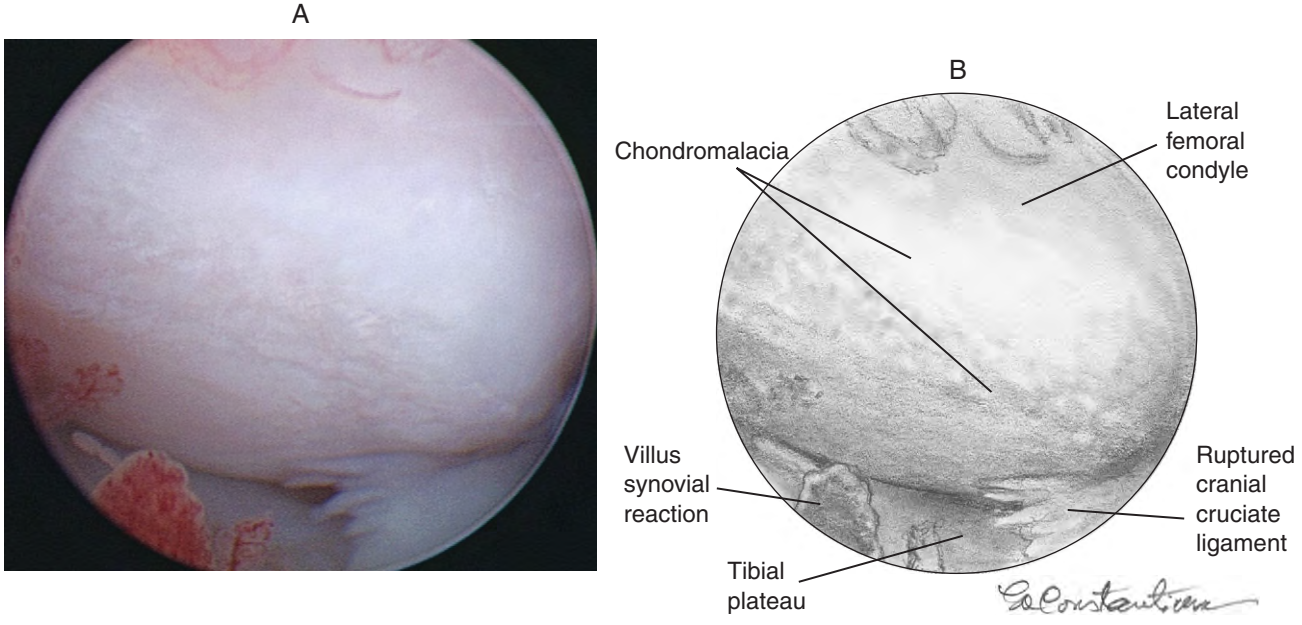



**Fig. 14–117**
Chondromalacia on the femoral condyle with cartilage roughening and fissures in a dog with a cranial cruciate ligament injury.

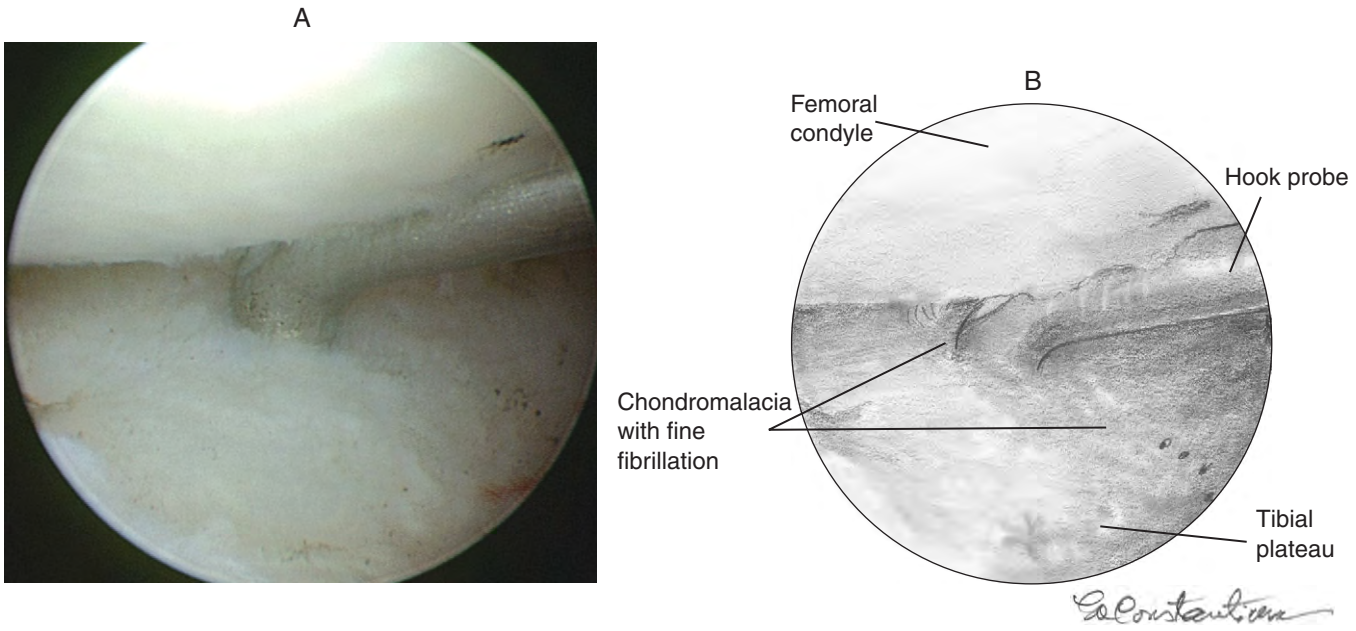



**Fig. 14–118**
Chondromalacia on the tibial plateau with fine fibrillation in a dog with a cranial cruciate ligament injury. The tip of the hook probe is buried in the soft cartilage without resistance.

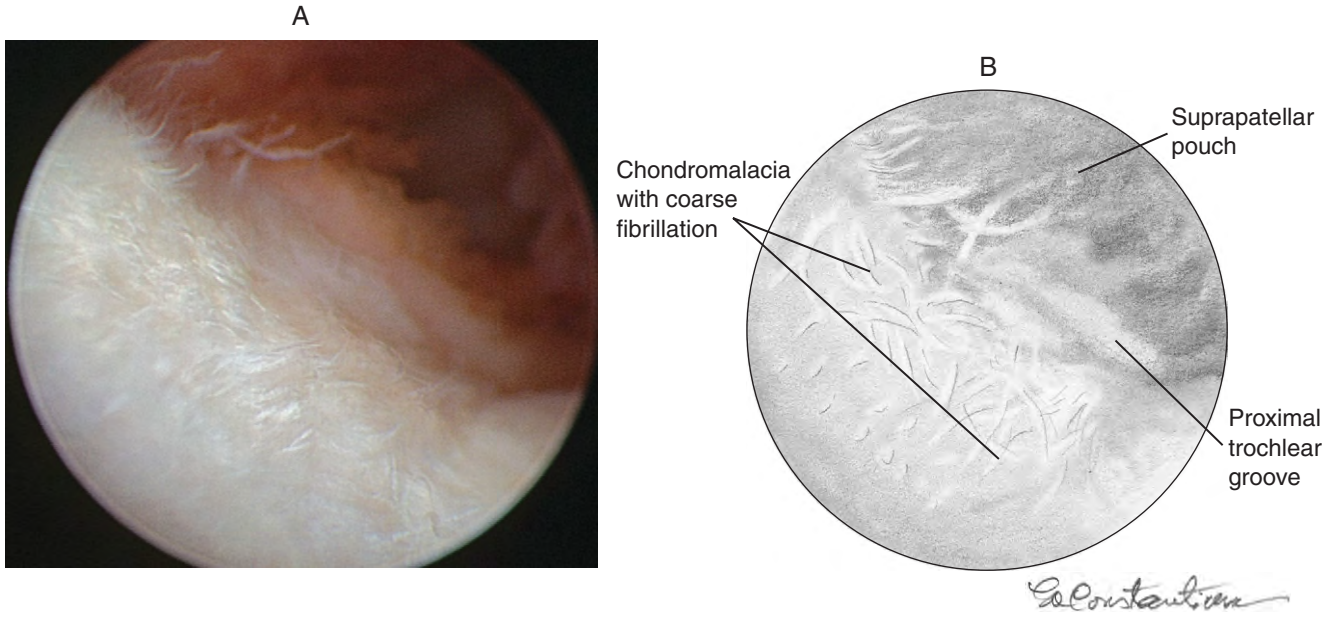



**Fig. 14–119**
Chondromalacia in the trochlear groove with coarse fibrillation in a dog with a cranial cruciate ligament injury.

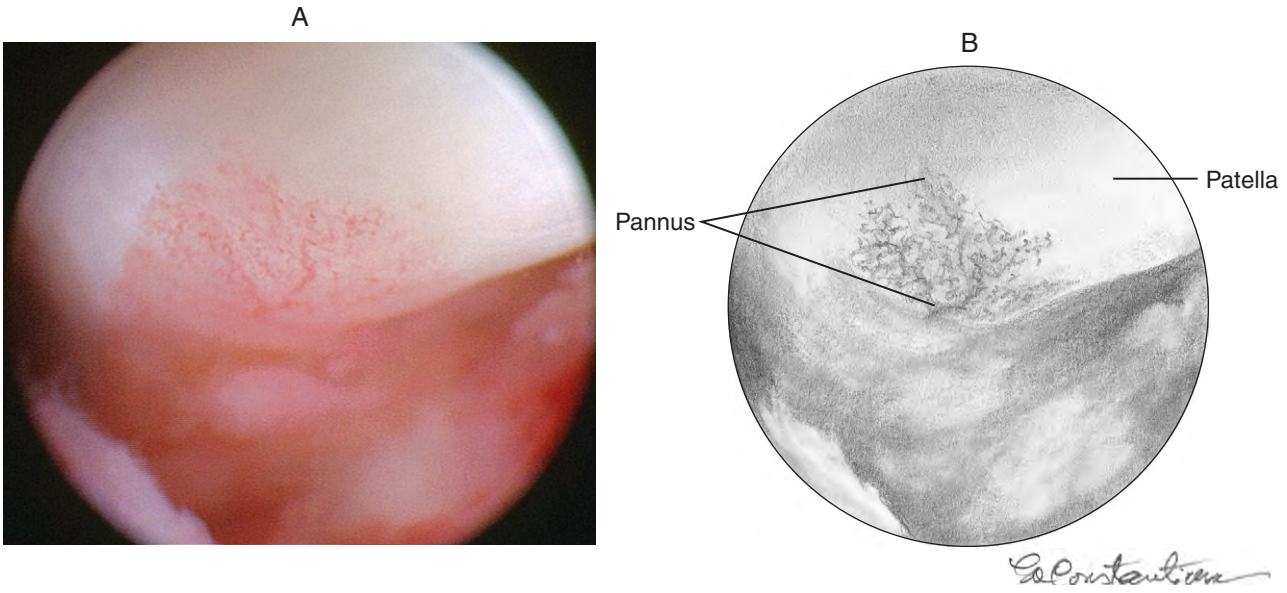



**Fig. 14–120**
Neovascularization or pannus on the caudal aspect of the patella in a dog with a cranial cruciate ligament injury.

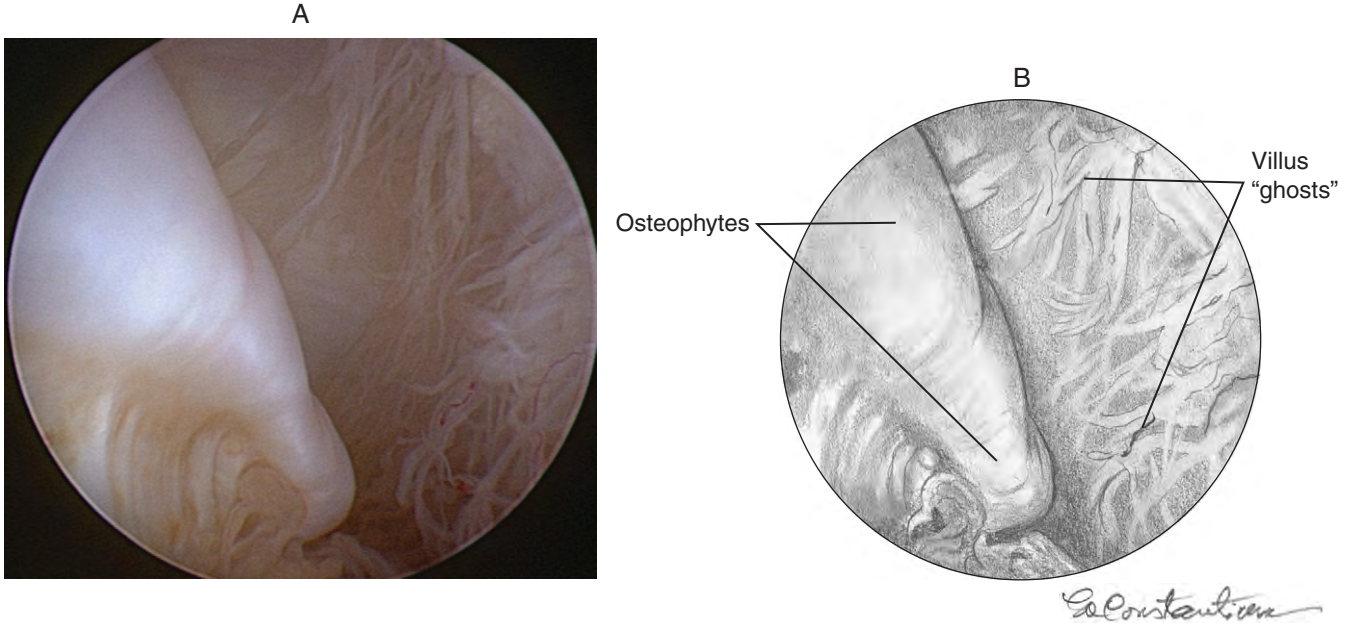



**Fig. 14–121**
A large ridge of osteophytes on the abaxial surface of the medial trochlear ridge in the stifle of a dog with a cranial cruciate ligament injury. The fine villi are nonreactive old remnants of active synovial villus reaction and are referred to as "ghosts."

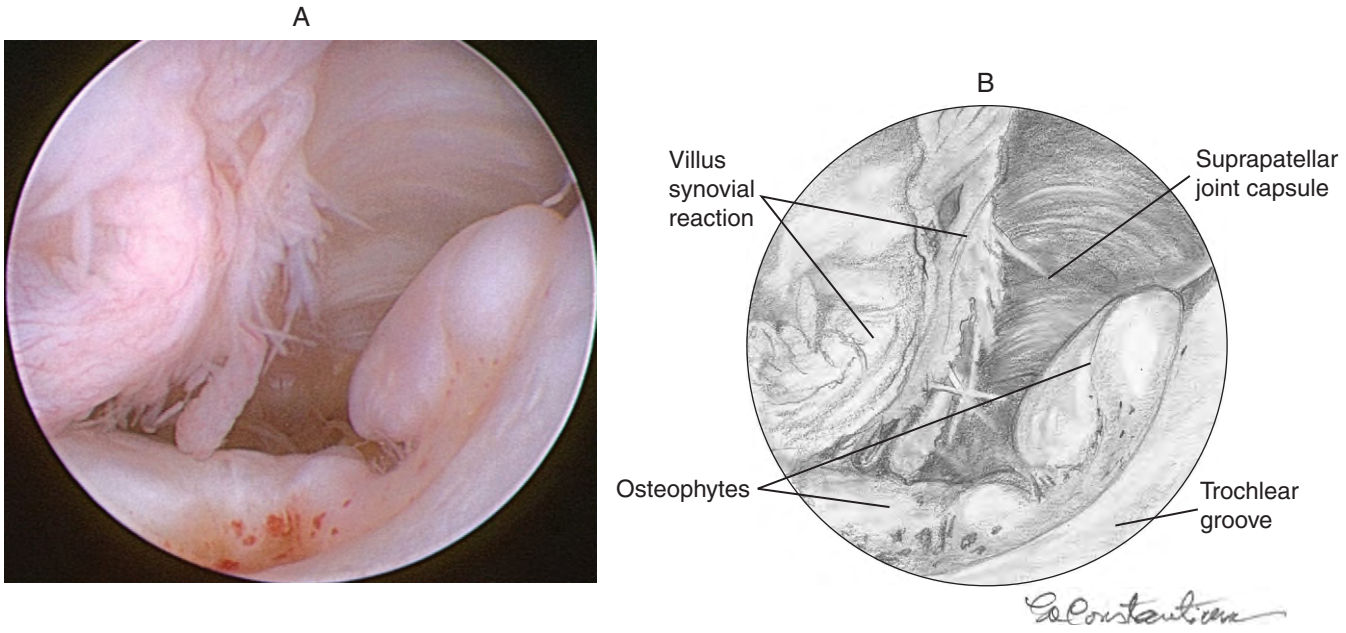



**Fig. 14–122**
Multiple osteophytes at the proximal end of the trochlear groove in the stifle of a dog with a cranial cruciate ligament injury.

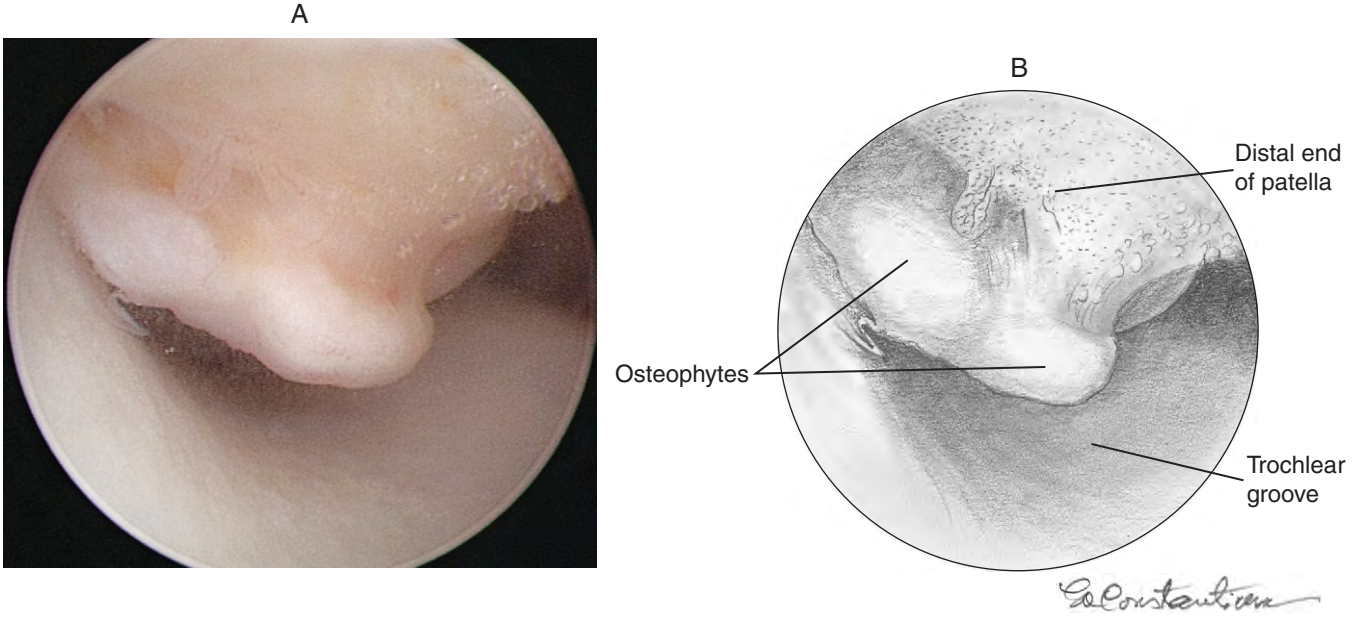



**Fig. 14–123**
Osteophytes on the distal end of the patella in the stifle of a dog with a cranial cruciate ligament injury.

villus synovial reaction (see Fig. 14-116) seen in the cruciate compromised stifle makes effective visualization of the cruciate ligaments and menisci difficult to impossible. Complete cruciate ligament ruptures or major partial tears may be visible without cranial compartment debridement, but the chance of missing a minor partial tear of the cranial cruciate ligament is greatly increased when debridement is not performed. If the only purpose of arthroscopy is to confirm a diagnosis of cruciate ligament injury that is going to be followed by an open arthrotomy and if free strands of ruptured ligament are seen, then the arthroscopic portion of the procedure can be completed without removing the fat pad or cranial compartment villus synovial reaction. For any operative arthroscopic procedures, partial fat pad removal and partial cranial compartment synovectomy are essential.

When the cranial cruciate ligament ruptures, the strands of ruptured ligament separate like the end of a frayed rope, with strands from acute ruptures having sharp pointed tips and well-defined striations within the individual loose strands (Fig. 14-124). As the rupture becomes chronic, the ends of the strands become blunted and they lose their sharp margins and striations (Fig. 14-125). With progressive chronicity, the ligament ends undergo remodeling to become nodules of fibrous tissue (Fig. 14-126) and are eventually completely reabsorbed. Combinations of acute and chronic appearance of ruptured fibers (Fig. 14-127) are common, lending support to the theory that there is a slow progression with repeated episodes of partial tearing over a period of time to eventual complete rupture. Partial tears show the same pattern of ruptured fiber change from acute to blunting and resorption with progressive chronicity, but they also have a variable quantity of intact fibers. With early partial tears and a minimal number of ruptured ligament fibers, they are most typically first seen as ruptured ligament strands from the caudal aspect of the insertion of the cranial cruciate ligament medially, laterally (Fig. 14-128), both medially and laterally, or occasionally in the central portion of the ligament. A probe is used to palpate and manipulate the caudal area of the insertion of the cranial cruciate ligament if it appears normal on initial examination. Minimal ligament injuries can also be detected, even in the absence of visible ruptured fibers, by the presence of easily visible cross striations in the intact ligaments, indicating that the normal tension has been taken off of the ligament (Fig. 14-129).

The classically described injuries to the medial meniscus have been documented with arthroscopy, including bucket handle tears (Fig. 14-130), broken bucket handle or parrot beak tears (Fig. 14-131), cranial displacement of bucket handle fragments (Fig. 14-132) or the entire caudal pole of the meniscus (Fig. 14-133) with entrapment cranial to the femoral condyle, and crushing or maceration of the caudal pole. The complete range of described classifications of meniscal injuries from the human literature can be seen.[8,9] Additional pathology that cannot be easily visualized with open surgery has also been defined with arthroscopy. The most significant of these findings is that damage to the lateral meniscus occurs more frequently

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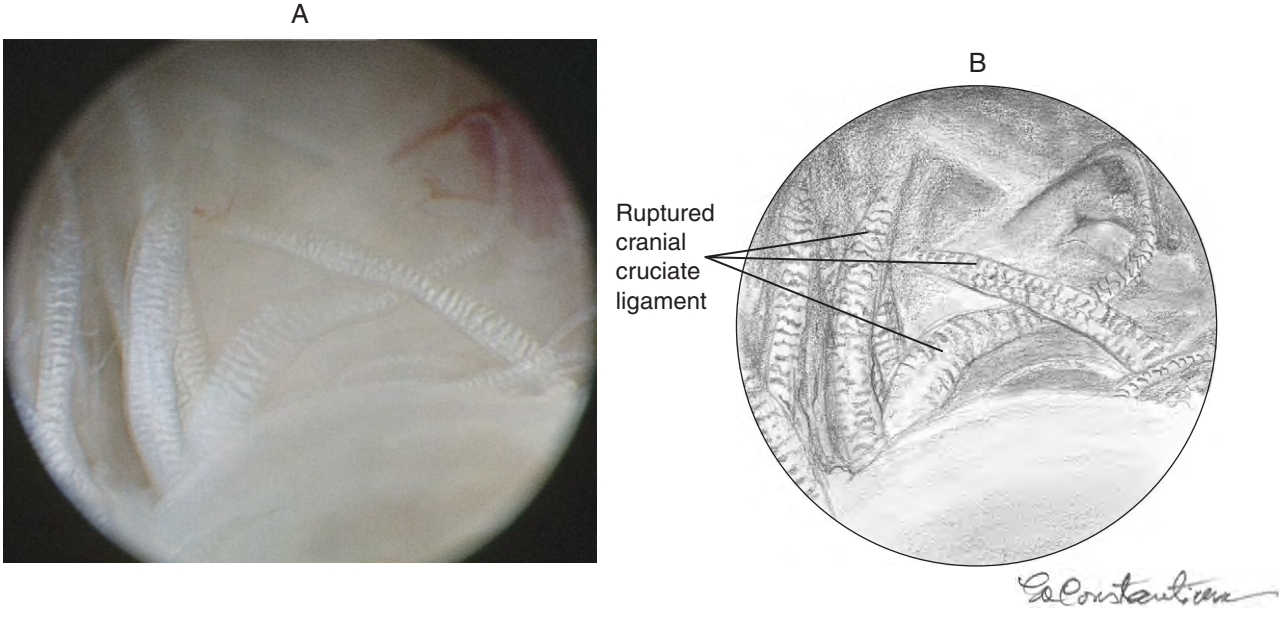



**Fig. 14–124**
Close-up view of acutely ruptured strands of cranial cruciate ligament with sharp pointed tips and well-defined cross striations.

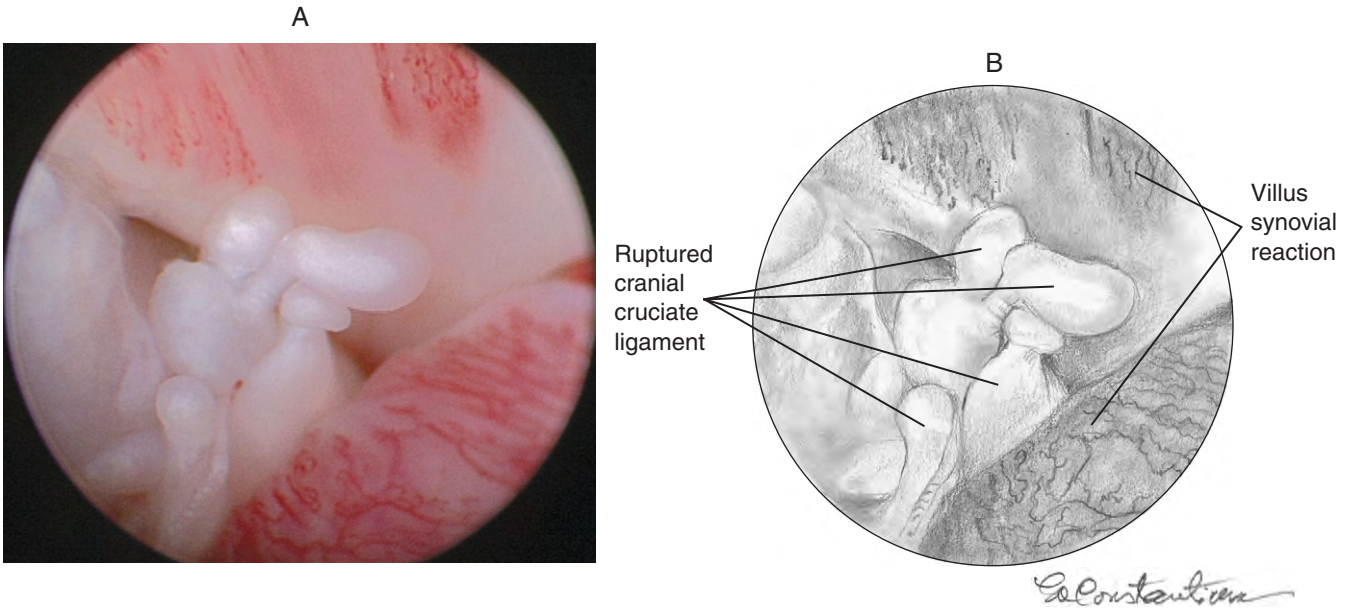



**Fig. 14–125**
Close-up view of ruptured strands of cranial cruciate with blunted ends and loss of cross striations typical of chronic changes.

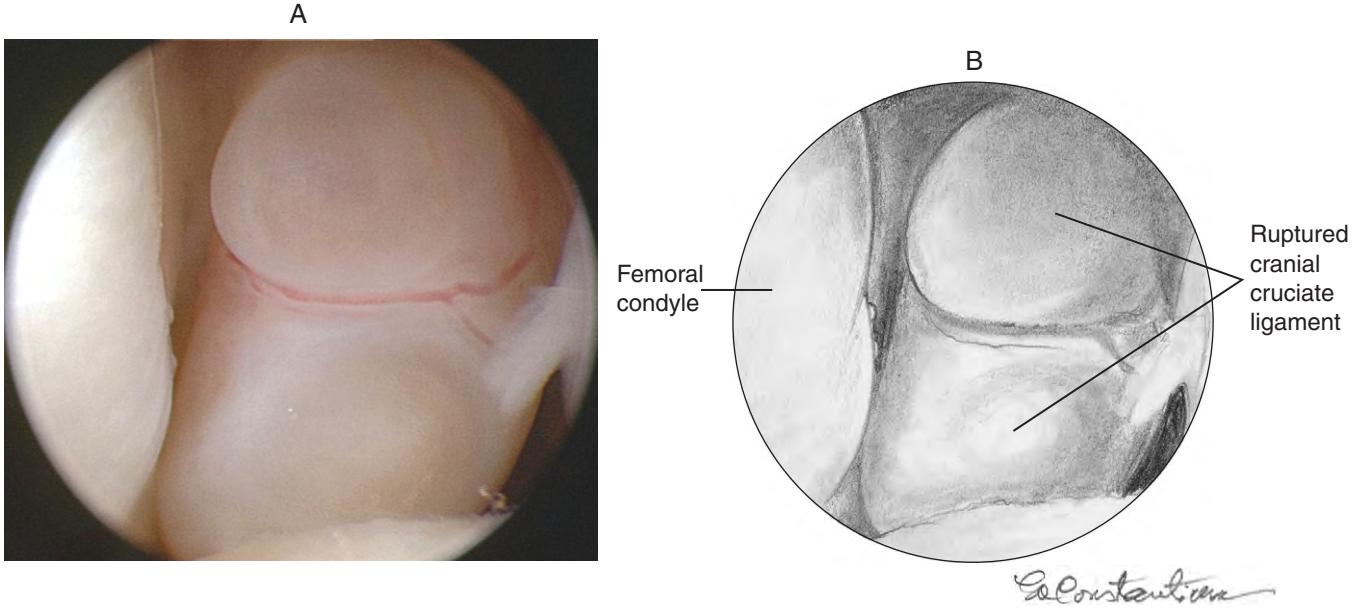



**Fig. 14–126**
Chronic cranial cruciate ligament remnants that have undergone extensive remodeling into nodules of fibrous tissue.

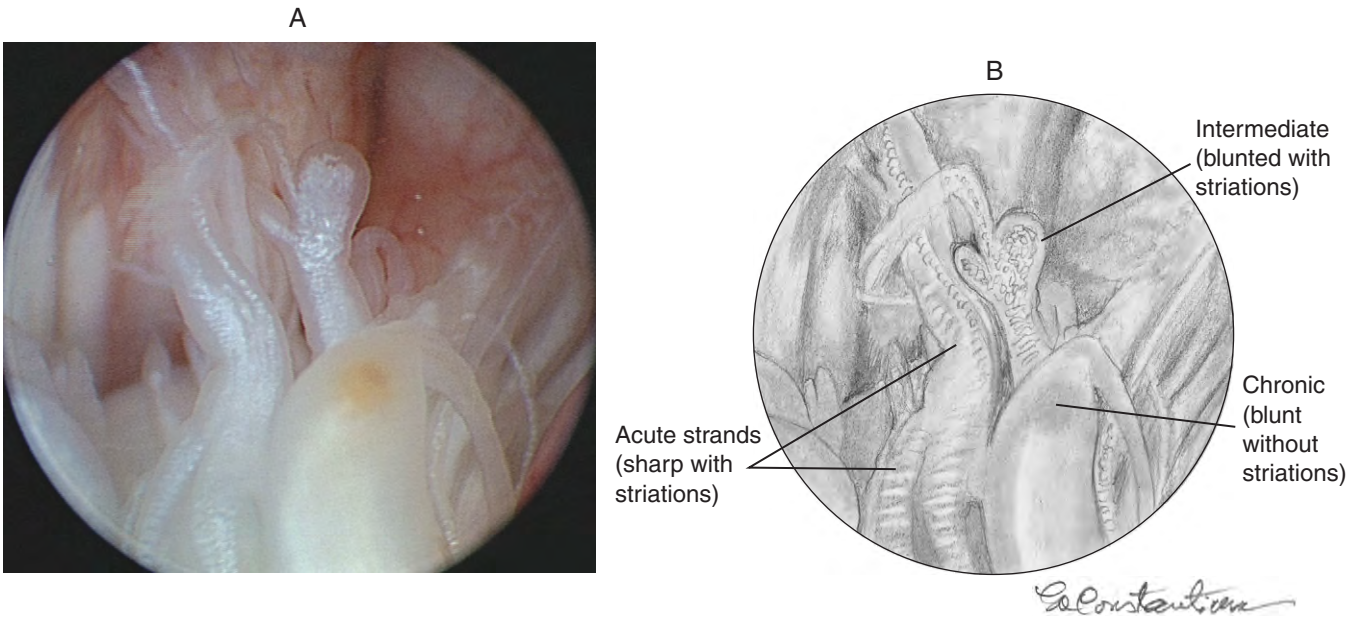



**Fig. 14–127**
Close-up view of a cranial cruciate ligament with recently ruptured strands with sharp points and cross striations along with other ruptured strands showing chronic changes of blunting and loss of cross striations.

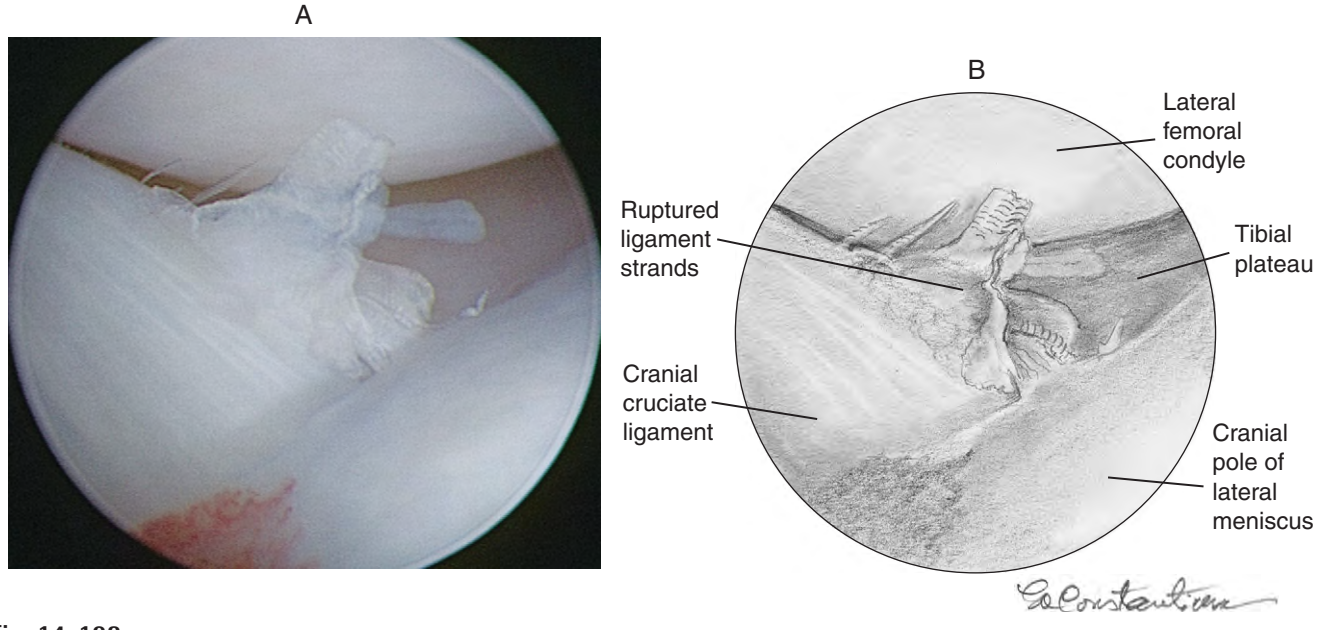



**Fig. 14–128**
Ruptured strands peeking out laterally from the insertion of a partially ruptured cranial cruciate ligament.

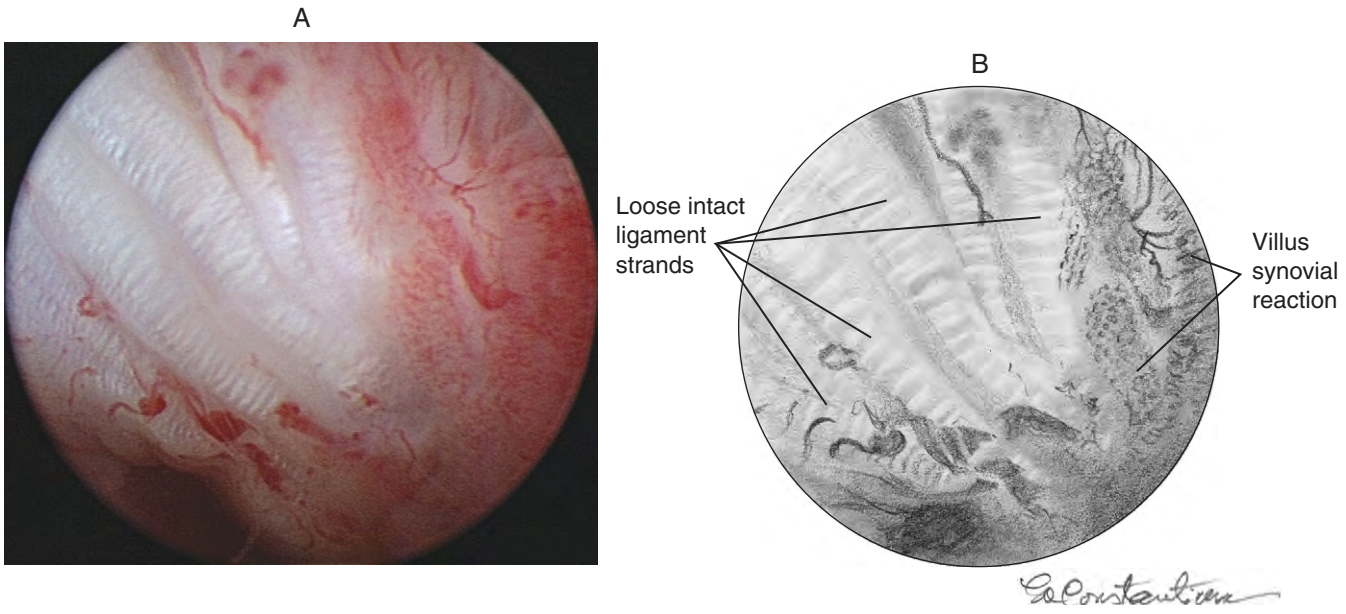



**Fig. 14-129**
Prominent, easily seen cross striations in a loose caudal cruciate ligament in a stifle with a partially ruptured cranial cruciate ligament.

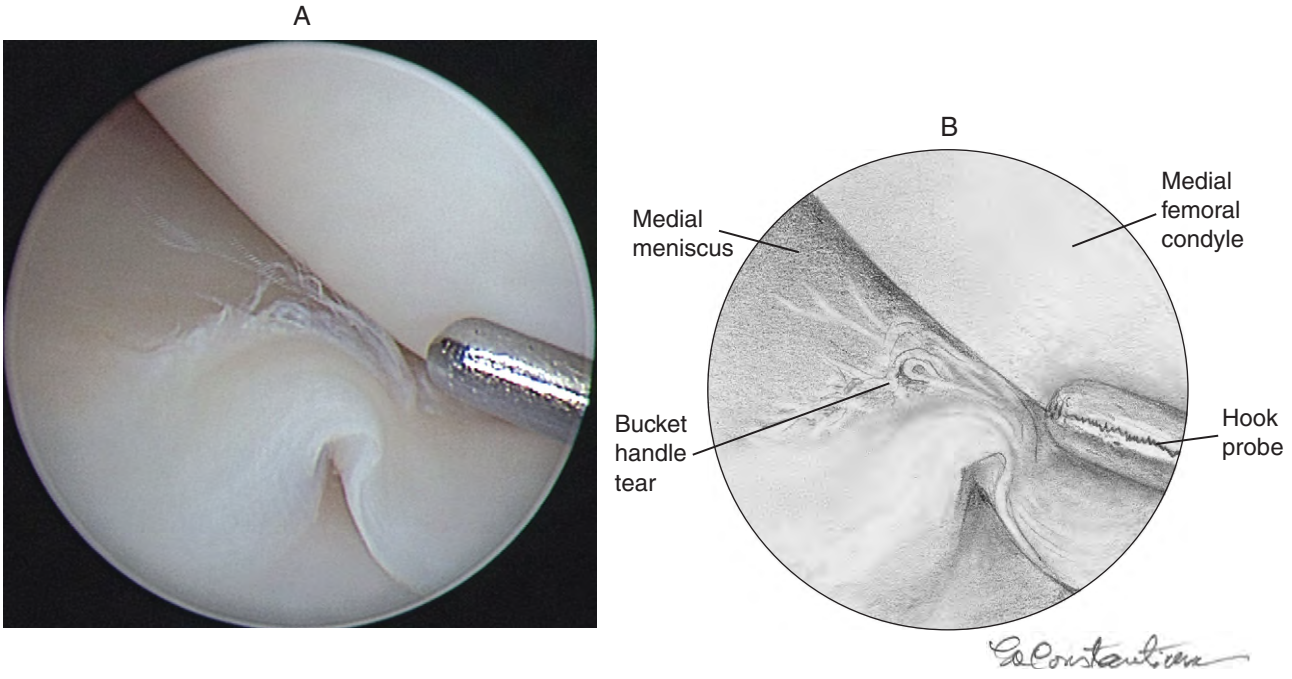



**Fig. 14-130**
A small longitudinal or bucket handle tear in the caudal pole of the medial meniscus of a dog with a cranial cruciate ligament rupture.

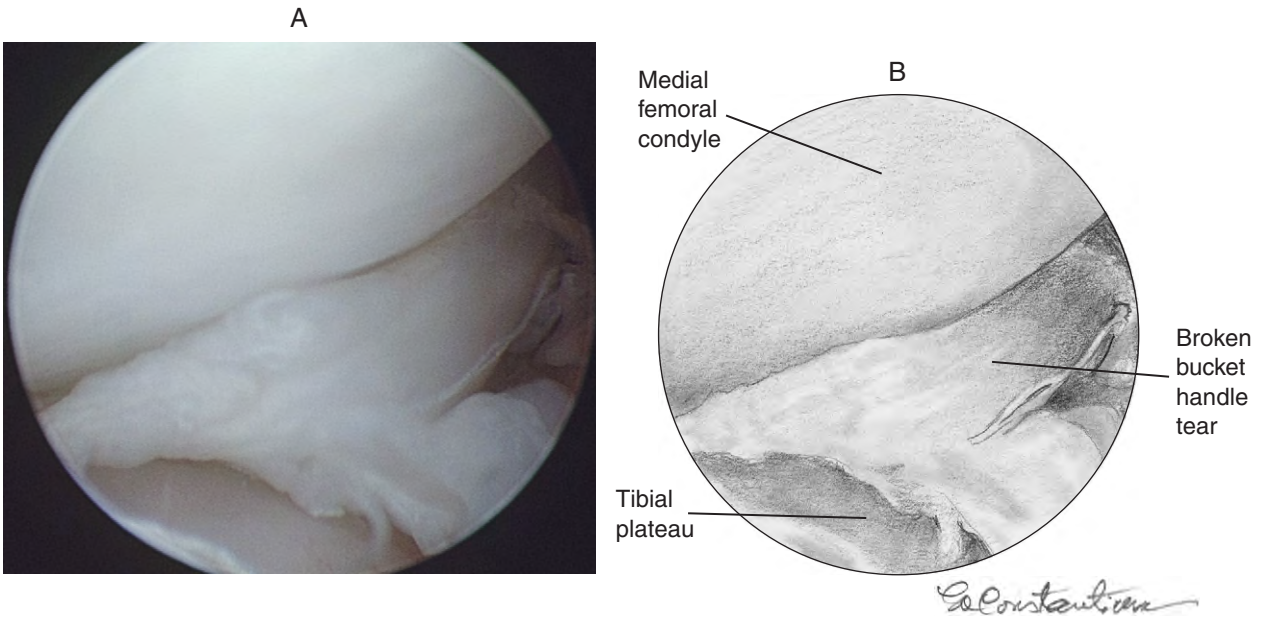



**Fig. 14-131**
A broken bucket handle or parrot beak tear of the caudal pole of the medial meniscus where one end of the bucket handle breaks away from the meniscus, creating a free end.

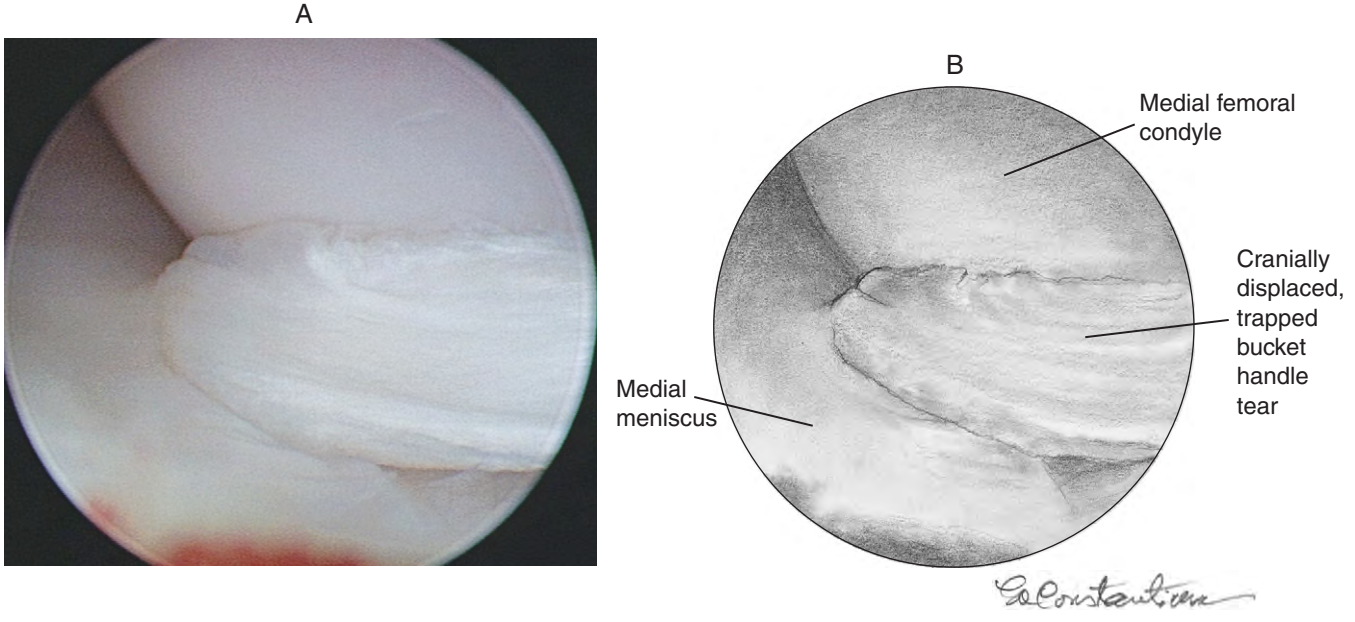



**Fig. 14-132**
A bucket handle tear of the caudal pole of the medial meniscus that is folded, displaced cranially, and trapped in front of the femoral condyle.

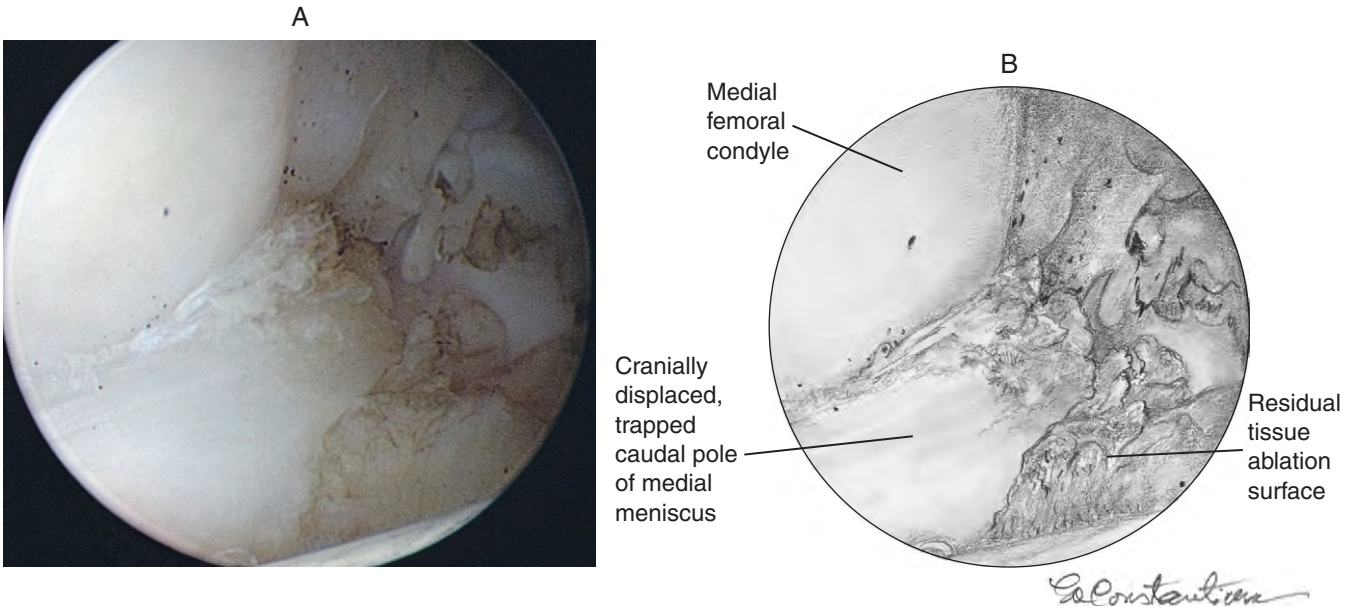



**Fig. 14–133**
The entire caudal pole of the medial meniscus has been displaced cranially and trapped in front of the medial femoral condyle. The black debris and darkened areas of tissue are the residuals of bipolar radiofrequency tissue ablation.

than medial meniscal injuries.[9] The most common lateral meniscal injury is fraying, or radial tearing, of the cranial portion of the axial margin, which can be mild (Fig. 14-134) or major (Fig. 14-135).

Arthroscopic debridement of minor partial cranial cruciate ligament injuries, complete resection of the remnants of major partial tears, and resection of the ends of complete ruptures has become the standard surgical approach, obviating the need for open arthrotomy in management of the cruciate compromised stifle. Debridement of minor partial tears is typically done with radiofrequency and complete resections are performed using a combination of radiofrequency and the power shaver. Radiofrequency is used initially to remove the fat pad and debride the villus synovial reaction in the cranial joint compartment to improve the visual field (Fig. 14-136), the power shaver is used to removed the majority of the ligament (Fig. 14-137), and radiofrequency is used to smooth the remnants of the ligament ends (Figs. 14-138 and 14-139). Hand instruments have been used for ligament removal but they make the procedure too time-consuming.

Partial meniscectomies are performed with arthroscopy using hand instruments, the power shaver, radiofrequency, or a combination of these techniques. Total meniscectomies can also be performed but are uncommonly needed. The damaged areas of the meniscus are removed with the power shaver for larger lesions (Fig. 14-140), followed by radiofrequency to smooth and shape the resection margin; radiofrequency alone is used for smaller lesions (Figs. 14-141 and 14-142).

Meniscal release can be performed arthroscopically as part of the stifle debridement technique or for combination with a TPLO. Transection of the caudal meniscotibial ligament of the medial meniscus is the preferred technique and is most commonly done with radiofrequency (Figs. 14-143 and 14-144); however, it can also be done with a power shaver, a scalpel blade (number 11 or 12), an arthroscopic knife, or even an 18-gauge hypodermic needle. In joints with minimal cruciate ligament injuries and no drawer instability the cruciate ligament is not removed, making access to the meniscotibial ligament difficult. If access cannot be achieved, then a caudal meniscal body radial meniscotomy is performed under arthroscopic guidance. This technique is done by placing a 20-gauge needle into the joint caudal to the medial collateral ligament (Fig. 14-145), the needle is repositioned until the desired location and angle are achieved, and the needle is replaced with a number 11 scalpel blade to make the meniscal incision (Fig. 14-146). A hook probe is used after the cut to confirm that the meniscotomy is complete and the caudal pole of the meniscus moves freely away from the cranial portion. The stifle is routinely reexamined after placement of TPLO implants to check for adequate removal of cruciate ligament

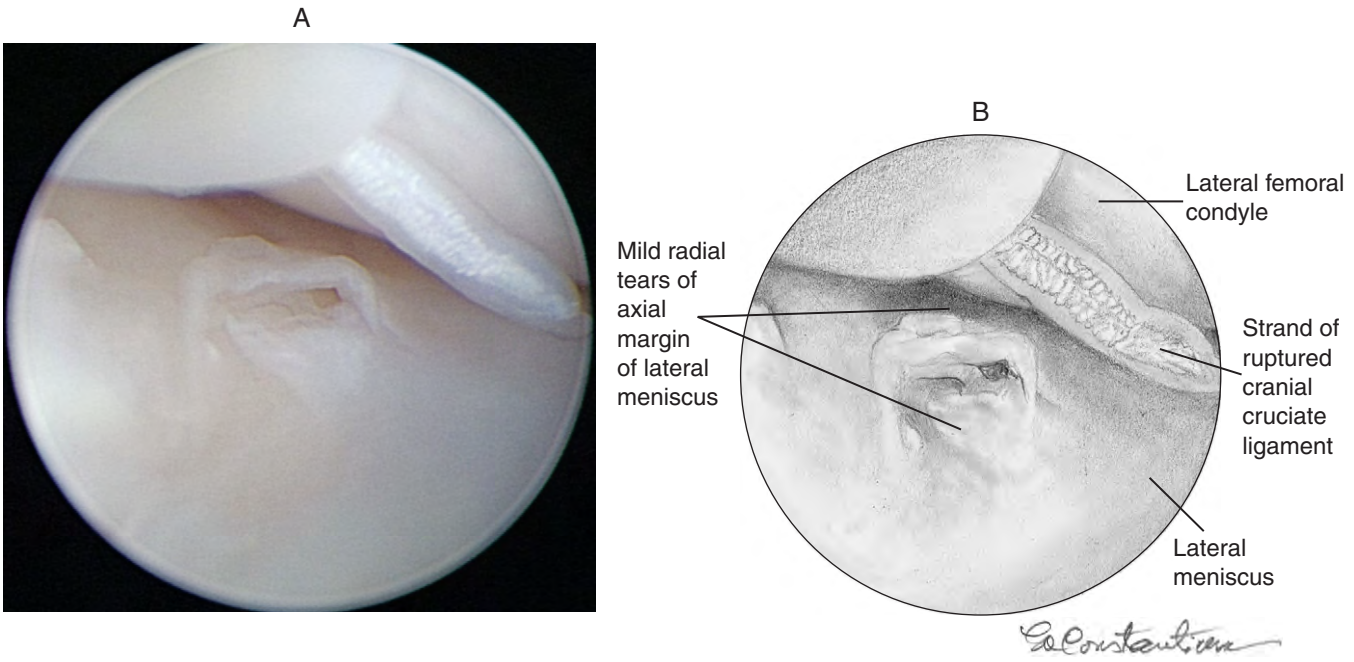



**Fig. 14–134**
A close-up of mild fraying or radial tearing of the axial margin of the cranial pole of the lateral meniscus in a stifle with a partially ruptured cranial cruciate ligament.

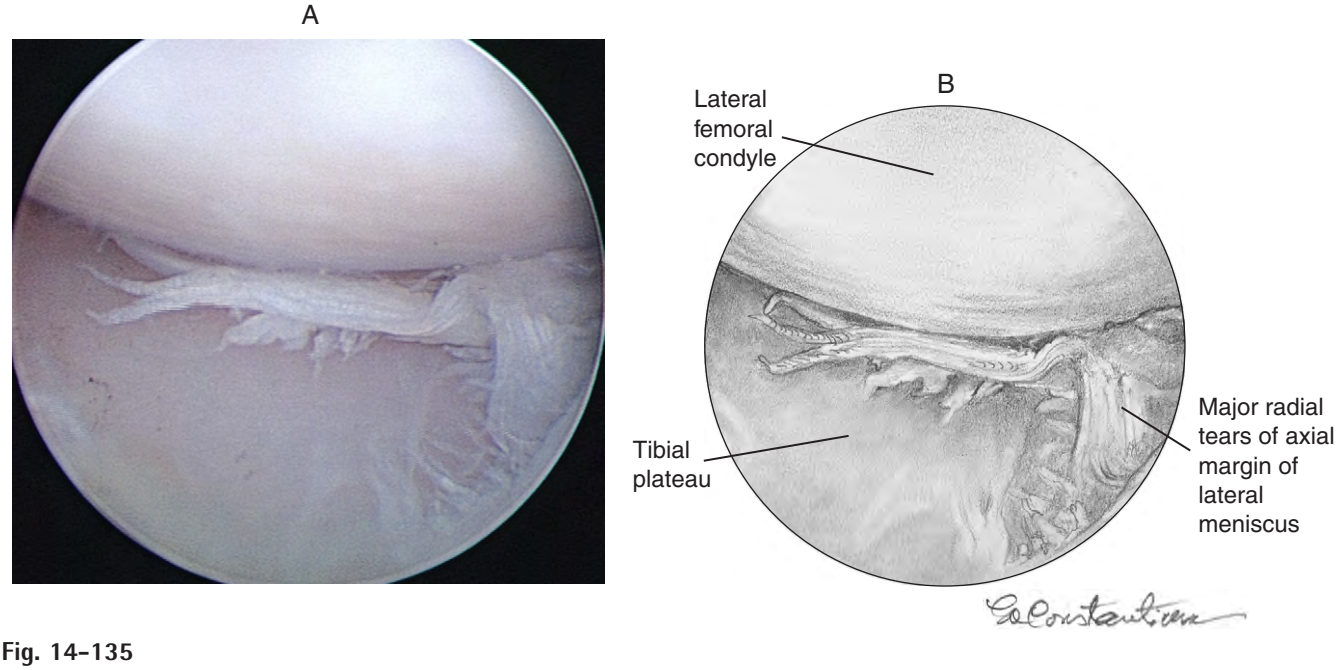



**Fig. 14–135**
A major radial tearing injury of the axial margin of the cranial pole of the lateral meniscus in a dog with a ruptured cranial cruciate ligament.

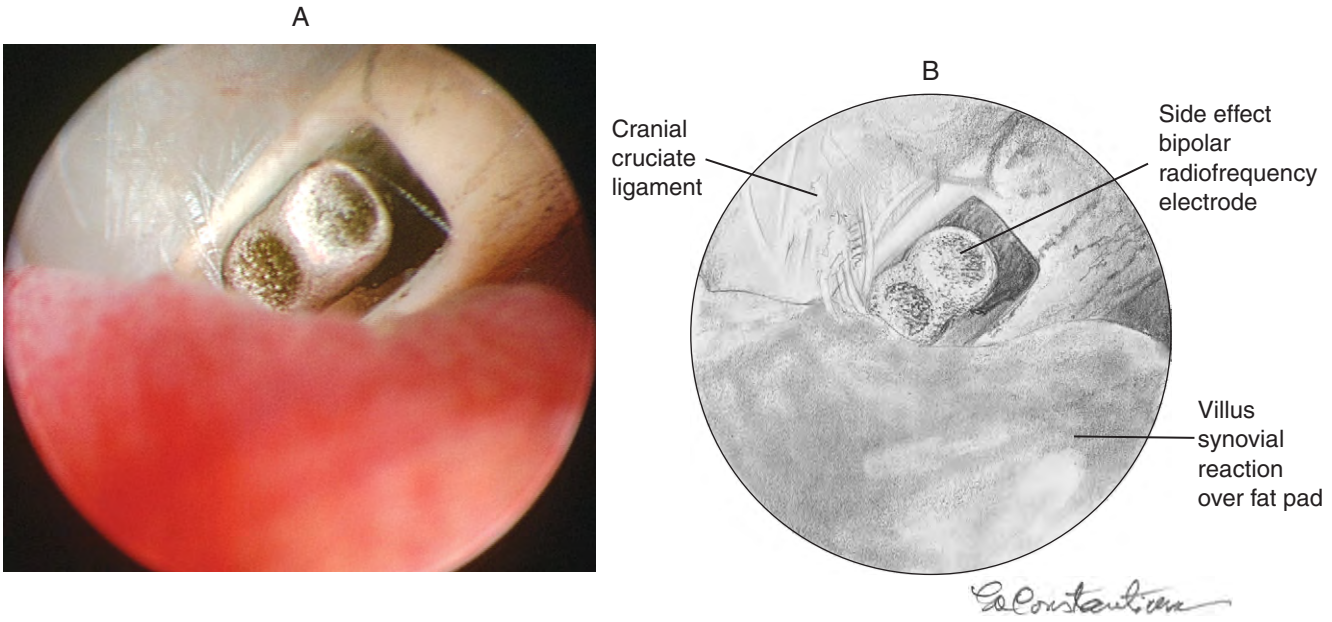



**Fig. 14–136**
The fat pad is partially removed and a partial cranial compartment synovectomy is performed using radiofrequency to improve the visual field.

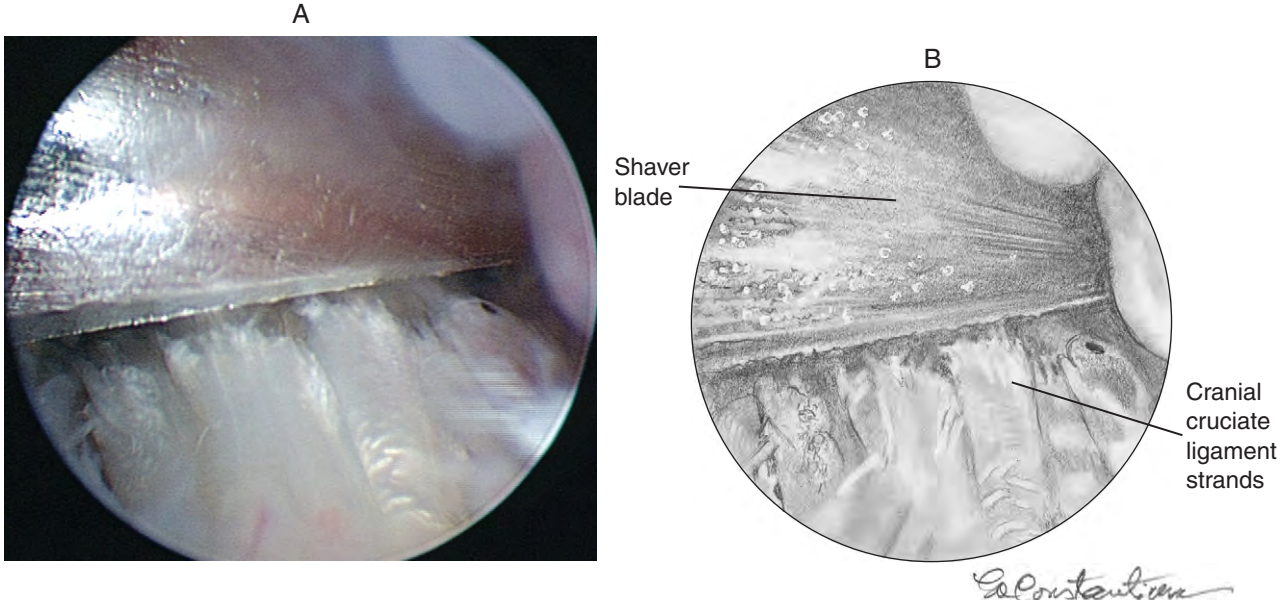



**Fig. 14–137**
Removal of a ruptured cranial cruciate ligament with a power shaver using a 4-mm aggressive cutting blade.

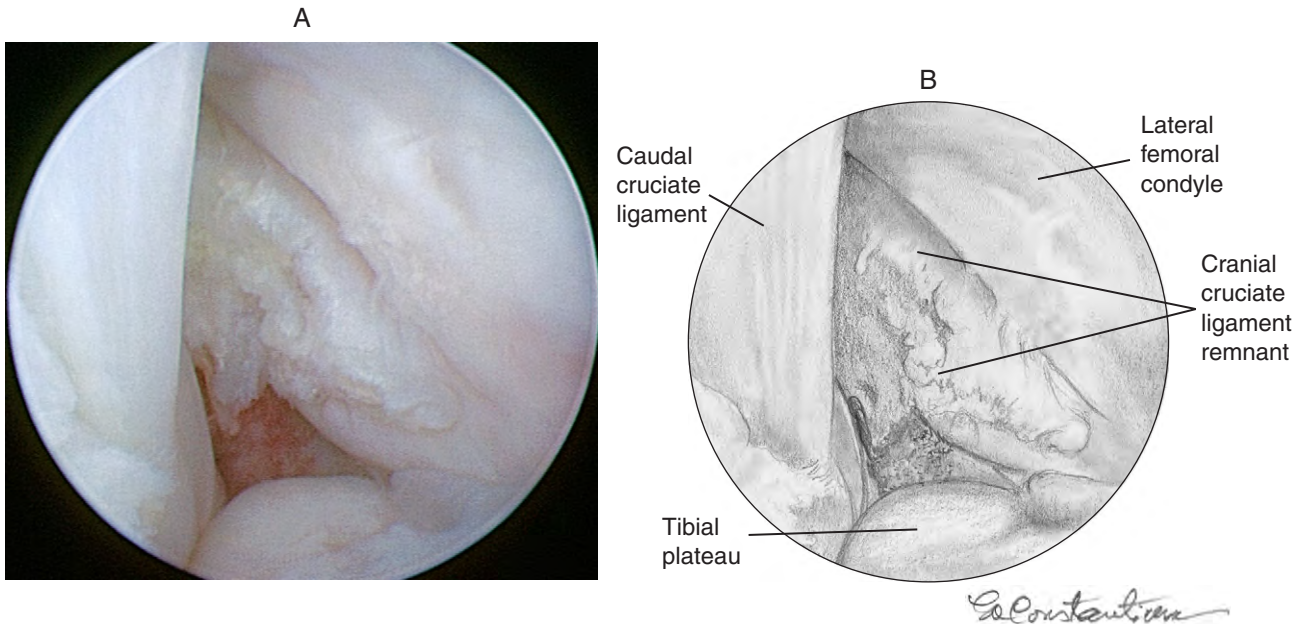



**Fig. 14–138**
The remnants of the origin of the cranial cruciate ligament on the medial aspect of the lateral femoral condyle after removal with the power shaver.

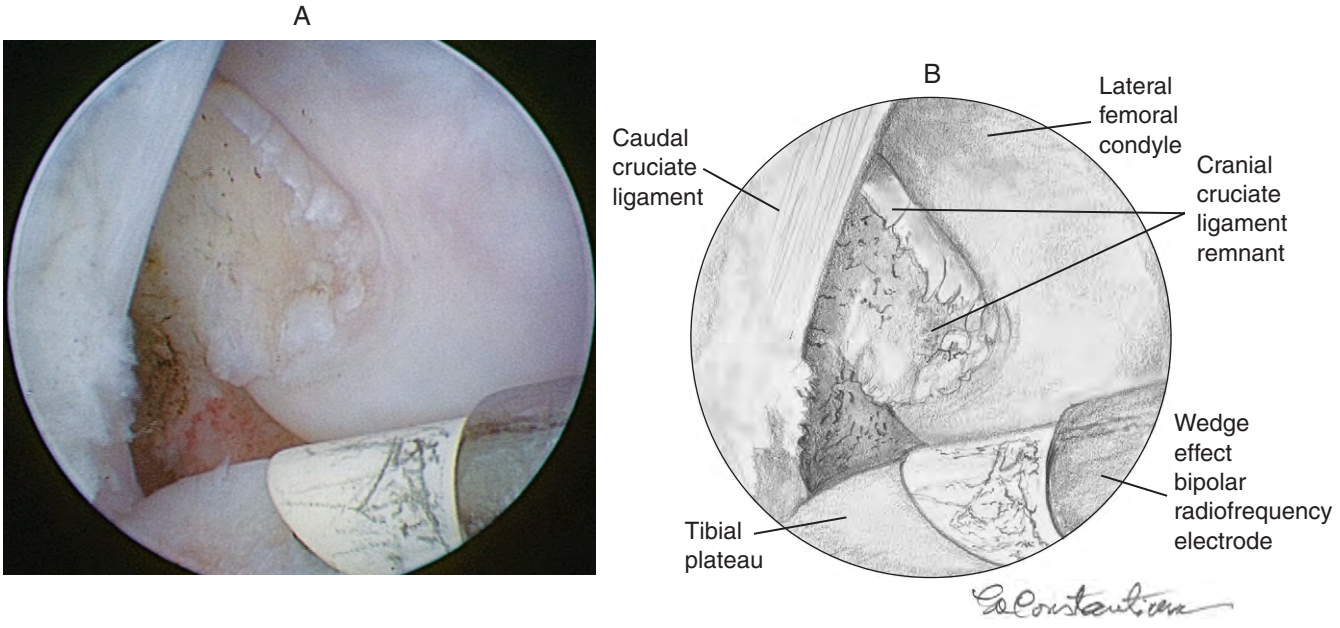



**Fig. 14–139**
Radiofrequency is used to smooth the ligament remnants after the ligament has been removed with the power shaver.

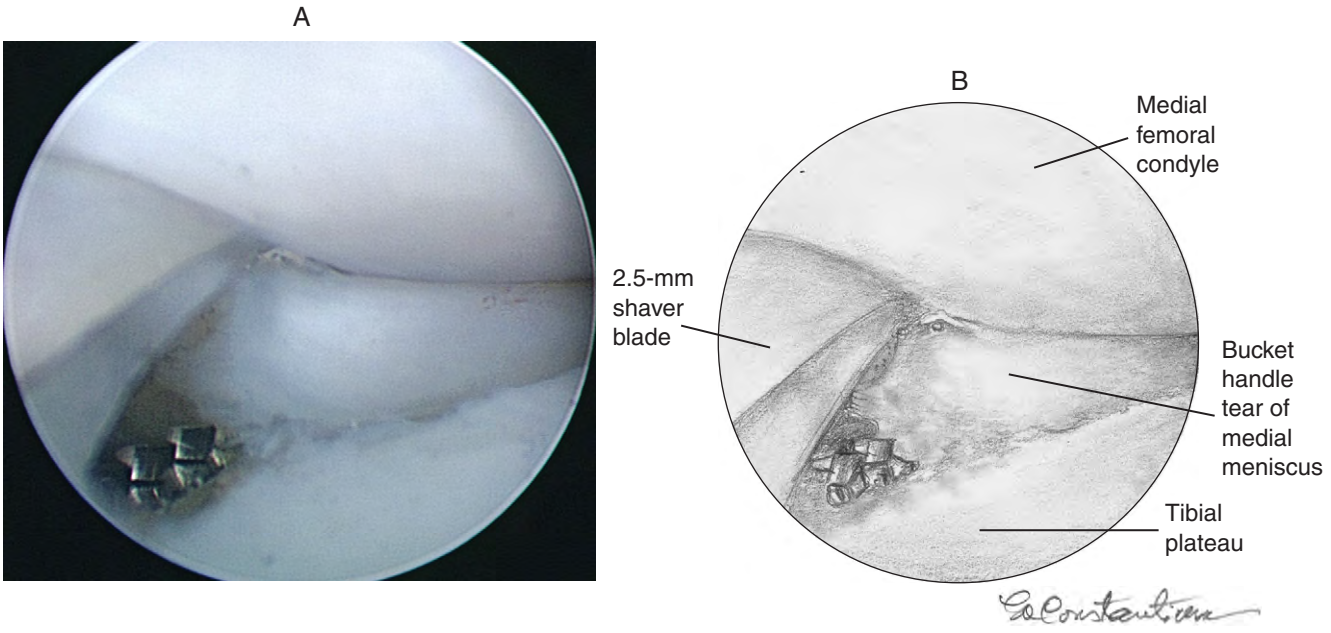



**Fig. 14–140**
Removal of a bucket handle tear with a power shaver using a 2.5-mm aggressive cutting blade.

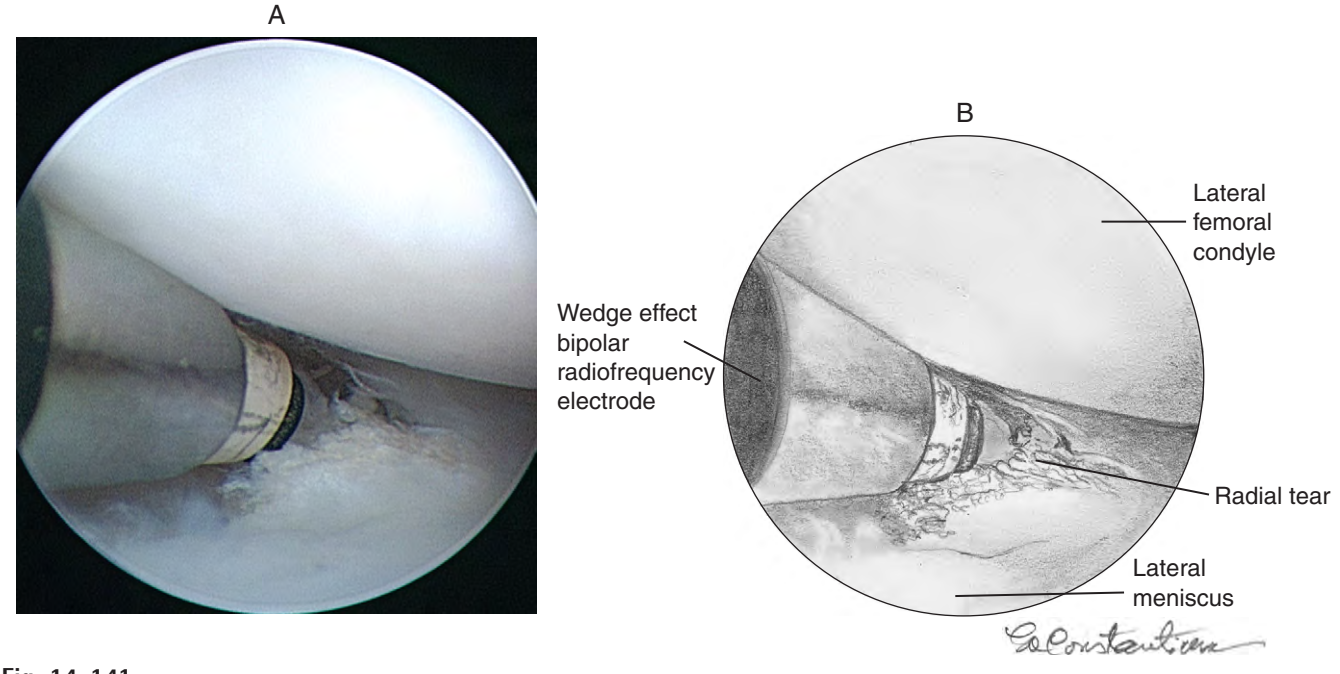



**Fig. 14–141**
Removal of the damaged portion of the lateral meniscus seen in Fig. 14-135 using radiofrequency. Care is taken to prevent damage to the adjacent cartilage surfaces.

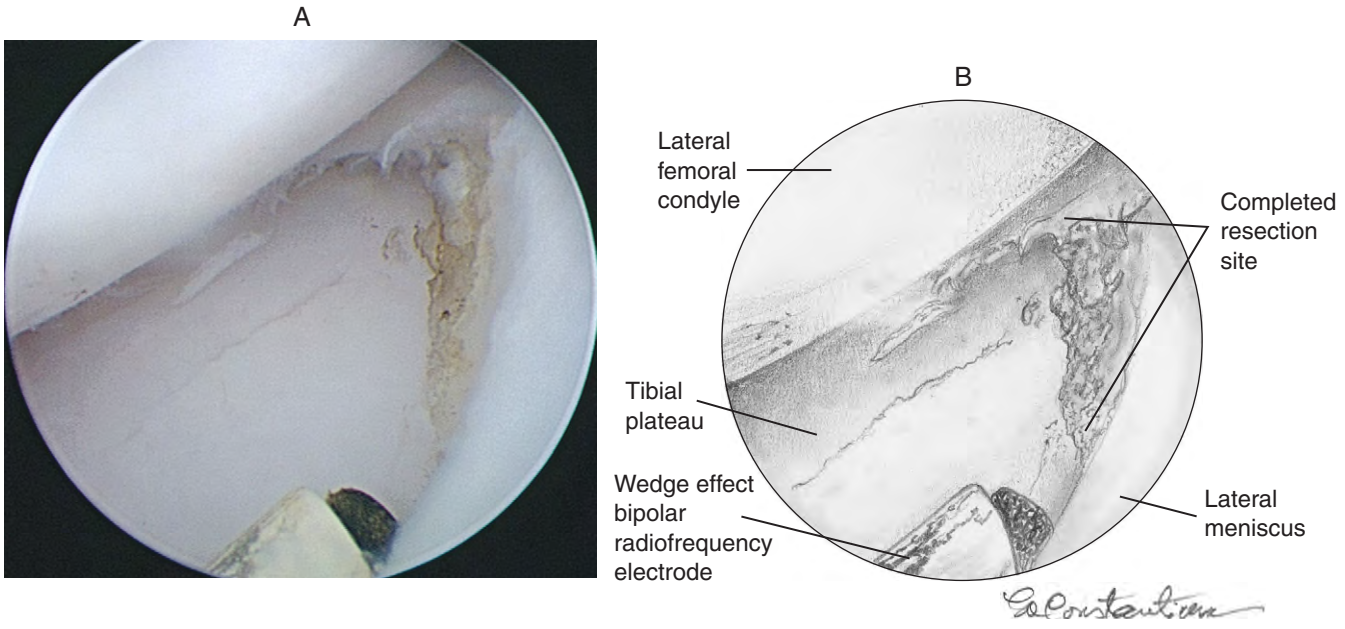



**Fig. 14-142**
Completed removal of the meniscal lesion seen in Fig. 14-141.

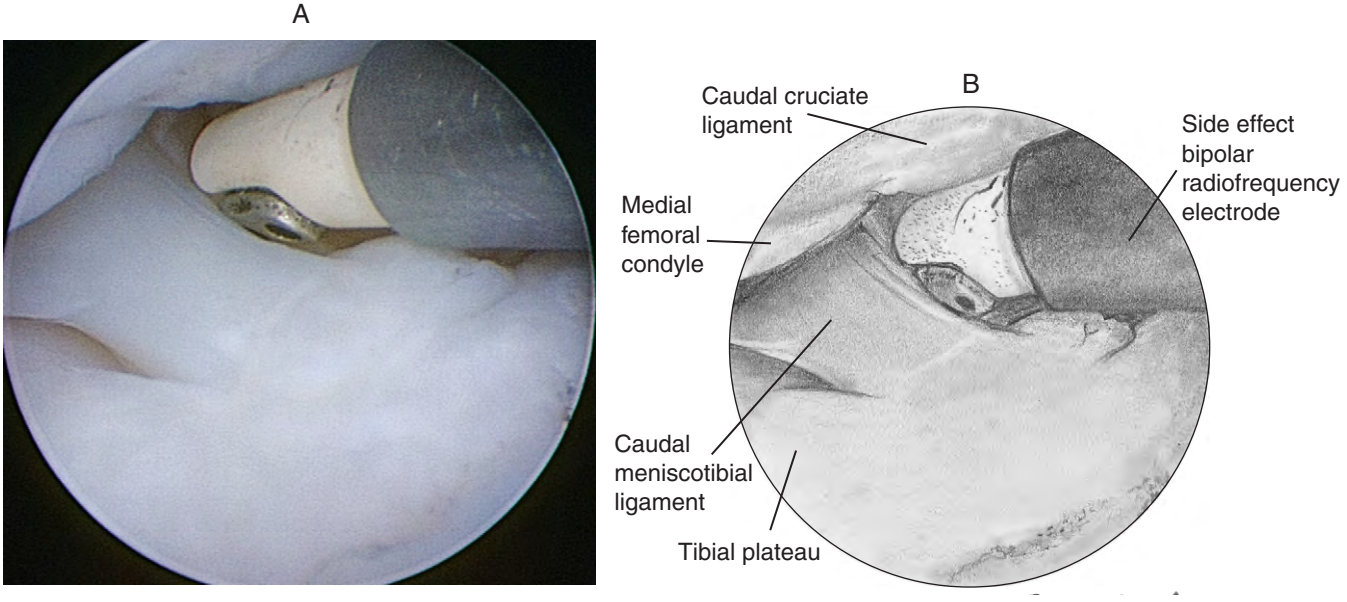



**Fig. 14-143**
The caudal meniscotibial ligament of the medial meniscus is most easily cut with radiofrequency using a 2.3-mm diameter side effect electrode. The electrode shafts are malleable and the tip is bent about 30 degrees to provide a better angle for application of the electrode to the ligament.

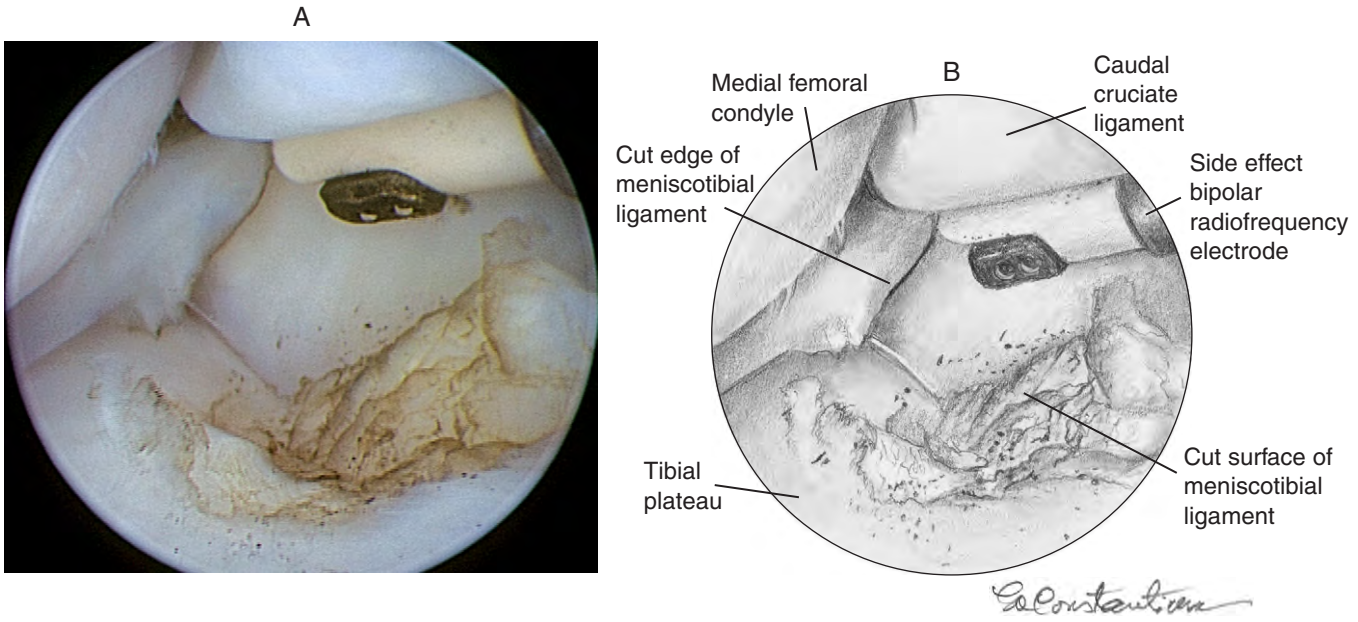



**Fig. 14-144**
Completed transection of the caudal meniscotibial ligament in Fig. 14-143.

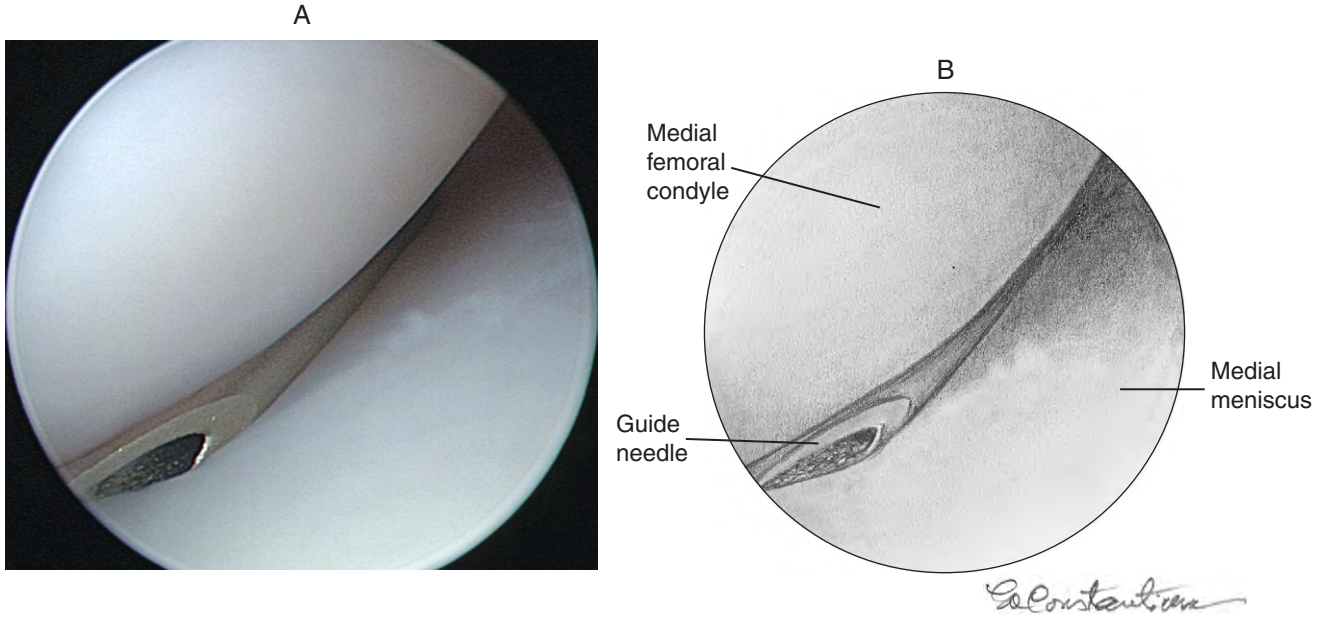



**Fig. 14-145**
Meniscal release with a radial midbody incision is guided by placement of a hypodermic needle caudal to the medial collateral ligament, directed craniomedially, and aligned with arthroscopy across the body of the medial meniscus.

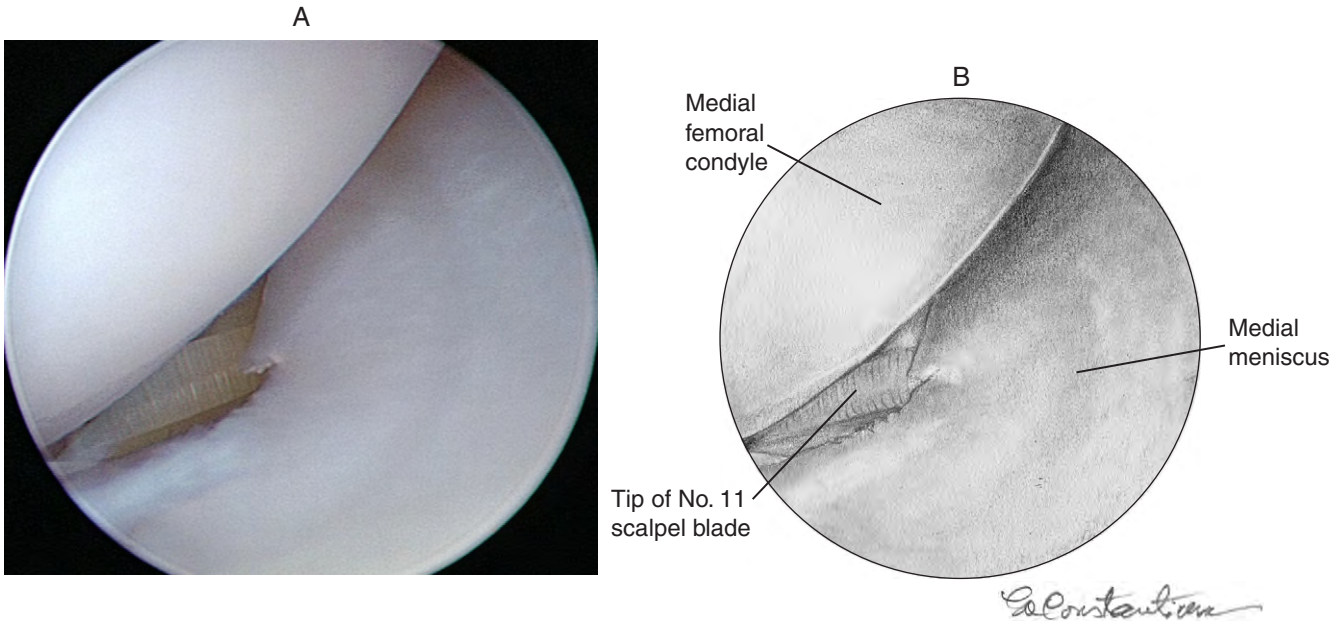



**Fig. 14–146**
A number 11 scalpel blade is inserted in the same plane as the needle to transect the meniscus.

remnants, for adequate meniscal debridement and release, and for the occasional inadvertently placed intraarticular screw.

## Caudal Cruciate Ligament Injuries

Injuries of the caudal cruciate ligament are rare. Caudal cruciate ligament injuries are commonly associated with trauma rather than with the idiopathic onset of cranial cruciate ligament injuries. Mild fraying of the caudal cruciate ligament can be seen with cranial cruciate ligament rupture and is clinically insignificant. Avulsion of the origin of the caudal cruciate ligament from the lateral aspect of the medial femoral condyle is occasionally seen in young dogs. If the fragment is large and the ligament is otherwise intact, the fragment can be reduced and stabilized with arthroscopic or open technique. If the fragment is small or is in multiple pieces, or if the caudal cruciate ligament is damaged, removal is performed. When a diagnosis of caudal cruciate ligament injury is made, complete examination of the stifle joint is conducted to rule out meniscal injuries, collateral ligament injuries, and cranial cruciate ligament injuries.

## Isolated Meniscal Injuries

Meniscal injuries are commonly seen with cruciate ligament ruptures, whether partial or complete, but meniscal injuries are rare in the absence of cruciate ligament injuries. The number of cases of isolated meniscal injuries that have been seen is inadequate to accurately classify the incidence and pattern of damage.

## Osteochondritis Dissecans

The stifle joint is an uncommon but defined location for OCD and lesions typically occur on the lateral condyle of the femur in young large breed dogs. Bilateral lesions are common, lesions may be seen on the medial femoral condyle, and diagnosis may not be made until dogs are older than the typical presentation interval. Signalment, history, and physical findings are insufficient to establish a diagnosis, but localization to the stifle joint can usually be achieved. Radiographs showing a condylar defect are diagnostic, but absence of a visible lesion in the presence of joint effusion does not rule out OCD and is sufficient indication for arthroscopy. Bilateral radiographs are recommended, even with no other evidence of bilateral involvement, and bilateral arthroscopy is pursued if there is any evidence of pathology in the asymptomatic stifle.

Arthroscopy for stifle OCD is performed with the patient in dorsal recumbency and with a craniomedial telescope portal, craniolateral operative portal, and a suprapatellar egress portal. OCD lesions are typically easily visible on the medial aspect of the central portion of the lateral femoral condyle as a loose flap of cartilage with easily defined margins (Fig. 14-147), although they can occasionally appear as soft or movable cartilage without loose or definable margins, as a frayed cartilage defect without a loose cartilage fragment, or as an irregular cartilage defect without a loose cartilage fragment. Villus synovial proliferation occurs with OCD in the stifle but is typically less than that seen with cruciate ligament injuries and is more localized to the area of the lesion.

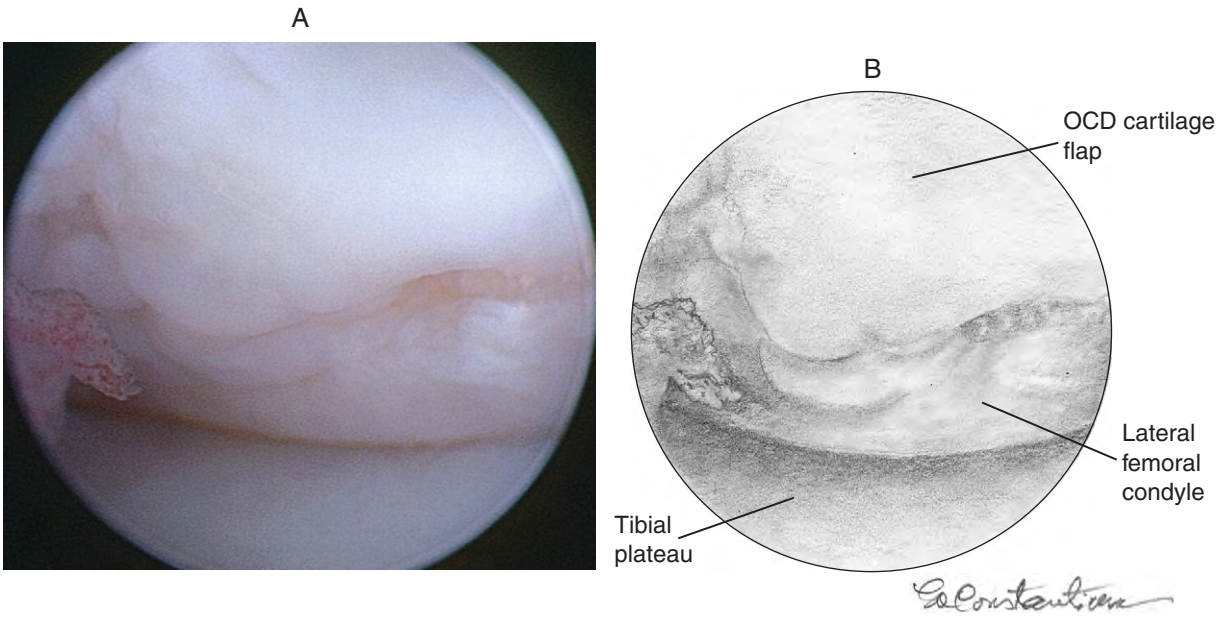



**Fig. 14–147**
An osteochondritis dissecans lesion on the lateral condyle of the femur.

Partial fat pad resection and cranial compartment partial synovectomy are performed to improve visualization of the femoral condyles and OCD lesion. Flexion of the joint brings the lesion into view and provides access for flap removal and bed debridement. Removal of the free flap is performed with a curved mosquito hemostat or with arthroscopic grasping forceps using technique similar to that for shoulder joint OCD. The cartilage defect is evaluated for residual loose cartilage fragments and the margin of the lesion is palpated with a hook probe for any remaining detached cartilage, which is then removed with hand instruments or a power shaver. Using a hand instrument or the shaver, the surgeon gently debrides the bed of the lesion to expose bleeding bone, being careful to avoid removing an excessive amount of bone (Fig. 14-148). Microfractures can be created in the debrided bed to enhance healing. The joint is irrigated thoroughly with saline and all compartments of the joint are examined for any residual loose fragments.

## Arthroscopic-Assisted Patellar Fracture Management

Patellar fracture management is facilitated with arthroscopy for assisting fracture reduction or removing small nonstructural fragments. For fracture reduction, arthroscopy is used to visualize the articular surface of the fracture and the cranial surface of the patella is opened for implant placement. The patient is placed in dorsal recumbency and standard arthroscopy portals are used. If the joint is opened for fracture reduction or by the injury, the telescope can still be used in the open joint.

## Long Digital Extensor Tendon Injuries

Avulsion of the origin of the long digital extensor tendon from its femoral attachment, partial tears, or complete ruptures are an uncommon but defined source of stifle joint pathology. Partial or complete injuries without bone avulsion appear similar to bicipital tendon injures or cruciate ligament injuries with visible ruptured fibers and can be acute or chronic in appearance. Avulsed bone fragments can be seen radiographically, are typically small when acute, and can enlarge with time. Tendon transection or removal of bone fragments can be achieved with arthroscopy. The patient is placed in dorsal or lateral recumbency and standard stifle portals are used. The operative portal may need to be enlarged for removal of large fragments.

## Cruciate Stabilization and Cruciate Prosthesis Failures

Breakdown of intraarticular stifle stabilization techniques are effectively evaluated arthroscopically (Fig. 14-149) and assessed with joint stress and manipulation with the hook. Loss of fascial strip integrity has the same appearance as cruciate ligament injuries (Fig. 14-150). Removal of the compromised tissue is performed with the same technique as is used for cruciate ligament debridement. Examination and removal of intraarticular implants is also performed with arthroscopic technique. Meniscal

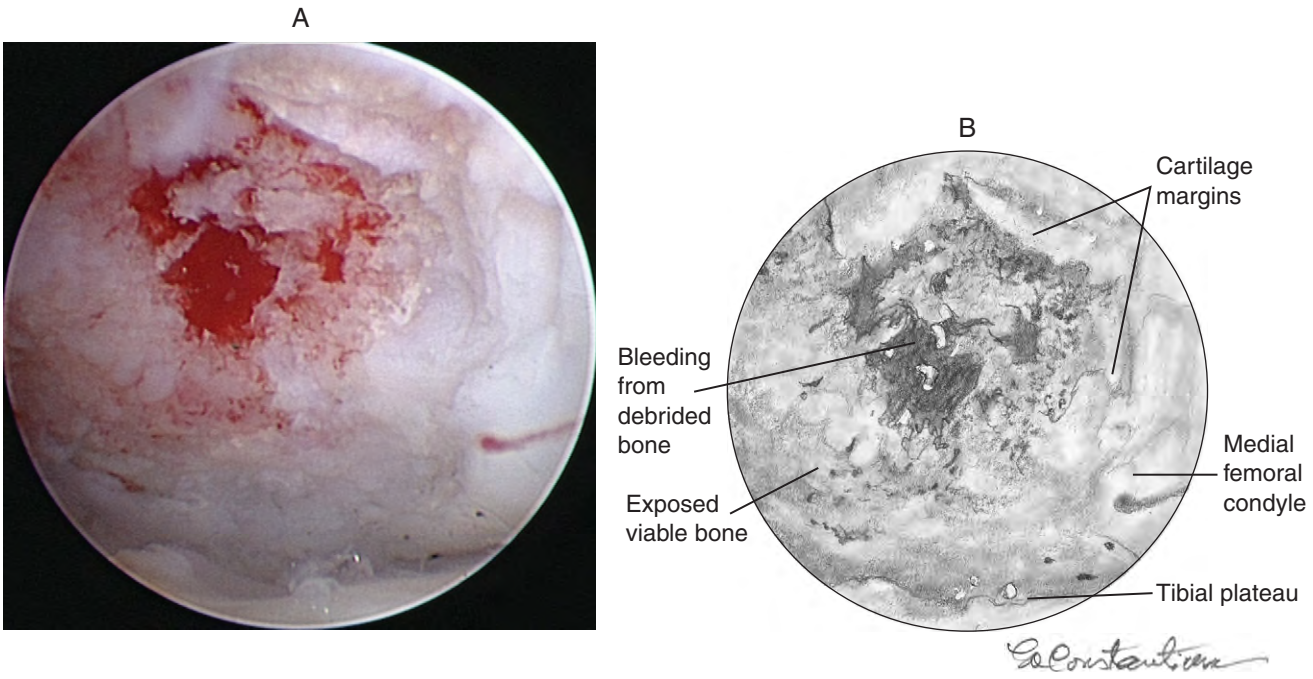



**Fig. 14–148**
An osteochondritis dissecans lesion after cartilage flap removal and debridement of the bed and margins of the lesion.

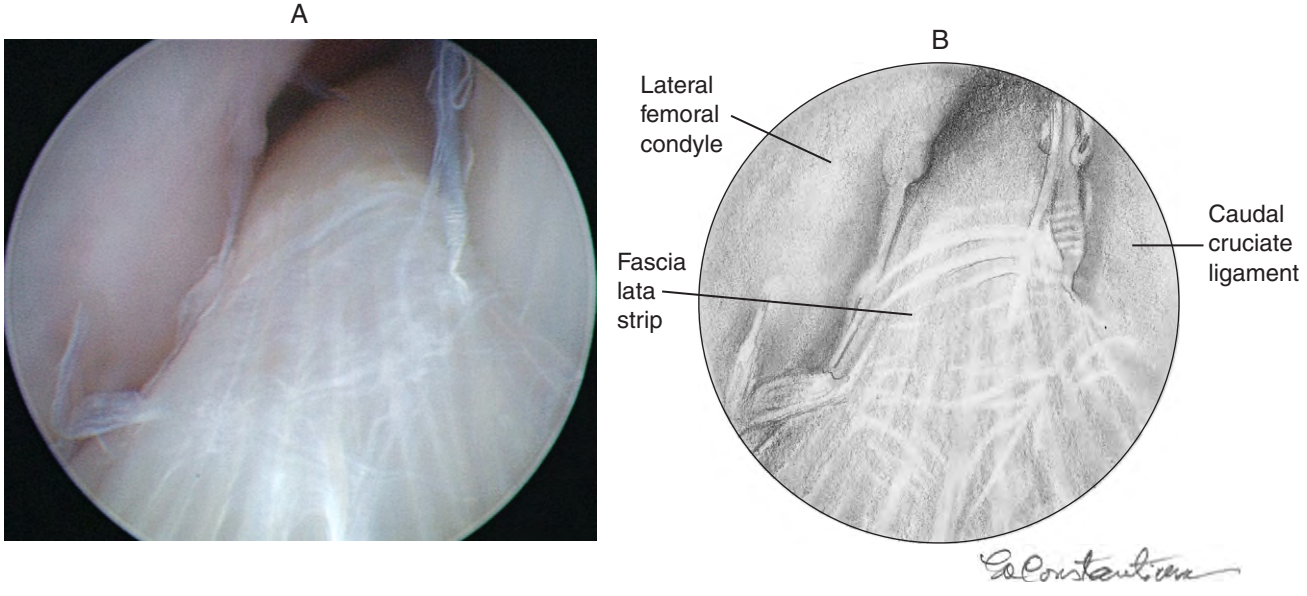



**Fig. 14–149**
A compromised fascia lata strip in the stifle of a dog with drawer instability after failure of the stabilization technique.

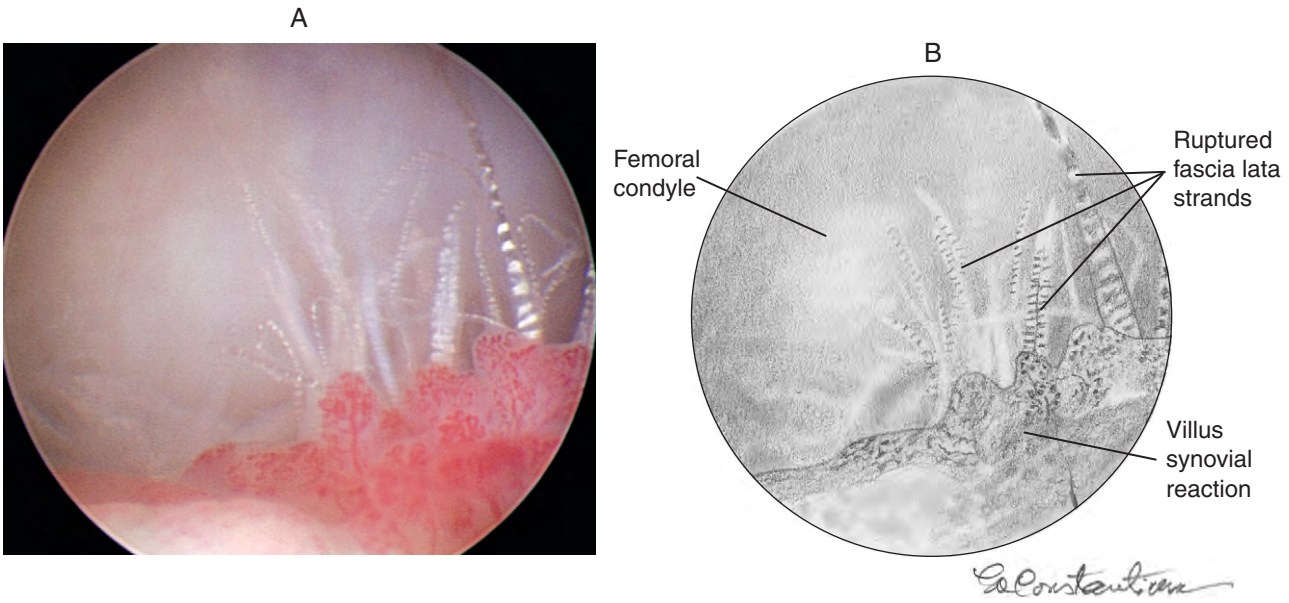



**Fig. 14–150**
Ruptured fascia lata strands from the stifle in Fig. 14-149 with the same appearance as ruptured strands of cranial cruciate ligament.

assessment is important in evaluation of these cases because a significant portion of the technique failure can be related to meniscal injuries that have occurred since the reconstruction was performed or that were overlooked at the time of open surgery. Reassessment of inadequate results with extracapsular stabilization techniques or with TPLOs is another application of arthroscopy, especially when the joint was not explored or debrided at the time of the previous surgery.

### Arthroscopic Biopsy of Intraarticular Neoplasia

Intraarticular neoplastic masses can be found with arthroscopy during stifle exploration in cases of lameness and stifle pain that do not have radiographic changes or only show soft tissue changes. Arthroscopy can also be used to obtain biopsy specimens of distal femoral epiphyseal or tibial plateau bone lesions seen on radiographs. In many cases, this is a less traumatic approach for obtaining biopsies than open surgical technique.

### Arthroscopic-Assisted Medial Patellar Luxation Correction

Transection of the medial femoropatellar ligament, medial patellar fibrocartilage, and medial retinaculum to release the medial constraints on the patella and to allow patellar realignment has been suggested for treatment of medial patellar luxation. There is inadequate information or case material available on this technique to determine long-term results, technique, or proper case selection criteria. Joint assessment before surgery is an indication for adding arthroscopy to the protocol for medial patellar luxation correction. Arthroscopy has been used to evaluate traumatic lateral femoropatellar ligament rupture and to remove a sequestered trochlear recession wedge.

### Degenerative Joint Disease, Chondromalacia, and Synovitis

DJD with associated cartilage and synovial changes is an unlikely primary diagnosis in the stifle joint and is most likely secondary to other defined joint pathology. If a primary cause is not obvious, a more thorough examination is warranted to definitively rule out early partial cranial cruciate ligament injuries, caudal cruciate ligament pathology, meniscal damage, long digital extensor tears, popliteal tendon ruptures, or other primary etiology.

## ARTHROSCOPY OF THE TIBIOTARSAL JOINT

### Indications

Arthroscopy of the tibiotarsal joint is indicated when there is hind leg lameness with pain, crepitus, or swelling or thickening of the tibiotarsal joint, or when radiographic changes suggest OCD, intraarticular fractures, or DJD. Tibiotarsal joint disease is commonly accompanied by significant joint swelling or thickening, making localization of the involved joint easier than with more

proximal joints. The tarsal joint is a suggested site for synovial biopsies to diagnose immune-mediated polyarthric disease.

## Patient Preparation, Positioning, and Operating Room Setup

Tibiotarsal joint arthroscopy can be performed as a unilateral or bilateral procedure based on the pathology. Dorsal recumbency is the position I most commonly use for the patient for both unilateral and bilateral procedures, with the patient's legs extended caudally and abducted or adducted for access to the medial or lateral aspects of the joint, respectively. The monitor is placed at the head of the table or obliquely on either side of the table far enough cranially to be out of the way of the sterile operative field. The surgeon stands at the foot of the table and the assistant stands on the side of the table of the joint that is being examined. For placement of two portals in the plantar aspect of the joint, the patient can be placed in ventral recumbency with the leg or legs extended off the caudal end of the table.[8]

## Portal Sites and Portal Placement

### Telescope Portals

All four quadrants of the tibiotarsal joint can be entered for arthroscopy. The portal selected for entry into the tibiotarsal joint depends on the location of the joint lesion. Telescope and operative portals are interchangeable at all sites.

Dorsomedial and dorsolateral portals are placed either medial or lateral to the long digital extensor tendon and the tendon of the cranial tibial muscle on the dorsal aspect of the joint (Fig. 14-151). To establish a dorsal tibiotarsal telescope portal, a 20-gauge, 1-inch needle is placed in the joint at the site of maximum joint capsule distention, joint fluid is aspirated, the joint is distended with saline, a stab incision is made with a number 15 scalpel blade at the needle site or on the other side of the extensor tendons, and the telescope cannula is placed into the joint using the blunt obturator.

Plantaromedial or plantarolateral portals are placed at the junction of the plantar margin of the distal tibial articular surface and the plantar portion of the trochlear ridge of the talus on their respective sides of the joint (Fig. 14-152). Joint capsule thickening secondary to joint pathology may make initial plantar joint entry difficult. In some cases of marked joint capsule thickening, the joint is entered with a miniarthrotomy rather than a true telescope portal. A miniarthrotomy is performed by making a stab incision through the skin, subcutaneous tissues, and joint capsule with a number 10 scalpel blade to make an incision into the joint. The telescope cannula is placed into the joint with the telescope in place and the joint is examined. The plantaromedial portal provides good access to plantar OCD lesions on the medial ridge of the talus and for removal of loose joint bodies from the caudal compartment of the joint.

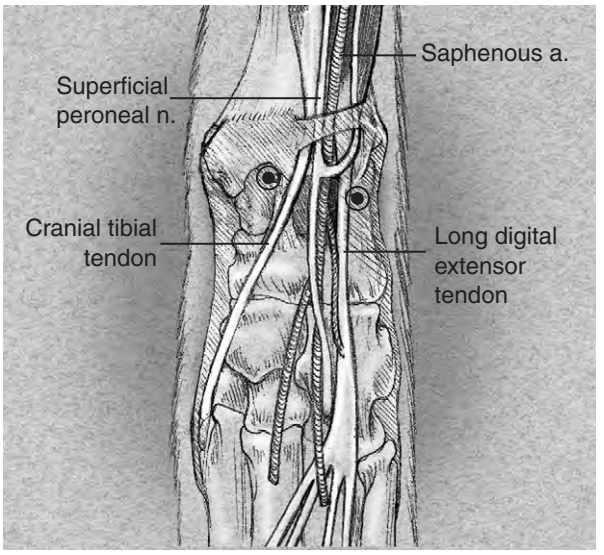



**Fig. 14–151**
Portal sites on the dorsal aspect of the tibiotarsal joint. The two portals shown (*circles*) are interchangeable telescope and operative portals. They are located distal to the dorsal margin of the distal tibial articular surface and are medial or lateral to the long digital extensor tendon, the tendon of the cranial tibial muscle, and the neurovascular bundle. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

### Operative Portals

Access to OCD lesions on the plantar portion of the medial ridge of the talus, the most common indication for tibiotarsal arthroscopy, is most easily achieved through a medial operative portal distal to the medial malleolus and immediately caudal to the collateral ligament (see Fig. 14-152). Limited space in the hock joint may preclude placing separate telescope portals and operative portals. In these cases, the miniarthrotomy performed at the selected telescope portal site is enlarged to serve as a combination portal with the telescope and as a site for instruments to be inserted through the same incision. On the dorsal aspect of the joint, the operative portal is established on the side of the extensor tendons not used for the telescope, with initial needle placement for locating the portal site if possible or with a simple stab incision through skin, subcutaneous tissue, and joint capsule.

To place two portals on the plantar aspect of the joint, the patient is placed in ventral recumbency and an operative portal is placed in the apposing corner of the joint

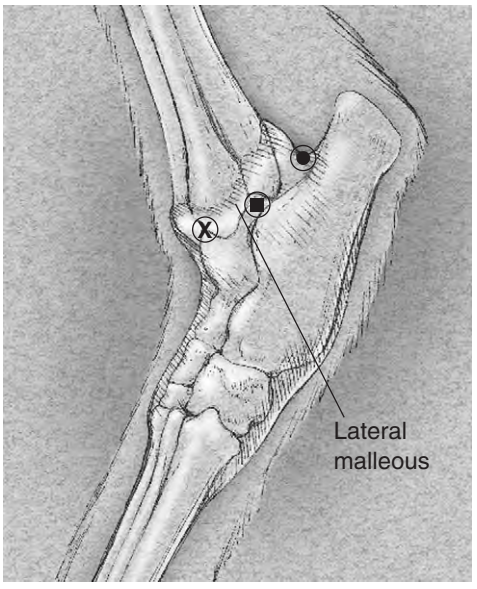



**Fig. 14-152**
Portal sites on the lateral aspect of the tibiotarsal joint. Medial portals are placed at the same respective locations on the medial aspect of the joint. The plantarolateral, or plantaromedial, telescope portal (*circle*) is placed at the junction of the plantar margin of the distal tibial articular surface and the plantar portion of the medial, or lateral, ridge of the talus. Operative portals can be placed as medial or lateral portals caudal to the collateral ligaments (*square*). An egress portal (*X*) or needle is placed if needed at the dorsolateral, or dorsomedial, telescope and operative portal site. *(Adapted from Freeman LJ, editor:* Veterinary endosurgery, *St Louis, 1999, Mosby.)*

from the telescope portal to achieve adequate access, visualization, and triangulation.[8] Access for operative instrumentation on the medial side of the joint can also be achieved with the medial operative portal as is used to access OCD lesions. On the lateral aspect of the joint, a lateral operative portal can be established or a plantarolateral miniarthrotomy can be used.

If needed, an egress cannula can be placed at any unused portal site, but the tibiotarsal joint is very small and in many cases there is not enough room for three portals. Egress is most commonly through a 20-gauge needle placed at an unused portal site, the operative portal, or a miniarthrotomy incision.

## Examination Protocol and Normal Arthroscopic Anatomy

The anatomy that is seen, structures used for orientation, and examination protocol vary by the portals that are used. The tibiotarsal joint is small, normally allowing minimal joint distraction for examination and manipulation, and the joint capsule is too close to the bony structures of the joint to allow retraction of the arthroscope for a wide visual field. Multiple portals may be required for complete examination of tarsal joint pathology.

Orientation is established upon entering the tibiotarsal joint using the concave distal articular surface of the tibia and the ridges of the convex proximal articular surface of the talus (Figs. 14-153 and 14-154). Space within the tibiotarsal joint is limited and examination requires careful manipulation of the joint through flexion and extension with varus and valgus stress and with small movements of the telescope in depth, angle, and rotation. The distal articular surface of the tibia and the proximal surface of the talus (see Fig. 14-153), the dorsal or plantar margins of the distal tibial articular surface (see Fig. 14-154), and the dorsal or plantar joint space are examined. Transposing the telescope among portal locations facilitates complete examination of the joint.

## Diseases of the Tibiotarsal Joint Diagnosed and Managed with Arthroscopy

### Osteochondritis Dissecans

OCD is the most common arthroscopic diagnosis in the tarsal joint and can be either unilateral or bilateral. Tibiotarsal OCD lesions occur most commonly on the plantar aspect of the medial ridge of the talus but can also occur on the plantar aspect of the lateral ridge and dorsally on either the medial or lateral ridge. Plantaromedial lesions typically contain bone and are large relative to the size of the joint (Fig. 14-155). Significant villus synovial reaction is typically present, especially with plantar lesions, adding to the difficulty of the arthroscopic procedure (Fig. 14-156). Preoperative radiographs are obtained to establish a tentative or definitive diagnosis, to evaluate for bilateral disease, and to localize the lesion. Bilateral arthroscopy is performed at the same time if bilateral lesions are found. Lesions on the plantar aspect of the medial ridge of the talus are approached with a plantaromedial telescope portal and a medial operative portal or a plantaromedial miniarthrotomy. The lesion is visualized (see Fig. 14-155), and the loose fragment is elevated if needed, grasped (Fig. 14-157), and removed. Minimal debridement of the defect is done with removal of loose fragments from the margin and within the bed of the lesion. These plantaromedial OCD lesions are typically large relative to the size of the joint and leave a deep defect in the ridge of the talus (Fig. 14-158). Extensive debridement with curettage or with a power shaver has a potential detrimental effect on long-term results. Dorsal OCD lesions of the talus are typically smaller (Fig. 14-159) than plantar lesions and are approached through dorsal portals with loose fragment removal and defect debridement.

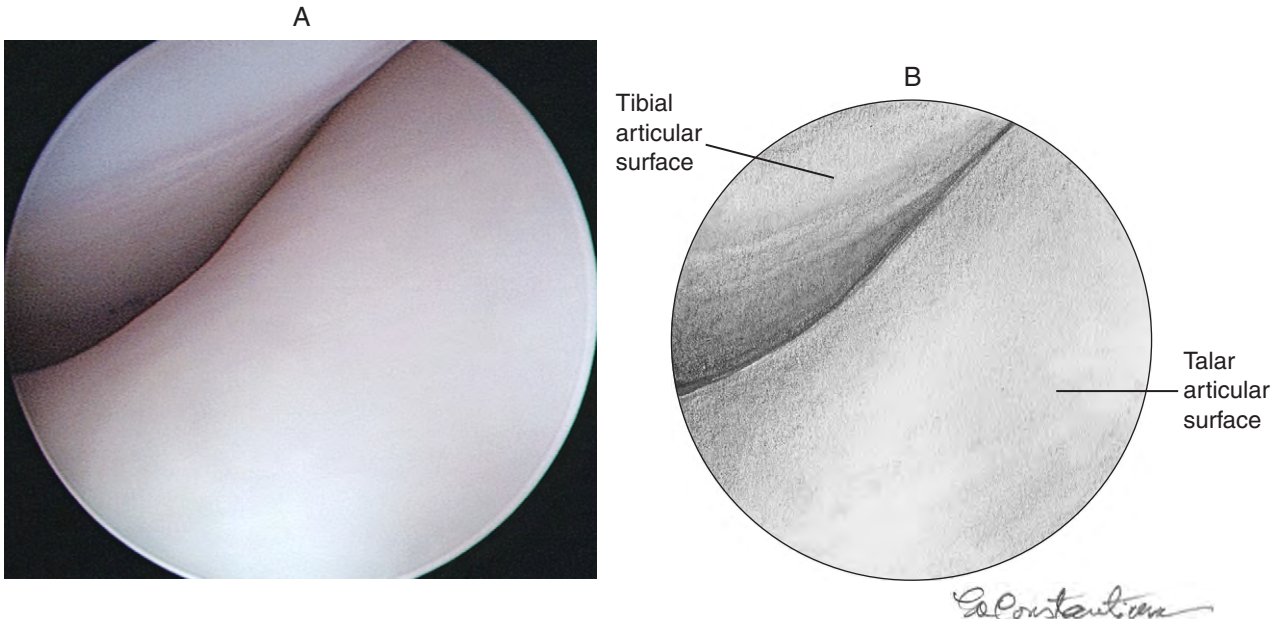



**Fig. 14–153**
The distal articular surface of the tibia and the proximal articular surface of the talus.

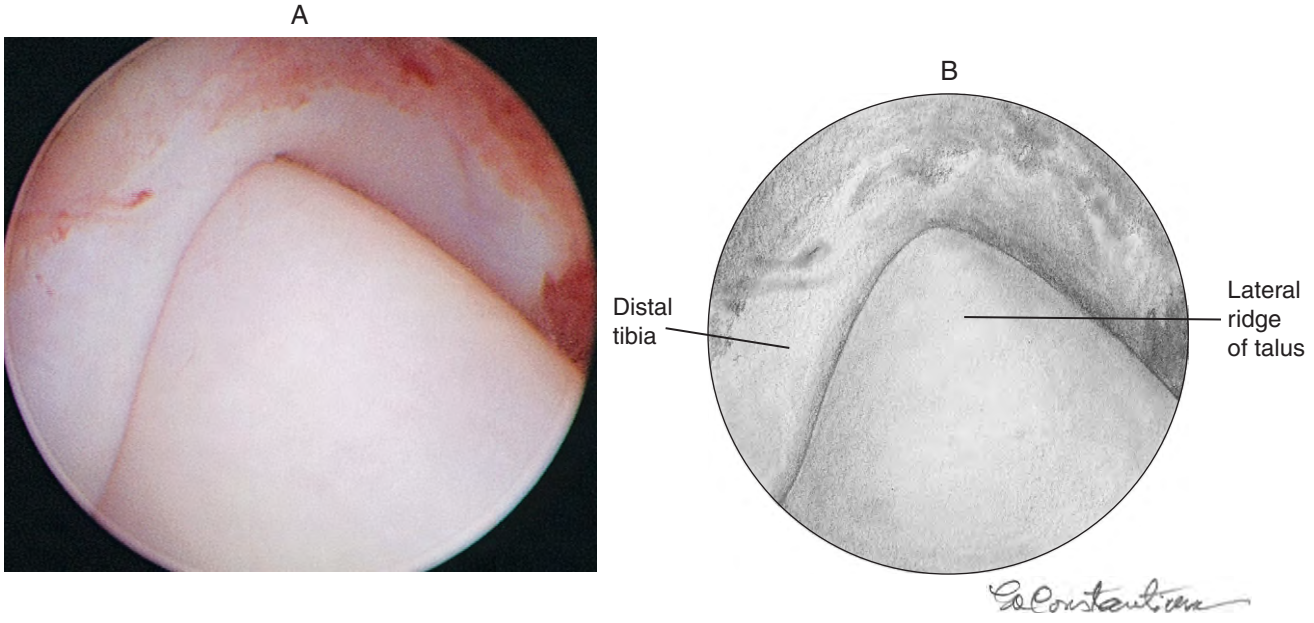



**Fig. 14–154**
The caudal margin of the distal tibial articular surface and the plantar portion of the lateral ridge of the talus.

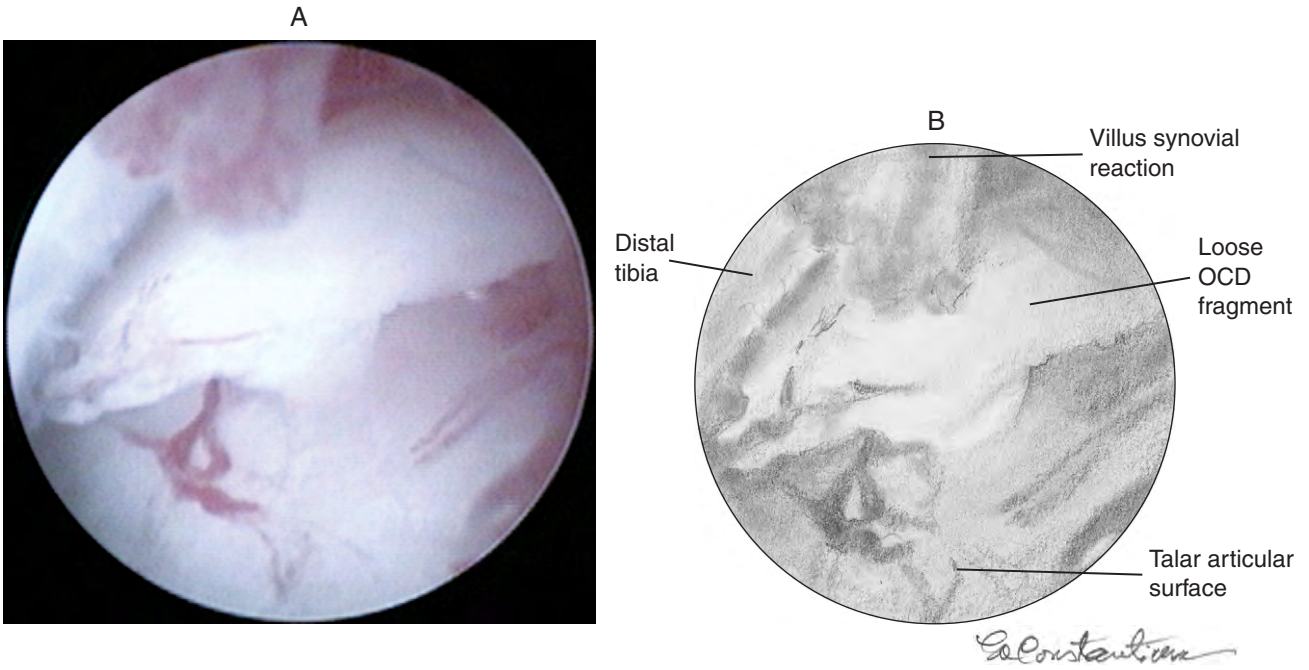



**Fig. 14–155**
A large, loose osteochondritis dissecans fragment containing bone and cartilage in the plantar portion of the medial ridge of the talus.

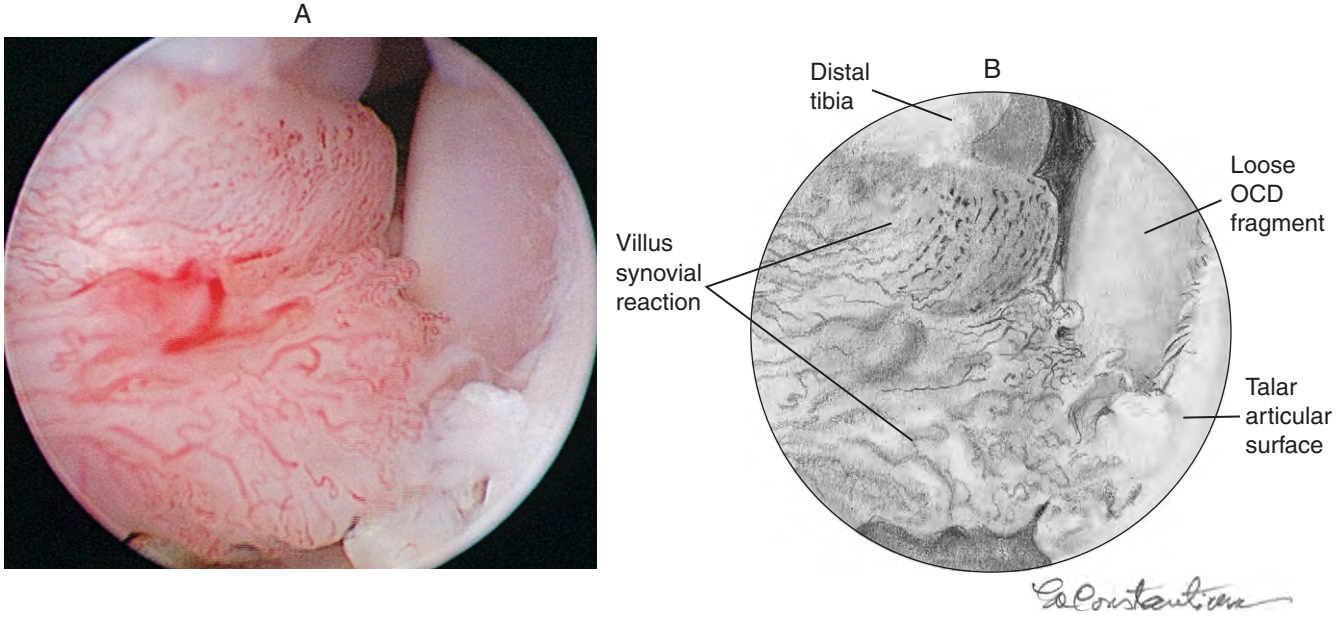



**Fig. 14–156**
Extensive villus synovial reaction in the plantar joint compartment of a tibiotarsal joint with a plantar osteochondritis dissecans lesion.

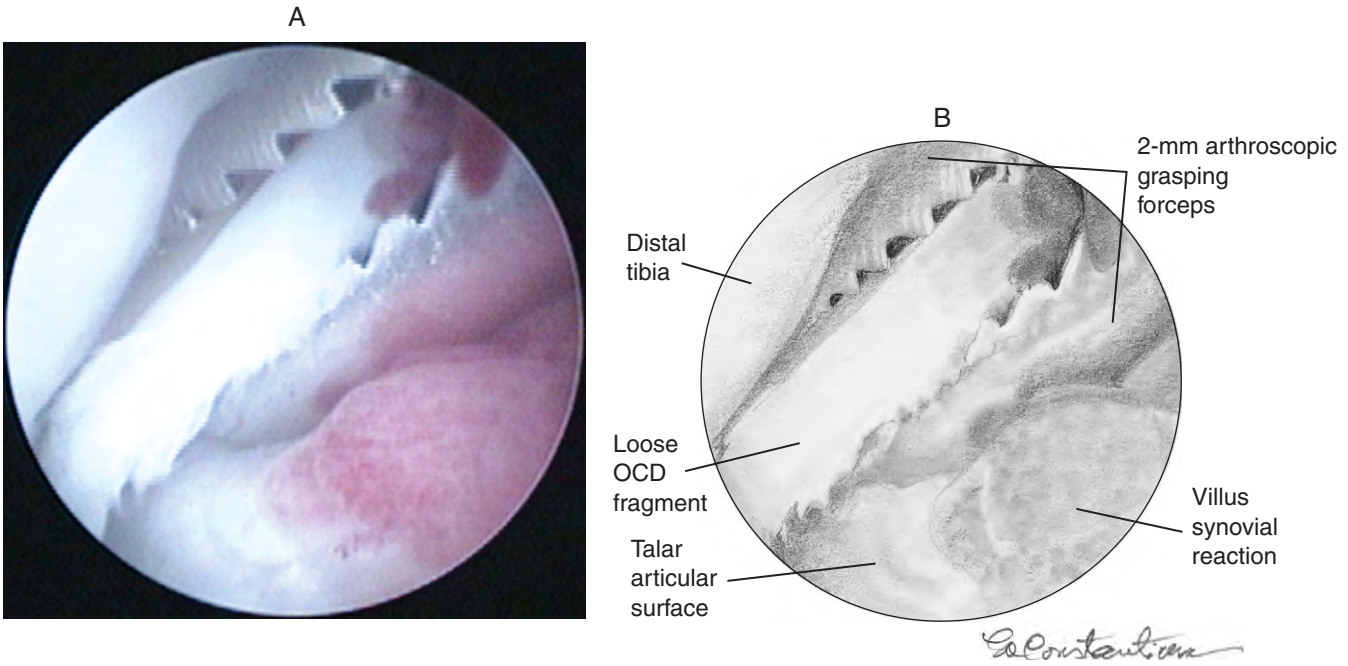



**Fig. 14–157**
Removing the large, loose plantar osteochondritis dissecans osteochondral fragment seen in Fig. 14-155 from the medial ridge of the talus with 2-mm arthroscopic grasping forceps.

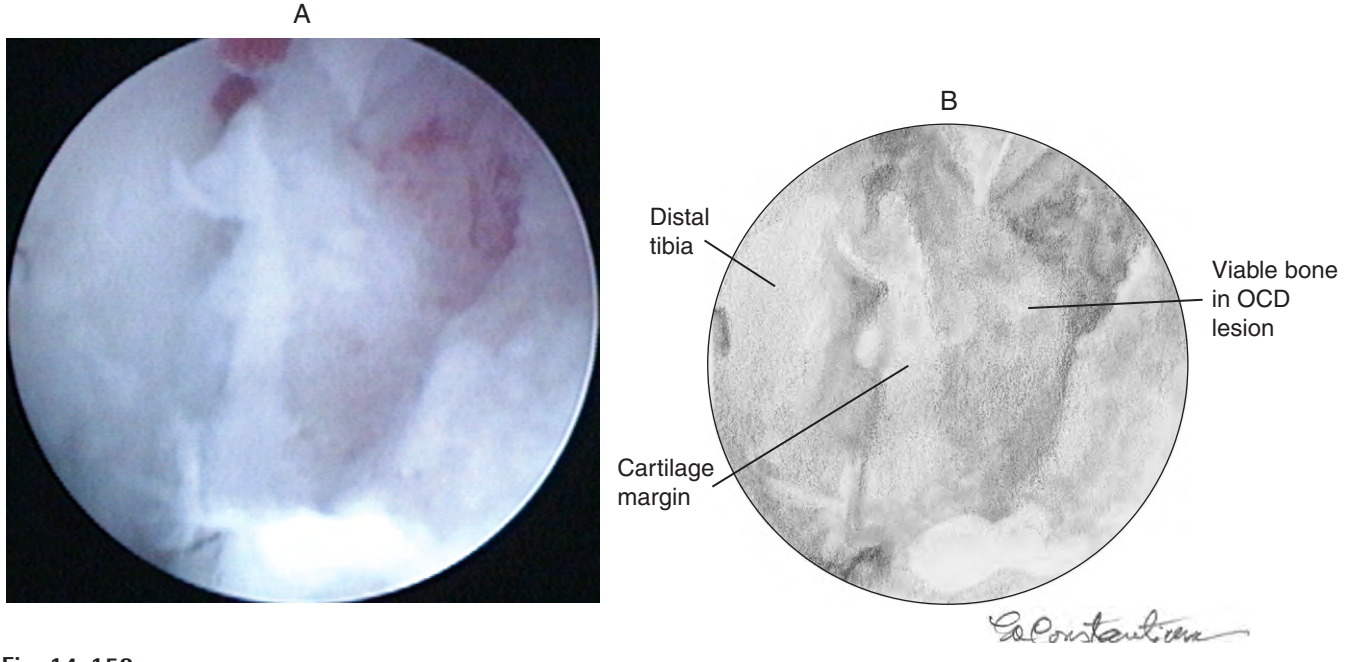



**Fig. 14–158**
The defect in the medial ridge of the talus following removal of the lesion in Figs. 14-155 and 14-157.

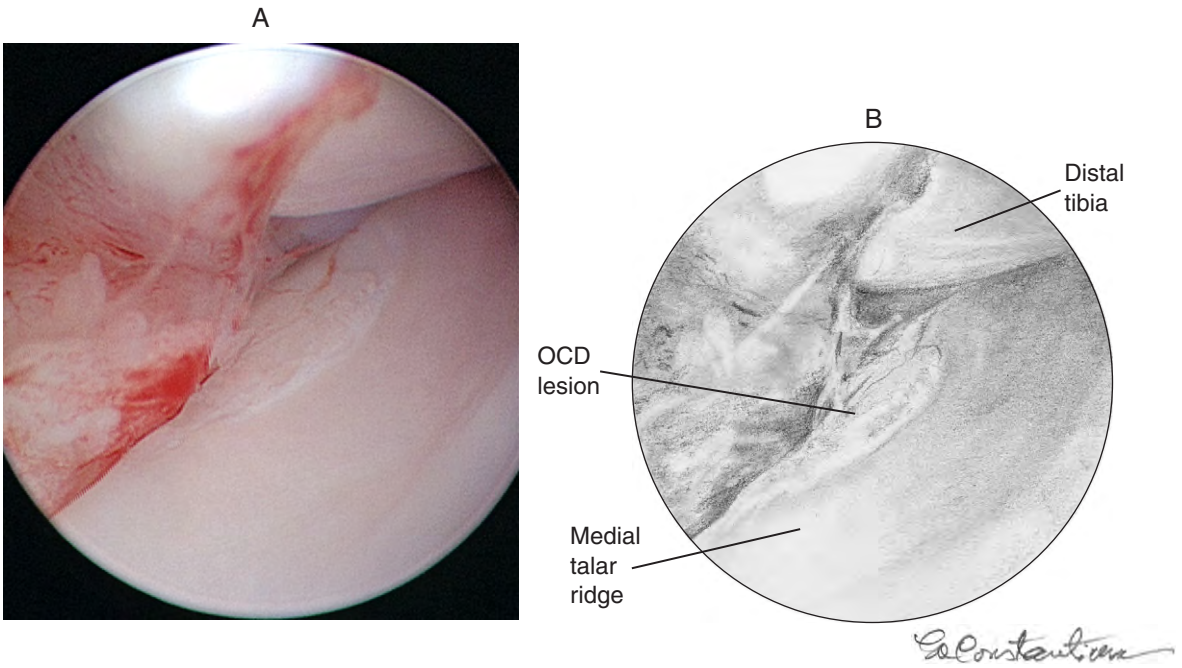



**Fig. 14-159**
A typical small osteochondritis dissecans lesion on the dorsal aspect of the medial ridge of the talus.

Osteophytes commonly form over these dorsal OCD lesions and can be larger than the OCD lesion.

### Arthroscopic-Assisted Intraarticular Fracture Management

Evaluation and management of intraarticular fractures of the talus can be assisted with arthroscopy for diagnosis, to facilitate decision making for treatment options, for removal of small fragments (Fig. 14-160), and for improved visualization of the intraarticular fracture line when fracture repair is selected as the treatment option.

### Soft Tissue Injuries

All of the soft tissue structures in and around the tarsal joint can be injured, and arthroscopy provides a minimally invasive approach for diagnosis and assisting in selecting and planning open operative procedures. Extensive ligament injuries are not managed with arthroscopy and require open surgical stabilization with ligament reconstruction, tarsal fusion, or external splint support.

### Arthroscopic Diagnosis of Immune-Mediated Erosive Arthritis

Arthroscopy is an effective method for joint examination and biopsy specimen collection in cases of suspected immune-mediated arthritis.

### Degenerative Joint Disease

Cartilage wear lesions are seen in the tibiotarsal joint without an indication of primary etiology. These appear similar to the wear lesions seen in the elbow joint with "incongruity" and may be an indication of similar pathology in the tibiotarsal joint or may be a manifestation of old untreated OCD lesions or old fractures. These lesions can be seen on the medial or lateral ridges of the talus, on the distal articular surface of the tibia, or on both surfaces (Fig. 14-161).

## PROBLEMS AND COMPLICATIONS

Significant complications are uncommon with arthroscopy in small animals. In my experience of arthroscopy done in more than 1000 joints, there have been only three cases of suspected nerve irritation. In these three cases, the patient experienced excessive postoperative pain for approximately 6 weeks; none exhibited any functional nerve deficits and all three cases resolved completely with time.

Additional actual and potential complications of arthroscopy include the following:

1. Failure to enter the joint: Inability to establish telescope or operative portals prevents performing the procedure. This is a common complication for beginners and becomes much less common with experience.

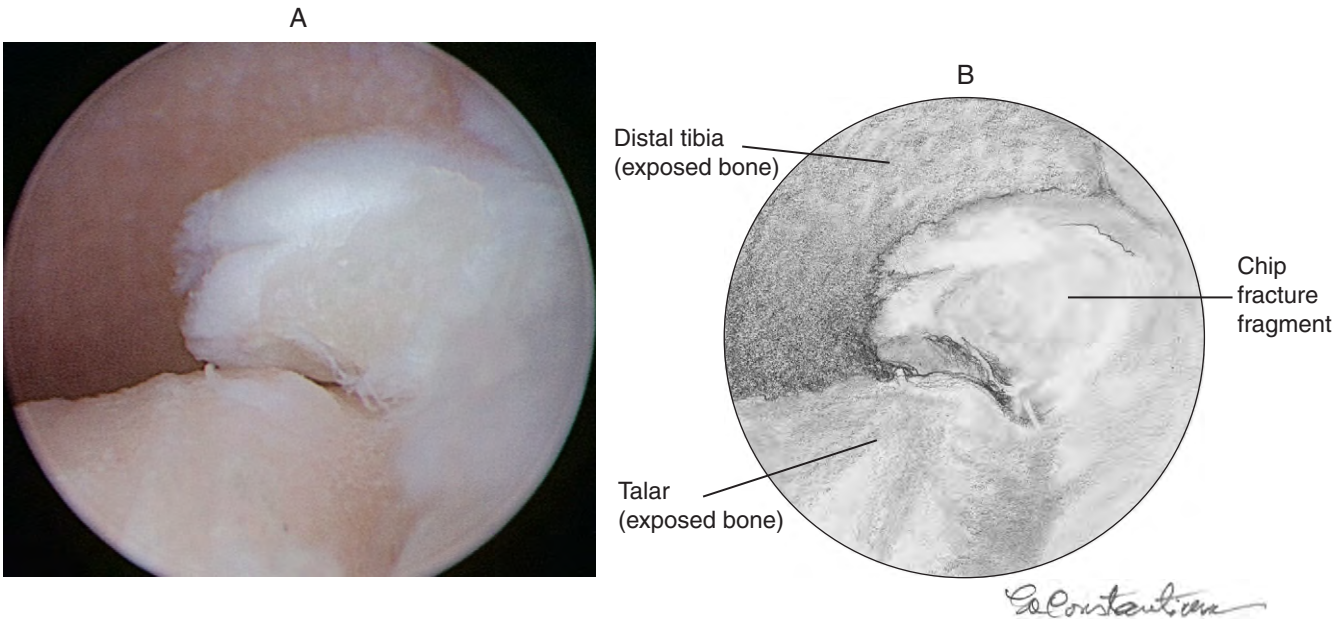



**Fig. 14–160**
An intraarticular fracture fragment in the tibiotarsal joint. The fragment was removed with arthroscopy. The cartilage has been worn off of the portions of the articular surfaces of the distal tibia and talus that are visible in this image.

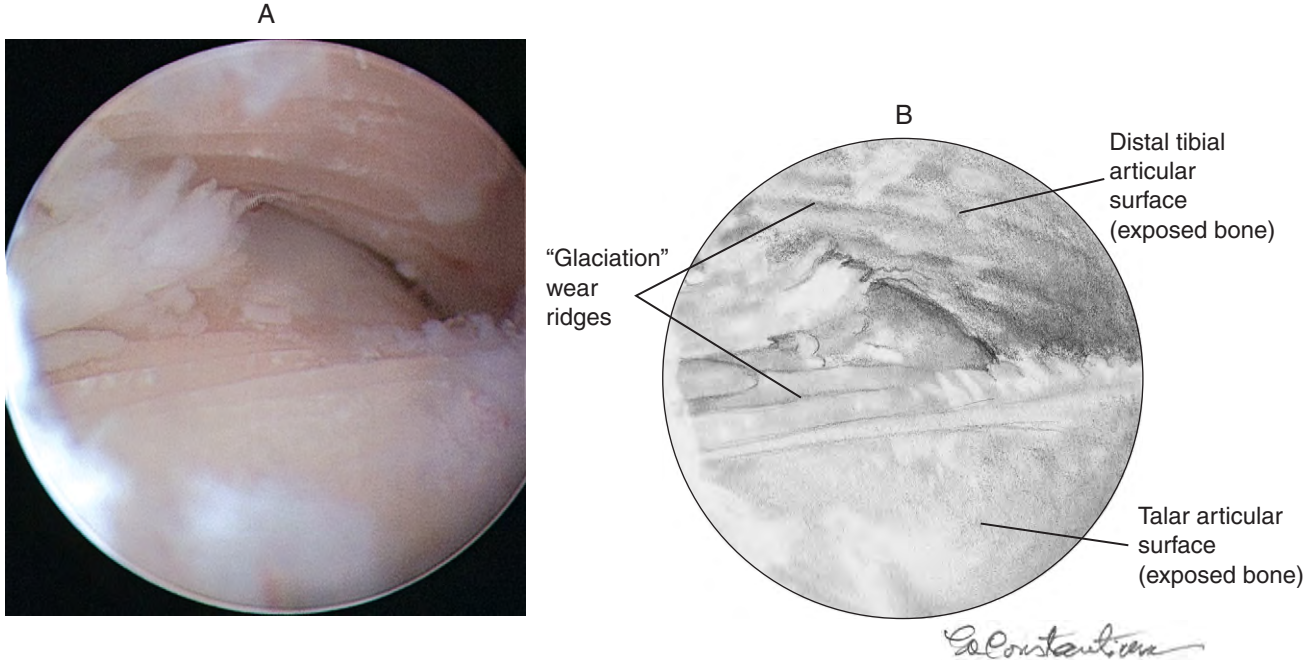



**Fig. 14–161**
Severe wear lesions in the tibiotarsal joint involving an extensive area of both articular surfaces. Bone wear in this joint shows a "glaciation" wear pattern similar to the cartilage wear described for the elbow joint.

2. Articular cartilage damage: This is also common in early cases for the beginner and decreases with experience. Most articular cartilage damage is of limited significance and is difficult to find without the magnification of the arthroscope. Minimizing articular cartilage damage is important, but the small amount of cartilage damage is much less than occurs with an open arthrotomy. Arthroscopy is also much less traumatic to periarticular tissues than an open arthrotomy.
3. Periarticular fluid accumulation: Extravasation of fluid around joints interferes with arthroscopy by collapsing the joint capsule and obscuring visualization. This fluid is readily reabsorbed and rarely causes a problem for the patient.
4. Infection: Iatrogenic infection is reported in the human literature as a complication of arthroscopy,[1] but it has not occurred in arthroscopy I have performed in more than 1000 joints.
5. Vascular injury: Vascular injury is also reported in the human literature as a complication of arthroscopy.[1] Damage to small subcutaneous vessels has occurred infrequently in small animal patients, but there have not been any cases of significant vessel damage or blood loss. Interference with visualization can occur when blood enters the joint from injured periarticular vessels.
6. Nerve injury: Damage to nerves is the most serious complication of arthroscopy.

## Nerves at Risk during Canine Arthroscopy

### Shoulder Joint (Lateral Telescope Portal)—Suprascapular Nerve

The suprascapular nerve courses around the cranial aspect of the scapula, across the lateral aspect of the scapular neck distal to the end of the scapular spine, and lies approximately 1 cm dorsal to the margin of the glenoid. This is the most commonly injured nerve in human shoulder arthroscopy.[1] A common mistake made by beginners in small animal shoulder arthroscopy is to miss the joint when inserting the telescope cannula and slide dorsally along the lateral aspect of the scapular neck. When this happens, the suprascapular nerve is at risk.

### Shoulder Joint (Caudolateral Operative Portal)—Axillary Nerve

The axillary nerve runs with the axillary artery across the caudal aspect of the shoulder joint from dorsomedial and goes distal and lateral around the joint capsule. This places the nerve in close proximity to the operative portal site used for removal of OCD lesion of the humeral head and removal of UCGOC fragments. This nerve can be damaged when there is difficulty establishing this operative portal.

### Elbow Joint (Medial Telescope Portal)—Ulnar Nerve

The ulnar nerve courses along the cranial border of the medial head of the triceps on the medial aspect of the epicondyle to cross the caudomedial portion of the elbow joint and continue distal on the caudal portion of the medial aspect of the ulna. This places the nerve within 1 cm of the telescope portal. A frequent error made in attempting to enter the elbow joint is to be too far caudally and slide away from the joint on the medial surface of the ulna. The ulnar nerve is at risk when this occurs.

### Elbow Joint (Craniomedial Operative Portal)—Median Nerve

The median nerve crosses the medial extent of the flexor surface of the elbow joint, deep to the craniomedial flexor muscles, in close proximity to the medial collateral ligament. This is within 1 cm of the operative portal, but because the location of this portal is accurately established by intraarticular observation of needle placement, little risk is involved.

### Elbow Joint (Craniolateral Telescope Portal)—Radial Nerve

The deep branch of the radial nerve crosses the flexor surface of the elbow joint, cranial and medial to this portal, and deep to the extensor muscles. Correct placement of this portal is into the protrusion of the distended craniolateral joint capsule at the junction of the articular surfaces of the capitulum and the radial head. There is little risk for radial nerve damage when the portal is properly placed at this location. Inadequate distention of the joint before portal placement or cranial displacement of the insertion site can cause the cannula to slide medial on the cranial surface of the joint capsule. The radial nerve is at risk when this occurs.

### Carpal Joint (Dorsal Telescope and Operative Portals)—Lateral Branch of the Superficial Radial Nerve

This nerve, along with the cranial superficial antebrachial artery and the accessory cephalic vein, lies between these two interchangeable portals on the dorsal aspect of the joint. At the level of the carpal joint, this nerve contains only sensory fibers. The combined neurovascular bundle can be palpated and avoided when establishing these portals.

### Hip Joint (Dorsal Telescope Portal and Caudal Egress Portal)—Sciatic Nerve

The sciatic nerve lies a sufficient distance from the hip joint that there is little risk of damage during placement of the dorsal telescope portal. Egress portal placement is performed by locating the portal site with a needle using intraarticular observation with the telescope. Again, there is little risk.

### Stifle Joint

There are no significant nerves in proximity to the current stifle joint portals.

### Tibiotarsal Joint (Dorsal Telescope and Operative Portals)—Superficial and Deep Peroneal Nerves

The superficial and deep peroneal nerves, the cranial tibial artery, the cranial branch of the saphenous artery, and the cranial branch of the saphenous vein all cross the dorsal aspect of the tibiotarsal joint. At the level of the tibiotarsal joint, the nerves are primarily sensory, although they do contain fibers that supply muscles in the paw. The combined neurovascular bundle with the tendons of the cranial tibial and long digital extensor muscles can be palpated on the dorsal aspect of the joint and avoided when making these portals, thus minimizing the possibility of nerve damage.

### Tarsal Joint (Plantar Telescope and Operative Portals)—Tibial Nerve

The termination of the tibial nerve and the caudal branch of the saphenous artery run caudal to the tibia and medial to the calcaneus. They are caudomedial to the plantaromedial telescope portal. The operative portal for OCD lesions on the caudomedial ridge of the talus is on the medial aspect of the joint away from the dorsal and plantar neurovascular structures.

## CONTRAINDICATIONS

Small patient? The size of patient that can be examined with arthroscopy is only limited by instrumentation and the operator's ability. Arthroscopy has been successfully performed in the hip and stifle of dogs as small as 7 pounds and in the stifle and shoulder of cats.

Joint sepsis? Irrigation is a recommended treatment for septic arthritis and extensive irrigation is done when arthroscopy is performed.

As for any surgical procedure, all the standard concerns for anesthesia exist, but there are no specific anesthetic contraindications for arthroscopy.

## REFERENCES

1. Andrews JR, Timmerman LA, editors: *Diagnostic and operative arthroscopy,* Philadelphia, 1997, WB Saunders.
2. Arciero RA and others: Irrigating solutions used in arthroscopy and their effects on articular cartilage, *Orthopedics* 9:1511-1515, 1986.
3. Reagan B and others: Irrigation solutions for arthroscopy, a metabolic study, *J Bone Joint Surg* 65A:629-631, 1983.
4. Bert JM and others: Effects of various irrigating fluids on the ultrastructure of articular cartilage, *Arthroscopy* 6:104-111, 1990.
5. Jurvelin JS and others: Effects of different irrigation liquids and times on articular cartilage: an experimental, biochemical study, *Arthroscopy* 10:667-672, 1994.
6. Gradinger R and others: Influence of various irrigation fluids on articular cartilage, *Arthroscopy* 11:263-269, 1995.
7. Freeman LJ, editor: *Veterinary endosurgery,* St Louis, 1999, Mosby.
8. Beal BS and others: *Small animal arthroscopy,* Philadelphia, 2003, WB Saunders.
9. Ralphs SC, Whitney WO: Arthroscopic evaluation of menisci in dogs with cranial cruciate ligament injuries: 100 cases (1999-2000), *J Am Vet Med Assoc* 221:1601-1604, 2002.

# 15 Looking Forward in Rigid Endoscopy

Ronald J. Kolata

The MAS* "revolution" began in the late 1980s in human surgery, catalyzed by the advent of the charge coupled device (CCD) chip that allowed miniaturization of video cameras. This technologic advance allowed a surgeon using an existing laparoscope to stand upright while viewing, on a video monitor, what before he or she squinted at with one eye, holding the scope, while hunched over the patient. Having the image on a video screen also allowed an assistant to simultaneously view the same image as the surgeon. Thus the surgeon was free to use both hands to perform procedures and was able to have a surgical assistant provide appropriate assistance. Some surgeons accepted this as a revolutionary step in surgery. Patients saw advantages in having surgery performed through small ports: There were no big incisions and there was less postoperative pain. These features of MAS caused a groundswell of lay acceptance for this type of surgery. Competition then accelerated the change. Surgeons and hospitals that provided MAS gained patients at the expense of those who did not. The medical-surgical device industry soon began supplying devices and instruments specifically designed to meet the needs of MAS. Still, there are many needs that are not yet met, preventing MAS from being used in performing many complex procedures. The deficiencies of current technology must be overcome before MAS will meet its initial promise. In human and veterinary medicine the future of MAS depends on a number of interconnected factors: technology, economics, and patient needs.

## IMAGING TECHNOLOGY

### Cameras

The ability to conveniently obtain a video image with sufficient clarity and definition was the key to the beginning of MAS, and visualization continues to be an important factor for improvements in MAS. Video cameras using CCDs are the standard means of obtaining images for MAS. Image quality of these devices has improved greatly. Cameras used for MAS are in their sixth generation and have improved from a single CCD chip camera having 600 lines of resolution to cameras using three CCD chips and having up to 1100 lines of resolution.[1,2] In addition, three-chip cameras provide better color reproduction, because each chip registers only one color (red, green, or blue) rather than having one third of the pixels of a chip registering one color as in a single-chip camera. Further advances in camera image quality depend on developments in miniature circuit technology. Because this technology is driven by a multitude of needs in a wide range of human activities (e.g., home video cameras), improvements will continue.

In addition to CCD chips, complementary metal oxide semiconductor (CMOS) chips are used to obtain images (ST Microelectronics, Geneva, Switzerland). CMOS chips presently do not give the resolution of CCD chips but have advantages of requiring less off-chip circuitry, requiring less power, and putting out a digital signal that does not have to go through a processor before it can be fed to a monitor. These attributes of CMOS chips coupled with light-emitting diode (LED) technology offer the possibility of giving surgeons low-cost, battery-powered scopes.

### Monitors

In addition to the quality and resolution of cameras, the resolution of monitors is an important contributor to the quality of the image seen. Analog television monitors with 600- by 480-pixel screens have been replaced by high-resolution digital computer monitors, either cathode ray tube (CRT) or LED flat screens, having 1240 by 1060 pixels per screen.[2] Unlike old monitors, new monitors display digitized rather than analog output from the camera, thus greatly improving image quality and providing the surgeon with a more realistic image and greater detail. Size and power requirements elicit one problem associated with the presently used monitors, that

*In this chapter, rigid endoscopy (either laparoscopy or video-assisted thoracic surgery) is referred to as minimal access surgery (MAS) to avoid multiple and confusing terms. MAS presently depends, in large part, on rigid endoscopes and therefore the future of rigid endoscopy depends on developments in MAS.

is, the disruption of the natural motor and visual axis of the surgeon performing an MAS procedure.[3] Presently the surgeon stands looking up and away from the direction of the activity of his or her hands. Having the motor and visual axes decoupled (hands working in a direction not where the surgeon is looking) creates fatigue and reduces the dexterity and efficiency of manipulations. The use of flat panel displays partially addresses this problem by allowing the display to be moved to positions that are less fatiguing for the surgeon and assistant. ViewSite (Storz, Germany), a patented system in development, projects the video image on a sterile screen that can be placed on the patient, allowing the surgeon to look down at the area where he or she is working. A similar but more advanced system is the suspended image system (Thorn-EMI, Hayes, Middlesex, UK). Two retroreflectors and a beam splitter create an image that appears to be projected on the patient. Both of these systems address some of the conditions that make videoscopic surgery difficult and fatiguing. Such systems may come into general use; they will compete with a more versatile and less complex technology, that is, organic LED-based screen technology (Universal Display Corp., Ewing, NJ). This technology uses organic molecules that can be stimulated to emit light of various colors. Screens made of these materials can be thin, flexible, robust, and lightweight. Being thin and flat, these screens will be placed wherever the surgeon finds most advantageous during a given procedure.

## Telescopes

The present rod lens system used in rigid endoscopes is bulky and delicate and produces distortion of the edge of the image because of the fisheye lens needed to provide a panoramic view. Using a conventional biconvex lens system and placing a miniature CCD or CMOS chip just behind the lens can overcome some of these disadvantages.[4] If a bundle of optical fibers is used to transmit light, the telescope can be flexible, thus allowing it to be more versatile and eliminating the need for separate straight and angled scopes.

Digital processing also eliminates distortion associated with current rod lens systems. An advantage of a digital signal is that it can be processed to reduce noise and enhance image quality. Digitization will become increasingly important as enhancement of images is used to add information to what the surgeon views on the monitor screen. One method, called *wave front coding* (CDM Optics, Inc., Boulder, Colo), uses a hybrid system consisting of a spheric lens with real-time digital filtering of the image produced. This system renders a real-time image that has enhanced depth of field and contrast without the distortions of the lens system.

In MAS there is a trend toward smaller scopes and instruments: 3-mm scopes are being used in pediatric surgery and for some procedures in adults. These so-called needle scopes and small-diameter instruments can allow veterinarians to easily perform MAS in animals with small body size. However, small scopes have small fields of view that require them to be positioned close to the object of interest, resulting in glare and image distortion.[5] Improvements in image capture, lighting, and digital processing will allow smaller scopes to deliver full-screen images without distortion. Reducing the diameter of fibers delivering light will help to further reduce the diameter of scopes used in MAS. A method to deliver high-intensity light through fibers as small as 0.1 mm has been developed (Cogent Light Technologies, Inc., Santa Clarita, Calif). Another potential improvement is the use of diodes as light sources. Rather than needing a fiberoptic bundle to provide light for the scope, small diodes would be used to illuminate the surgical field. Diodes provide the possibility for more versatility in the geometry of the light array and can make scopes lighter, more robust, and less costly. Further on the horizon is the single fiber telescope/camera.[6] This device uses a single emitter/detector fiber. The distal end of the fiber is moved in sinusoidal waves at very high speed by magnetic fields. The fiber scans an image made by a lens system and produces a 1500- by 1500-line digital image. This single fiber system has the potential to be scaled down to a single millimeter in diameter, making it possible to get a high-resolution image from a very small device.

## Three-Dimensional Viewing

Since the advent of MAS, there has been concern about limitations imposed by two-dimensional viewing of three-dimensional anatomy during surgery, and efforts have been made to develop three-dimensional video systems (Fig. 15-1). Some commercially available systems use a scope with two optical channels and two cameras to display right and left images. One system uses a head-mounted display (Vista Medical Technologies, Westborough, Mass) to present left and right images to the corresponding eye. Another system projects right and left images on a proprietary video monitor (Surgical Vision, Reading, UK) that presents the appropriate image to the appropriate eye. A similar three-dimensional system uses a monitor with a high-speed shutter that rapidly switches right and left images (Carl Zeiss, Oberkochen, Germany). A different version switches glasses that the surgeon wears so he or she sees in alternating fashion with the right or left eye (Opticon Co., Karlsruhe, Germany). With all the image switching systems, the right and left images are fused in the surgeon's brain to provide perception of a single image in three dimensions. A system using a scope with two optic channels and two cameras that send separate images to two video monitors in a viewing console is used with the

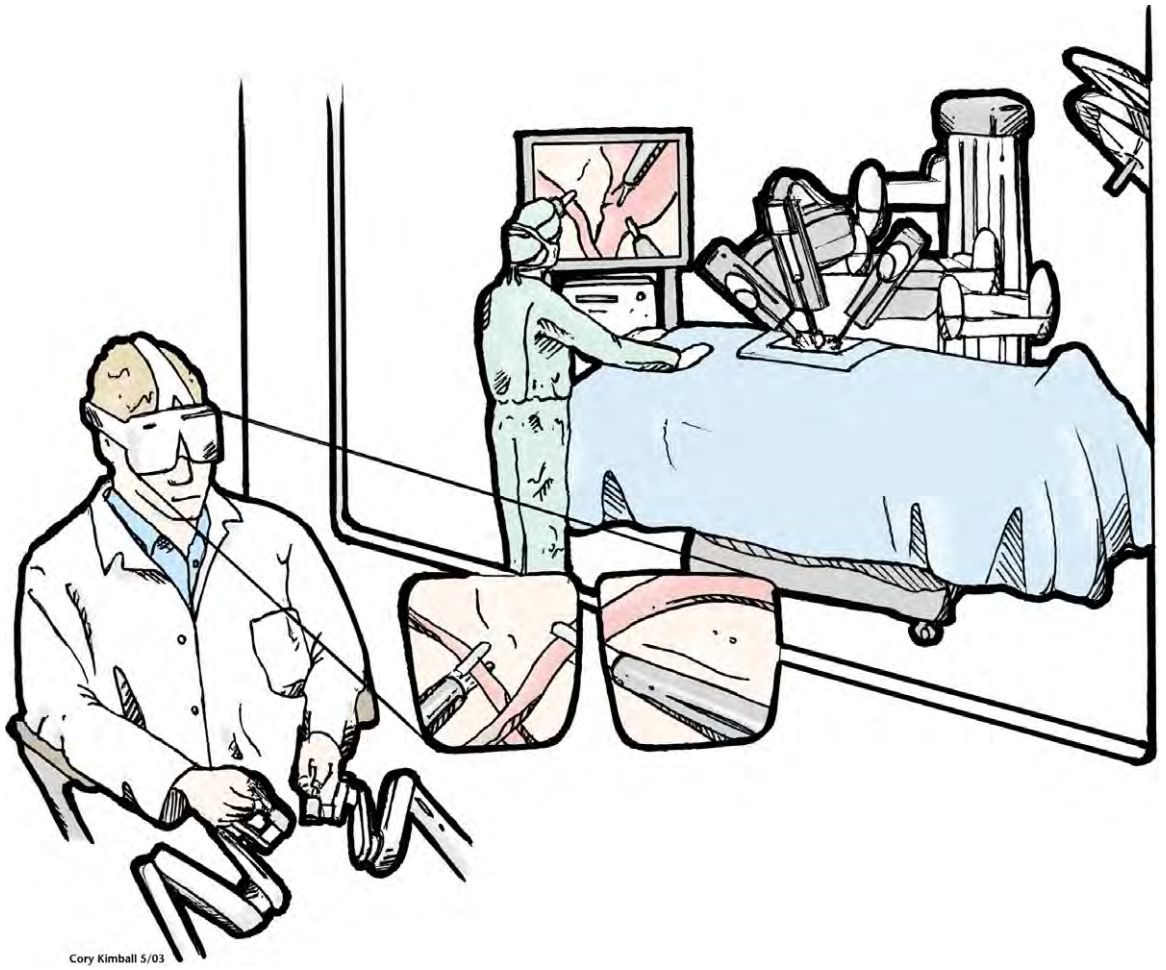



**Fig. 15-1**
A comfortable, head-mounted three-dimensional display and robotics improve the precision of minimal access surgery and reduce surgeon fatigue.

"da Vinci" robot (Intuitive Surgical, Mountain View, Calif). The viewing console presents the respective images to the surgeon's right and left eye, and, like the Zeiss system, the surgeon's brain perceives a three-dimensional image. Three-dimensional systems have limitations that keep them from being widely used.[7] The shutter systems have image quality that is poorer than that available in two-dimensional systems in brightness and in color reproduction, and surgeons become fatigued by eyestrain with the shutter systems. Dual scope systems do not provide depth cues over the full range of distances because of the inherent limitations of the optical telescope. Studies assessing the value of three-dimensional systems compared with two-dimensional systems report conflicting results for most tasks, although suturing is found to be easier using a three-dimensional system.[8] Some of the limitations of two-dimensional images are addressed by processing a digital image to sharpen edges and enhance texture and color. This has been shown to give back to the surgeon many visual clues associated with three-dimensional vision. Another strategy, although currently not being done, is to provide additional lighting to even out dispersion of light and soften shadows. The human brain can compensate for stereoscopic vision, and digital image processing can be used to enhance two-dimensional images to provide sufficient depth clues.[9] Three-dimensional systems will only become commonly used when a simple three-dimensional system with fewer disadvantages is developed.[7]

## Image Enhancement (Fig. 15-2)

Another means of enhancing the surgeon's perception is interactive image-guided surgery (IIGS) wherein the patient is scanned using computed tomography (CT) to derive an accurate volumetric representation of the anatomy in space.[10] These images are registered to a point on the patient. The stored three-dimensional CT image and the real-time two-dimensional laparoscopic image

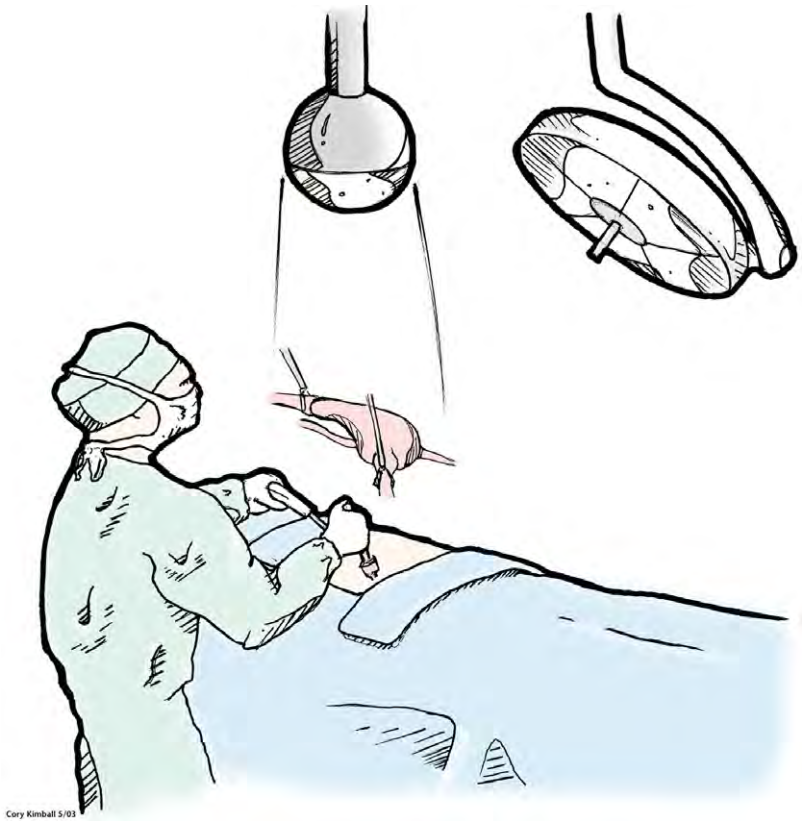



**Fig. 15–2**
An enhanced, suspended three-dimensional image can improve the surgeon's ability to see abnormal tissue and to dissect accurately while reducing surgeon fatigue.

are processed in a computer and superimposed on a video screen. Surgical instruments that can be tracked in spaces are used. As the surgeon works, the positions of the instruments are displayed with the combined CT and video image and updated in real time. The potential value of this method is that the surgeon can see the position of deeply seated structures (e.g., vessels and tumors) during dissection and the position of instruments being used. Magnetic resonance (MR) images may be used in the same manner as the CT images. Working within an open magnet MR imaging (MRI) system allows real-time MR and video imaging during surgery. This combination is likely to supplant CT and video. However, an even more versatile imaging combination may become available. With improvements in the resolution of three-dimensional ultrasound, combining a three-dimensional ultrasound image with a video image provides the advantages of a combination of the real-time MR images with video but in a less restrictive environment.

Using near-infrared light to expose unique features of tissue has been used to identify lung bullae during video-assisted thoracic surgery.[11] Chromophores are taken up by tissue in combination with specific wavelengths of light, thus identifying diseased and inflamed tissues.[12] Laser-induced tissue fluorescence has been used to differentiate normal and abnormal tissue.[13,14] These optical diagnostic techniques can be integrated into endoscopic systems, and by rapidly switching between laser and normal white light, the image that the surgeon sees on the monitor can be presented as the fluorescent area delineated on a normal white light view of the target area. Here again, LED technology has the potential to provide specific wavelengths of light in very simple, compact devices.

The digital imaging and high-speed computers are the keys to future improvements in image capture and display. Small scopes can deliver full-screen images. Optical three-dimensional images will compete with two-dimensional digitized and enhanced video images. The displayed image will coincide with the position of the patient's anatomy and will be optimized for the surgeon by magnification, color enhancement, and other desired factors. Surgeons will have systems that combine a miniature camera, small-diameter scopes with multi-wavelength lighting, and a lightweight "put anywhere" display. These will give the surgeon not only high-resolution images but also the ability to see things in

ways that precisely define abnormal from normal tissue and allow an uninterrupted "see, diagnose, and treat" sequence.

## INSTRUMENT AND DEVICE TECHNOLOGY

### Instruments

Specialized and miniature surgical instruments and devices will play a key role in the future of rigid endoscopy.[15] Instruments that perform specific tasks in a semiautomated fashion will make complex surgeries easier to perform by MAS, especially when restrictions on mobility and dexterity constrain the surgeon's activities. For instance, the appearance of a new generation of "clamp, coagulate, and cut" devices have made many procedures easier to perform by eliminating the need to ligate with sutures or hemostatic clips. Examples of these are the UltraCision Harmonic scalpel (Ethicon Endo-Surgery, Cincinnati, Ohio), which uses ultrasonic energy, and the Ligasure (ValleyLabs, Boulder, Colo), which uses radiofrequency electric current energy. New staplers and other fastening systems designed for specific MAS procedures are coming to the market. These make procedures easier to perform by eliminating the need to suture by hand, which has been an impediment to performing many complex surgical procedures by a minimally invasive approach. Abdominal hernias are being treated by MAS using specially designed mesh and small metal anchors that are similar to toggle bolts rather than sutures.

Sleeves and ports that allow the surgeon to place a hand within the patient's abdomen while maintaining pneumoperitoneum are being used in procedures that require greater dexterity than is available with available MAS instruments. These ports also allow removal of large organs from the abdomen, facilitating procedures such as live donor nephrectomy (which has become common). The technique of hand-assisted laparoscopy (HAL) is perhaps a transitional step until more dexterous instruments are developed for MAS. HAL surgery may prove to be helpful in veterinary large animal surgery.

Microelectronic mechanical systems (MEMS) can be integrated into MAS surgical instruments.[16] MEMS-augmented instruments may have, for example, strain sensors that provide information that replaces tactile feedback that is lost using current MAS instruments. Other potential applications are to use MEMS sensors that detect blood flow incorporated into instruments to differentiate malignant from normal tissue. One company (Verimetra, Inc., Pittsburg, Pa) is developing a scalpel that samples the force required to cut specific tissues and is able to communicate to the surgeon which tissue type is being cut.

Some instruments under development may supplant the use of rigid endoscopy for some MAS procedures. Flexible endoscopes with instruments that articulate and allow a surgeon to perform intraluminal surgery are being designed. Microwave, laser, radiofrequency, and ultrasonic tissue ablation devices are being developed and are being used to treat breast, liver, and kidney tumors and to treat prostatic hypertrophy. These systems use minimal percutaneous or natural orifice access and ultrasound or MRI guidance. The radiofrequency systems deploy electrode arrays into tissue via a small-diameter rod passed percutaneously via a small-diameter cannula. Intense ultrasound systems that use power levels many times those of diagnostic ultrasound are being developed as a means to ablate tissue. An advantage of ultrasound over other ablative technologies is that, by reducing power to diagnostic levels, ultrasound can be used to image the target lesion before and after treatment. Future developments will see ultrasound being used to treat deep structures without a surgical approach. The ultrasound beam will be focused percutaneously over long distances into the body, the lesion will be defined in three dimensions using diagnostic mode, and then the lesion will be treated using the high-intensity mode. These activities will be computer controlled and automated.

### Robotics

One early surgical robot was the AESOP[7] Robotic Endoscope Positioner (Computer Motion, Inc., Goleta, Calif). It held and moved the laparoscope, responding to either foot pedal or voice control, and eliminated the need for an assistant. This device has been modified and improved with better voice recognition capability and greater dexterity. Another method for eliminating the need for an assistant to maneuver a scope is to use a robotic laparoscope (OES ImagTrac, Olympus America, Inc., Melville, NY). The scope changes its view in response to commands given by the surgeon. Change of view is accomplished by moving the CCD chips relative to the image produced by the lens system and by moving the lens system to zoom and pan. The motors that move the chips and lens are activated by controls on the handle of an instrument being used by the surgeon or by voice command.

The surgical robots presently being used to perform MAS surgery are computer-controlled master/slave devices. They were conceived and developed as a means of providing surgical treatment for soldiers and astronauts at sites distant from the surgeon. Recently a cholecystectomy was performed on a patient in the United States by a surgeon in France. However, robots have limitations for performing surgeries at long distances because of the delay between input and output signals. Even so, robots have a role in complex MAS procedures,

because they give the surgeon manual dexterity that is not available with current MAS instruments. Robots also eliminate hand tremor and can be calibrated to scale, up or down, the surgeon's normal hand movements for greater precision. The da Vinci robot (Intuitive Surgical, Mountain View, Calif) is the first to be approved by the Food and Drug Administration for cardiac and general surgery. The Zeus robot (Computer Motion, Inc., Goleta, Calif) is intended to be approved. The current robots are expensive and have a limited number of instruments available. However, companies are developing simpler, lower technology versions of the current surgical robots. These will cost half the price of the current surgical robots. Small, low-cost surgical robots could extend the range of procedures that can be done by highly miniaturized MAS.

It is possible that true surgical robots will be developed that have instruments and sensors that allow them to perform parts of surgical procedures, such as ablating a lesion or suturing. The ROBODOC orthopedic robot (Integrated Surgical Systems, Inc., Davis, Calif), a robot used in hip replacement surgery, is such an instrument. It uses information from a CT scan of the patient's femur to map and then ream the femoral canal to the precise size of the prosthesis being used.

The future instruments for MAS will be optimized for specific tasks and will be ergonomically designed for the comfort of the surgeon and safety of the patient.[17] Instruments will be available that automatically perform multiple steps of a defined procedure. These instruments will incorporate sensors that provide tactile, auditory, and perhaps numeric feedback to the surgeon. Instruments that sense and identify diseased tissue will make ablative and extirpative surgery more accurate and less traumatic. Instruments that have the capability of moving with degrees of freedom comparable to the capability of the human hand may supersede the large surgical robots used today.

## TRAINING

At the introduction of laparoscopic surgery in the early 1990s, training was provided by early adopter surgeons and sponsored by laparoscopic device and instrument makers. As MAS became more mainstream, university-based educational systems came to have the dominant role in training. Unlike human surgery, veterinary demand for training has been, from the outset, primarily provided by educational institutions and surgical societies with the support of the industry. It is likely that MAS training will become incorporated into postgraduate surgical training.

Minimally invasive surgical procedures require a considerable amount of training and practice. The importance of training in MAS has been documented in studies showing that, because of the unnaturalness of the posture and movements associated with MAS and because of the complexity of some of the tasks demanded by MAS, repetitive practice is needed before a surgeon can be competent and efficient. One study recommended that skills training sessions be repeated 30 to 35 times because this was the number of times a task needed to be done before the time required to perform the tasks plateaued.[18] Another study found decreases in surgery time for cholecystectomy occurring over the first 200 procedures.[19] The decrease in the duration of the procedure resulted from the surgeon's becoming more skilled at complex tasks and performing them more efficiently. Training by use of computer-based simulators (LapSim, Surgical Science, Goteborg, Sweden) is available, and training methods will improve as computer speed increases and as advanced electromechanical devices providing feedback to the surgeon simulating tissue consistency are incorporated into the simulator. Such virtual reality simulators will allow a student to develop a high level of skill in performing the procedures before he or she performs them in a clinical setting. Interactive CD-ROM training and Internet-based training is becoming available, allowing surgeons to learn basic skills without the need to travel.[20] In the future, Internet technology with streaming video and audio may bring remote training and preceptoring to practicing veterinary surgeons (Fig. 15-3). This will require that a hub and satellite system be implemented and that a cadre of surgeons expert in MAS be available.[21] For example, the hub could be at a university teaching hospital and the satellites at referral practices. Surgeons who wish to be trained could travel to the nearest satellite MAS center and receive training. The novice surgeon would perform procedures on clinical cases under the guidance of an expert at the hub hospital. Because distance would not be a factor, a hub could serve satellites almost anywhere in the world.

## ECONOMICS

Many economic factors bear on how MAS will be adopted into veterinary surgery, and these may be the most critical. Minimally invasive surgery depends on sophisticated equipment, video monitors, cameras, scopes, and insufflators. These require a large capital expenditure. Ancillary equipment such as an electrosurgery generator, suction/irrigation, and other sophisticated and costly instruments are needed to efficiently perform complex procedures. Furthermore, the time required to perform MAS procedures is generally longer than it is to perform the corresponding conventional procedure; therefore it is more costly from the surgeon and staff's time perspective. Expense is the largest drawback of MAS in human surgery.[22] Even so, there has been a

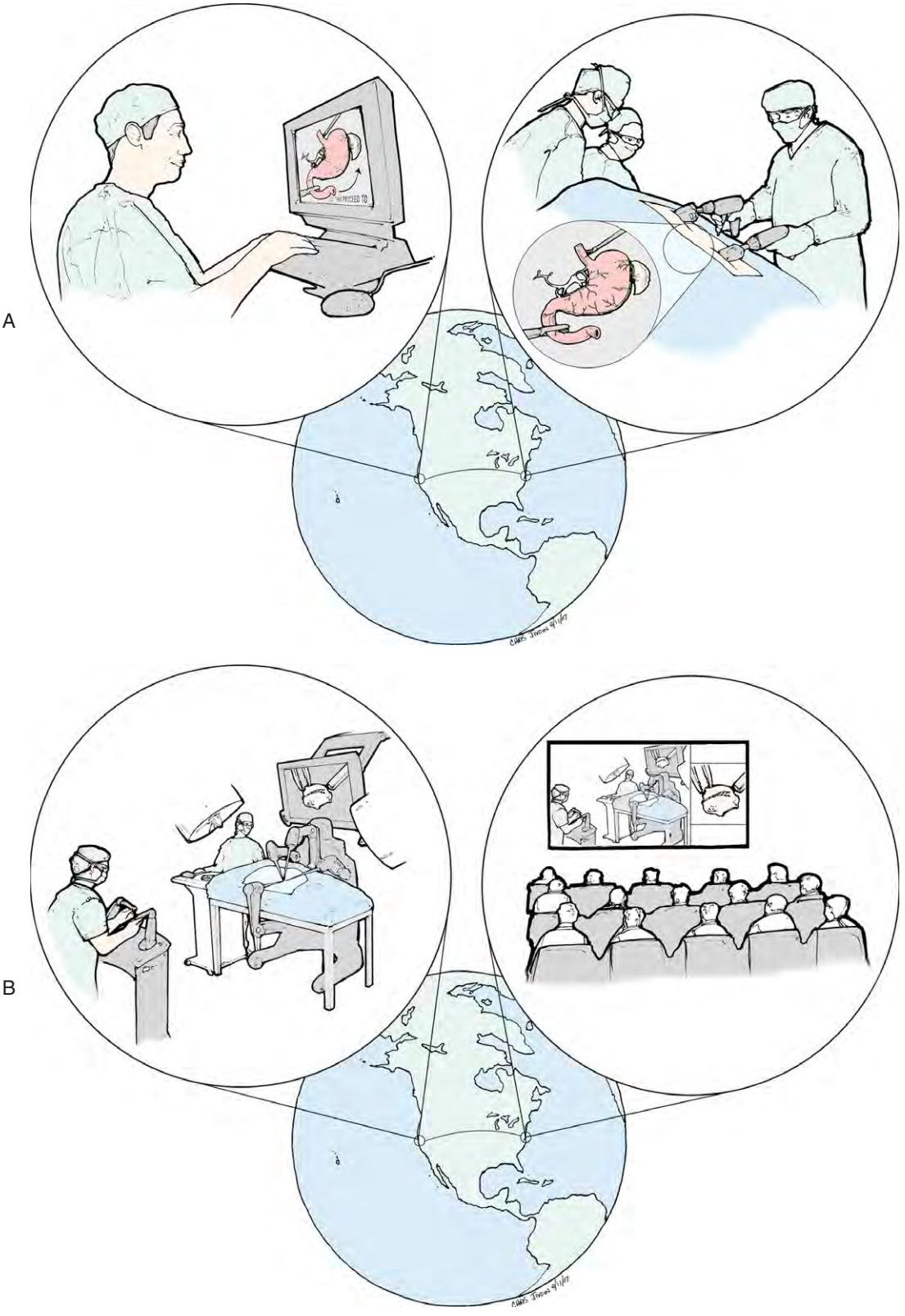



**Fig. 15-3**
A, Interactive intern systems will allow experts to assist in procedures and teach individual students, in real time, in remote locations. B, The same interactive systems will allow experts to teach and demonstrate procedures in real time to classes at universities.

rapid and nearly complete adoption of laparoscopic cholecystectomy. Furthermore, Nissen fundoplication, splenectomy, adrenalectomy, and donor nephrectomy are now predominately done laparoscopically,[23] whereas other procedures such as inguinal hernia and colectomy are rarely done laparoscopically. The reasons for this selective adoption are multiple: Patient benefit cannot be proven, the procedure is too difficult for the surgeon with current technology, there is no economic benefit (reduction in hospital stay, rapid return to work), and, in some cases, the rate of complications is unacceptably high. These assessments are problematic for many procedures, because they are being evaluated at early stages of development and therefore are more time consuming and costly and have greater incidences of complications than they will have in the future.

In human medicine the interplay between competing interests (patients, surgeons, hospitals, payers [e.g., insurance companies, taxpayers, health maintenance organizations]) influences which procedures are performed and how they are done.[24] The benefit of the patient being released from the hospital days earlier, having less discomfort, returning to work days to weeks earlier, and having a more pleasing cosmetic result influences the use of MAS compared with conventional procedures. In veterinary surgery the surgeon and client are the only ones involved in economic decisions and patient considerations, and it will be they who decide the future of MAS in veterinary surgery. Will the veterinary surgeon bear the costs of acquiring the equipment needed to perform MAS? Will he or she bear the cost in money and time to acquire the requisite skills to perform MAS? These initial acquisition costs are not the only factors that influence the economic viability of MAS for veterinarians; there are other economic factors involving use and fees. How much will it cost to use the equipment and perform MAS procedures? How many procedures will a surgeon do and what will be the income generated? Answers to these questions will depend on what clients are willing to pay for MAS procedures compared with what they pay for conventional procedures. Will clients be willing to bear the cost of the supplies, instruments, and added surgeon and staff time needed to have MAS procedures performed on their pet?

## THE FUTURE

Drivers for the adoption of MAS in humans have been primarily patient demand for less painful, less traumatic, and less disfiguring surgery. Surgeons and payers are motivated by the documented reduction in wound complications and more rapid return to normal activity. Patient benefit in animals may be more difficult to define. The issue of cosmesis is probably not as high a priority in animals as in people. Can the benefit of reduced postoperative pain and more rapid return to normal activity be determined, and will that justify the additional cost of MAS? The benefits of video thoracic surgery and arthroscopy are readily seen in veterinary medicine by rapid return of activity in dogs operated on by these methods. Is there a comparable benefit for MAS abdominal procedures and, if so, will it be enough to compensate for the complexity and expense of MAS? Controversy exists in human surgery about the degree of patient benefit of MAS versus some modified conventional procedures and whether or not changes in postoperative care could result in earlier return to normal activity in humans.

Important in veterinary practice is feasibility, efficacy, and efficiency. Will MAS provide these? Most likely it will. Feasibility for veterinary MAS is well established.[25-27] In some cases MAS methods make surgery easier.[28] Based on results obtained in human surgery, one can speculate that, in veterinary surgery, thoracic duct ligation, adrenalectomy, Heller's myotomy, and cryptorchid surgery can be made easier by MAS. Efficacy for veterinary MAS is still unknown and cannot be determined until more veterinarians perform MAS procedures and until the results of those procedures are objectively evaluated. It appears that for some groups, such as larger animals and zoo animals, MAS is of benefit, because it lessens the potential for catastrophic wound complications. Presently, most MAS procedures are being done at teaching hospitals and referral centers. Assessment of the efficiency of veterinary MAS depends on having more veterinarians engaged in performing MAS and on more procedures being done so that the real clinical and economic impact can be determined.

## REFERENCES

1. Kourambas J, Preminger GM: Advances in camera, video, and imaging technologies in laparoscopy, *Urol Clin North Am,* 28:5-14, 2001.
2. Schwaitzberg SD: Imaging systems in minimally invasive surgery, *Semin Laparosc Surg,* 8:3-11, 2001.
3. Emam TA, Hanna G, Cuschieri A: Comparison of orthodox vs off-optical axis endoscopic manipulations, *Surg Endosc* 16:401-405, 2002.
4. Boppart SA, Deutsch TF, Rattner DW: Optical imaging technology in minimally invasive surgery. Current status and future directions, *Surg Endosc* 13:718-722, 1999.
5. Berci G, Rozga J: Miniature laparoscopy, Quo vadis? The basic parameters of image relay and display systems, *Surg Endosc* 13:211-217, 1999.
6. Seibel EJ: Proceedings of SPIE—The International Society of Optical Engineering, V4158, 2001, Biomonitoring and Endoscopy Technologies, July 5-6, 2000, Amsterdam, pp. 29-39.

7. Hanna G, Cuschieri A: Image display technology and image processing, *World J Surg* 25:1419-1427, 2001.
8. Hanna G, Cuschieri A: Influence of two-dimensional and three-dimensional imaging on endoscopic bowel suturing, *World J Surg* 24:444-449, 2000.
9. Aslan P and others: Advances in digital imaging during endoscopic surgery, *J Endourol* 13:251-255, 1999.
10. Herline A and others: Technical advances toward interactive image-guided laparoscopic surgery, *Surg Endosc* 14:675-679, 2000.
11. Suzuki T and others: Infrared observation during thoracoscopic surgery for bullous disease, *J Thorac Cardiovasc Surg* 119:182-184, 2000.
12. Gurfinkel M and others: Pharmacokinetics of ICG and HPPH-car for the detection of normal and tumor tissue using fluorescence, near-infrared reflectance imaging: a case study, *Photochem Photobiol* 72:94-102, 2000.
13. Koenig F and others: Autofluorescence guided biopsy for the early diagnosis of bladder carcinoma, *J Urol* 159:1871-1875, 1998.
14. Chwirot BW and others: Spectrally resolved fluorescence imaging of human colonic adenomas, *Photochem Photobiol* 50:174-183, 1999.
15. Park AE and others: Laparoscopic dissecting instruments, *Semin Laparosc Surg* 8:45-42, 2001.
16. Salzberg AD and others: Microelectrical mechanical systems in surgery and medicine, *J Am Coll Surg* 194:463-476, 2002.
17. Den Boer KT and others: Problems with laparoscopic instruments: opinions of experts, *J Laparoendosc* 11:149-155, 2001.
18. Scott DJ and others: Laparoscopic skills training, *Am J Surg* 182:137-142, 2001.
19. Voitk AJ, Tsao SGS, Ignatius S: The tail of the learning curve for laparoscopic cholecystectomy, *Am J Surg* 182: 250-253, 2001.
20. Malassagne B and others: Teleeducation in surgery: European Institute for Telesurgery experience, *World J Surg* 25:1490-1494, 2001.
21. Schulam PG and others: Telesurgical mentoring. Initial clinical experience, *Surg Endosc* 11:1001-1005, 1997.
22. Mewman RM, Traverso LW: Cost-effective minimally invasive surgery: what procedures make sense? *World J Surg* 23:415-421, 1999.
23. Kohler L: Endoscopic surgery: what has passed the test, *World J Surg* 23:816-824, 1999.
24. Long KH and others: A prospective randomized comparison of laparoscopic appendectomy with open appendectomy: clinical and economic analyses, *Surgery* 129:390-400, 2002.
25. Richter KP: Laparoscopy in dogs and cats, *Vet Clin North Am Small Anim Pract* 31:707-727, 2001.
26. Marien T: Standing laparoscopic herniorrhaphy in stallions using cylindrical polypropylene mesh prosthesis, *Equine Vet J* 33:91-96, 2001.
27. Walton RS: Video-assisted thoracoscopy, *Vet Clin North Am Small Anim Pract* 31:729-759, 2001.
28. Trumble TN, Ingle-Fehr J, Hendrickson DA: Laparoscopic intra-abdominal ligation of the testicular artery following castration in a horse, *J Am Vet Med Assoc* 216:1596-1598, 2000.

# 16 Looking Forward in Flexible Endoscopy

James S. Barthel

The future of veterinary endoscopy is linked to developments in human endoscopy. Recent innovations in diagnostic endoscopy include video endoscopy, ultrasound endoscopy, and small bowel endoscopy. The realm of therapeutic endoscopy continues to expand. Stenotic lesions and bleeding lesions of the human hollow organ gastrointestinal tract are now more likely to be treated initially by the endoscopist than by the surgeon. The computer revolution has come to endoscopy. Computers are used to generate reports, and to store and disseminate images obtained with video endoscopes. In the future they will provide simulation for training purposes and assist with lesion diagnoses. These innovations are reviewed here; their potential application in veterinary medicine is left to the imagination of the reader.

## VIDEO ENDOSCOPY AND THE FUTURE OF ENDOSCOPE TECHNOLOGY

Fiberoptic endoscopes contain a fiberoptic coherent image guide bundle for image transmission and a fiberoptic incoherent light guide bundle, which transmits light for illumination. In video endoscopes, the fiberoptic coherent image guide bundle is replaced by an electronic image signal transmission system based on a charge coupled device (CCD). The image is viewed on a video monitor that is detached from the instrument rather than viewed through an eyepiece that is attached to the control housing of the instrument. Video endoscopes retain the fiberoptic incoherent light guide bundle for illumination.

The CCD is the most important element in a video endoscope. The function of a CCD is based on the ability of silicon to transform light into electrons. The image sensing surface of a CCD consists of an array of separate photosensitive elements. A light pattern striking the photosensitive surface of a CCD produces a charge distribution across the photosensitive elements that is proportional to the intensity of light at any given photosensitive element. The exposure time necessary to create the charge distribution is on the order of 10 to 50 ms. The method by which the charge distribution is read off the array of photosensitive elements accounts for architectural and performance differences between CCDs.

Size is an important consideration in CCD architecture. The CCD and its electrical connections must fit in the tip of an endoscope. Three types of CCD architecture are employed in currently available endoscopes: frame transfer, full frame readout, and interline transfer.

The *frame transfer* CCD consists of a sensor area and a light-protected storage area. After illumination for a time interval corresponding to one field duration ($^1/_{60}$ second), the charge accumulated in the surface regions of the sensor area is moved rapidly into the storage area and read out within the subsequent field duration. Meanwhile, illumination creates a charge distribution in the deep regions of the sensor area, which, during the following field duration, is moved into the storage area and read out. The alternating charge distribution readout method used by the frame transfer CCD allows the sensor area to contain only half as many rows of sensors as lines necessary to create a full monitor screen picture. However, the frame transfer CCD storage area must be the same size as the sensor area; therefore the storage area doubles the size of the device.

*Full frame readout* CCDs consist of an array of photosensors connected to a horizontal storage register by vertical CCD channels. The charge distribution can only be read off the photosensors when they are not being illuminated. Therefore each field time must consist of an illumination phase followed by a dark phase, during which the charge distribution is read off the photosensors.

The *interline transfer* CCD consists of columns of photosensor elements, each connected to a parallel column of light-protected CCD transport registers, which are routed to a supplementary horizontal CCD register. The number of photosensors per column corresponds to the number of lines on a full monitor screen. A single CCD transport cell serves two adjacent photosensors. During the first half of a field duration, charge is transported from one photosensor and during the second half from the adjacent photosensor. Because the area of the interline transfer

CCD devoted to charge transportation is relatively large, light sensitivity is reduced compared with that of other CCD architectures.

When illumination of a CCD is excessive, excess charge may build up on the photosensor elements and spill into adjacent elements creating an image "white-out." This phenomenon is referred to as *blooming*. Among the three CCD architectures described, the interline transfer CCD is the best protected against blooming and is the only CCD that can withstand laser.

There are two methods for creating a color image from a CCD. A filter mosaic transparent to the three primary colors red, blue, and green or to their complements cyan, magenta, and yellow* may be placed on the CCD. A specific color is associated with each photosensor element, and all colors are transmitted simultaneously. CCDs that use this method of color creation are referred to as *color chips*.

The second method of color creation involves sequential illumination of the CCD with the primary colors. Light passed through a rotating wheel composed of primary color filters sequentially illuminates the CCD field of view with red, blue, and green light. A synchronized switching circuit in the video processor unit attached to the CCD sequentially switches the signal from the CCD to a specific primary color dedicated memory bank during each phase of primary color illumination. From the contents of the color-specific memory banks, the video processor creates three simultaneous red, blue, and green video signals, which comprise the RGB video signal. The RGB signal is then fed to the RGB input of a video monitor to produce a color image.

Video endoscopy offers a number of advantages (Box 16-1) when compared with fiberoptic endoscopy. Because the control area of the video endoscope with its biopsy channel access port does not have to be held in close proximity to the endoscopist's face, there is less chance of the endoscopist being sprayed in the face with stool or stomach acid. Completion of a long procedure list is easier with the video endoscope because there is no tendency for the endoscopist to hunch over the instrument as the day wears on. The video image is substantially larger and easier to view than the optical image. Display of the image on a video monitor permits many individuals to view the procedure simultaneously. This increased image access improves the efficiency and interest of assistants and has a favorable impact on teaching. The digital signal produced by video endoscopy processor units permits real-time storage of images on videotape and various computer storage devices. Finally, the digital signal can be manipulated to enhance various features of the image in a manner similar to that used to accomplish subtraction radiography. Image manipulation may lead to improved diagnostic capabilities.

*Red, blue, and green are screen colors. To print, they are converted to cyan, magenta, yellow, and black.*

**Box 16-1 Advantages of Video Endoscopy**

Increased operator safety
Decreased operator fatigue
Improved image access
Real-time image storage capabilities
Image manipulation capabilities

There are few disadvantages to video endoscopy. The portability of currently available instruments is somewhat limited by the size and weight of the video monitors necessary for image viewing. The video processor and larger light sources add to the portability problem. Some disadvantages are specific to the type of CCD architecture and colorization method used in the video endoscopy system and thus are unique to specific manufacturers or a specific series of instruments. For instance, systems that use primary color sequential field illumination colorization technology are susceptible to *shadow bleeding*. Shadow bleeding is a phenomenon in which heavily shadowed areas are displayed in red rather than black. The red shadows can be misinterpreted as blood by the endoscopist. The blooming phenomenon seen with frame transfer and full frame transfer CCDs can be annoying to the endoscopist because attempts to view objects at very close distances result in a very bright whiteout of the image.

CCD technology has led to the development of extremely small video cameras that can be mounted on fiberoptic endoscopy equipment. The hybrid video camera fiberoptic endoscope system assumes the advantages of a video endoscope for a small price in image clarity. The small camera systems are particularly useful with special application endoscopes such as enteroscopes, which are not produced as video endoscopes.

The advantages of video endoscopy are many, whereas the disadvantages are few, and with each new generation of instruments, the disadvantages become fewer. There can be little doubt that the video endoscope will replace the fiberoptic endoscope.

## IMAGING BEYOND THE WALL WITH ULTRASOUND ENDOSCOPY

Medical ultrasound imaging devices use sound waves with a frequency of 1 to 25 MHz (million cycles per second). A brief period of sound wave generation is followed by a brief listening interval (pulse echo technique). The transmission of sound waves in tissue is dependent on the density and elasticity of the tissue. Sound waves are transmitted poorly through inelastic

tissue (scar) and readily through elastic tissue. Dense tissue transmits sound waves more readily than less dense tissue. High-density inelastic materials (bone) reflect ultrasound energy, whereas very low-density materials (gas) absorb ultrasound energy. Image resolution increases with increasing frequency; however, the depth of penetration decreases with increasing frequency.

Endoscopic ultrasonography takes advantage of the principles of ultrasound imaging. Placement of the ultrasound transducer on the tip of the endoscope permits highly detailed imaging of internal organs because the transducer can be placed in very close proximity to the target organ and gas and bone free paths can be easily established. Detailed images of the structure of the gastrointestinal tract wall can also be obtained.

Two types of ultrasound endoscopes are discussed here. These instruments employ different methods of ultrasound scanning and therefore have slightly different capabilities.

The first type is a mechanical *sector scanning* endoscope with the transducer mounted just distal to the bending section of the insertion shaft. The transducer may be operated at frequencies of 7.5 and 12 MHz and produces a 360-degree radial image perpendicular to the axis of the distal insertion shaft. The ultrasound transducer transforms the distal tip of the endoscope into a 42-mm rigid shaft. To eliminate gas from the path of the ultrasound energy, a latex balloon, which can be filled with water, surrounds the ultrasound transducer. A motor drives the rotating acoustical mirror in the transducer and is mounted just beneath the control housing. A 65-degree oblique view with an 80-degree field of view is obtained through the eyepiece of the instrument. There is a 2-mm biopsy channel. The instrument is bulky and difficult to manipulate. Its endoscopic features are of use only for assessing tip position.

The second type of ultrasound upper gastrointestinal fiberscope is based on *phased-array* technology. An array of stationary ultrasound transducers is contained in a convex housing on the tip of the instrument. There are no moving parts and thus no need for a rotating scanner and drive motor. This allows the distance from the tip to the bending segment to be decreased and permits a less oblique angle of view. The instrument is less bulky and more maneuverable. The instrument may be operated at 5 and 7 MHz and has color Doppler capability, which may prove useful for studying blood flow. The ultrasound image produced is a sagittal section rather than a cross section (such as that produced by the mechanical sector scanning instrument). The greatest interpretive experience exists with the cross-sectional images produced by the mechanical sector scanning instrument. However, there is no reason to assume that the sagittal section images produced by the phased-array instrument would be more difficult to interpret once experience is gained.

Certain principles of endoscopic ultrasonography technique are universally applicable. The narrow angle oblique visual field obtained through the ultrasound endoscope is suitable only for assessing the endoscope tip position with respect to a scanning target. Because these instruments have limited capability as endoscopes, an endoscopic examination with a forward viewing endoscope should be performed before endoscopic ultrasonography. Successful ultrasound imaging of a target lesion requires establishing an air-free path between the ultrasound transducer and the scanning target. Three methods have been used for establishing an air-free scanning path: (1) direct apposition of the transducer against the gastrointestinal tract wall, (2) installation of de-aerated water into the gastrointestinal tract such that it completely surrounds the transducer on the tip of the ultrasound endoscope, and (3) filling of the tip balloon with de-aerated water to achieve contact with the gastrointestinal tract wall. The method used depends on which part of the gastrointestinal tract is being examined and the nature of the scanning target. The water-filled tip balloon is satisfactory for most situations; however, on-the-spot experimentation is usually necessary to achieve best results. Strict attention to aspirating excess air from the gastrointestinal tract improves imaging. Gastrointestinal tract motility can interfere with successful ultrasound imaging. Therefore it is frequently helpful to administer anticholinergic agents or glucagon to slow gastrointestinal tract activity. Finally, the unique and nontraditional displays of internal anatomy obtained with the ultrasound endoscope can be confusing, and the learning period for performing endoscopic ultrasonography is lengthy. Initially, it is helpful to perform the procedures with fluoroscopic guidance to facilitate orientation.

The utility of ultrasound endoscopy in human medicine is being investigated. The technique appears to be useful in diagnosing disorders that produce thickening of the gastrointestinal tract wall. Endoscopic ultrasonography may prove to be superior to standard extracorporeal imaging techniques in the diagnosis and staging of esophageal carcinoma, pancreatic carcinoma, rectal cancer, papilla of Vater carcinoma, pancreatic tumors, bile duct carcinoma, adrenal tumors, and certain renal tumors. The identification of intramural and extramural vascular abnormalities, such as gastric varices, may be easily accomplished with endoscopic ultrasonography.

## SMALL BOWEL ENDOSCOPY

Approximately 5% of humans with gastrointestinal tract bleeding have no source for their bleeding identified after endoscopic evaluations of the esophagus, stomach, duodenum, and colon. This situation stimulated development of endoscopic techniques and instruments for examination of the small intestine. At present, three methods of

accomplishing small bowel endoscopy (enteroscopy) are in use: surgical enteroscopy, push enteroscopy, and assisted passive enteroscopy.

*Surgical enteroscopy* permits endoscopic examination of the entire small bowel. The procedure requires the skills of both a surgeon and an endoscopist. After appropriate patient preparation, the surgeon performs a laparotomy and mobilizes the small intestine. A noncrushing clamp is placed across the distal ileum to prevent distention of the colon with air and subsequent difficulty closing the abdominal incision. Meanwhile, the endoscopist passes an endoscope (a sterile pediatric or adult colonoscope) per os and navigates it into the distal duodenum. As the endoscope passes into the jejunum and becomes extraperitoneal, the surgeon grasps its tip and positions it so that he or she can accordion the entirety of the small bowel over the endoscope. The endoscopist then observes the small bowel mucosa as the surgeon manipulates the small bowel over the tip of the endoscope. If a lesion is discovered, the endoscopist signals the surgeon, who then marks the serosal surface of the small intestine with a suture ligature. Examination is accomplished only during the insertion phase of the procedures. Manipulation of the small bowel over the tip of the endoscope tends to traumatize the intestine and thus render examination during withdrawal inaccurate. After withdrawal of the endoscope, the surgeon resects the segments of diseased small intestine marked with ligatures.

*Push enteroscopy* does not require laparotomy. However, it only permits examination into the proximal jejunum. The procedure is performed with a sterile pediatric or adult colonoscope. Colonoscopes are preferred because of their additional length and stiffness when compared with standard upper endoscopes. The increased stiffness helps to minimize looping in the stomach and the increased length permits deeper insertion into the small bowel. For push enteroscopy, the pediatric colonoscope is passed per os and advanced into the distal duodenum. A series of rightward and leftward torquing maneuvers separated by withdrawal and advancing maneuvers is then applied to advance the instrument into the proximal jejunum. The procedure creates a fair amount of patient discomfort and sedation in excess of that necessary for routine upper endoscopy is usually required.

An endoscope specifically designed for push enteroscopy has a working length of 1675 mm with a 2.8-mm therapeutic channel, which permits passage of appropriately sized devices. Up-down and right-left tip angulation is 180 and 160 degrees, respectively. An 850-mm overtube is used with the instrument to prevent it from bowing in the stomach. My experience with this endoscope suggests that, in humans, the mid jejunum can be reached routinely. The mechanical features of this endoscope make it ideal for upper gastrointestinal endoscopy in large animals.

*Assisted passive enteroscopy* is performed with a Sonde type enteroscope. This endoscope is 5 mm in diameter and has a working length of 2675 mm. An inflatable tip balloon allows peristaltic activity to pull the instrument through the small intestine. There are no tip controls. Tip deflection is accomplished by manipulation of the surface of the abdomen. The instrument lacks a therapeutic channel. A 1-mm tip balloon insufflation channel and a 1-mm air-water channel are present.

Assisted passive enteroscopy is performed in the following manner. After nasal anesthesia in the form of 2% lidocaine and 1% phenylephrine is established, the passive enteroscope is passed nasally and positioned in the stomach. Next, a sterile pediatric colonoscope is passed through the mouth and into the stomach. Push enteroscopy into the proximal jejunum is performed with the colonoscope. Upon withdrawal of the colonoscope into the stomach, biopsy forceps are passed through the colonoscope and used to grasp a ligature tied on the tip of the passive enteroscope. Once the ligature is grasped, the passive enteroscope is guided into the proximal jejunum with the pediatric colonoscope where the ligature is released and the passive enteroscope tip balloon is inflated. With the enteroscope anchored in the jejunum by the inflated tip balloon, the colonoscope is withdrawn. Metoclopramide is administered intravenously to stimulate intestinal contraction. The instrument is then advanced approximately 8 inches every 15 minutes over the ensuing 6 to 8 hours. In the human, this technique allows the instrument to reach the ileum in most patients. Examination is accomplished during withdrawal, which takes 45 to 60 minutes. Between 50% and 70% of the small bowel traversed is actually examined.

## FUTURE OF STRICTURE THERAPY

Strictures of the human gastrointestinal tract are the result of either malignancy or scar formation in response to tissue damage. Endoscopic methods of treatment depend on the type of stricture encountered. Benign strictures resulting from scar formation are treated by dilation

**Box 16-2 Methods of Stenotic Lesion Dilation**

**Push Dilators**
Mercury-filled rubber dilators
Eder-Puestow metal olive dilators
Savory guidewire dilators

**Hydrostatic Balloon Dilators**
Positioned by guidewire
Through the scope

(Box 16-2). Malignant strictures are treated with both dilation and tissue ablation techniques.

The introduction of hydrostatic balloon dilators has enabled endoscopists to dilate lesions in the upper gastrointestinal tract and colon that could not be reached by push dilators. The delivery of dilation by hydraulic force rather than by mechanical means has eliminated the problems with bowing and curling encountered with push dilators. Lesions in the stomach and duodenum and throughout the colon are treatable with hydrostatic balloon dilators. Currently, any lesion that can be brought into view with an endoscope can be treated with these devices.

Hydrostatic balloon dilators can be delivered to the lesion by passage over a spring-tipped guidewire previously positioned across the stricture by fluoroscopic or endoscopic guidance or by passage through the therapeutic channel of an endoscope while the stricture is directly in view. Because the principles of hydraulics dictate the success of dilation with hydrostatic balloon dilators, they must be filled with water or dilute contrast media and not air. Air is easily compressed, making it difficult to transmit force from the filling syringe to the walls of the stricture. Water and contrast solutions are essentially noncompressible under the conditions that exist during a dilation and thus permit direct transmission of forces from the filling syringe to the stricture. Caulking gun and screw press devices are available to compress the plunger on the filling syringe and ensure that appropriate operating pressures are achieved and maintained.

Hydrostatic balloons come in various diameters and catheter lengths. Most are sold with designated operating pressures. Initially, the balloon is partially filled so that it can be moved back and forth and thus centered across the stricture. When the balloon is in position, it is filled until its designated operating pressure is achieved. The operating pressure is maintained for at least 3 minutes. Dilation is repeated three times. In general, it is prudent to monitor hydrostatic balloon dilations fluoroscopically to ensure that indentation of the balloon by the stricture is completely eliminated by the end of the dilation session. The absence of balloon indentation when the balloon is maintained at its operating pressure suggests successful dilation.

Extensive experience exists with the use of hydrostatic balloon dilators for dilation of stenotic lesions of the human esophagus. Initially, it was thought that hydrostatic balloon dilators might be safer than push dilators because they delivered pure radial force without an axial component. This has not proven to be true. Hydrostatic balloon dilators appear to offer no particular advantage over push dilators in the treatment of esophageal stenoses. The real advantage of hydrostatic balloon dilators is their ability to reach beyond the esophagus or distal colon to areas where the mechanical nature of push dilators prevents their use.

Endoscopic tissue ablation techniques for the treatment of malignant strictures of the hollow organ gastrointestinal tract include laser and electrocoagulation.

The term *laser* is an acronym for *l*ight *a*mplification by *s*timulated *e*mission of *r*adiation. Because radiant energy from a laser device is of a single wavelength and coherent, the laser radiant energy beam can be finely focused and its absorption characteristics can be accurately predicted. These properties make laser radiant energy suitable for medical applications that require precise "no-touch" delivery of tissue destructive amounts of energy. Argon, neodymium:yttrium aluminum garnet (Nd:YAG), and diode laser devices are used for endoscopic purposes because the radiant energy beams from these devices can be guided through a flexible quartz fiber that can be passed through the biopsy channel of an endoscope. Carbon dioxide laser devices are not used for endoscopic purposes, because suitable material for construction of a flexible beam guide is not available.

Thermal energy is responsible for the tissue destructive effects of laser radiant energy. Thermal energy is produced when laser radiant energy is absorbed into tissue. The amount of thermal energy produced by a radiant energy beam depends on its intensity, wavelength, and the incident tissue type. The argon laser operates at a wavelength of 500 nm, the Nd:YAG laser operates at a wavelength of 1064 nm, and diode lasers have wavelengths of 810 and 980 nm. The depth of tissue penetration is greater with the Nd:YAG laser than with the argon laser. With the Nd:YAG laser, photoenergies of between 50 and 100 W are used for tumor ablation. Additional variations in the actual tissue destructive effect of the laser beam can be achieved by varying the distance between the beam guide tip and the target tissue, the pulse duration, and the pulse frequency. The Nd:YAG laser is the most commonly used laser in gastrointestinal endoscopy.

In humans Nd:YAG laser therapy is useful for the treatment of exophytic obstructing malignancies of the hollow organ gastrointestinal tract. Submucosal tumors are more difficult to treat than exophytic tumors, because their borders cannot be easily defined, the risk of perforation is high, and the therapy is frequently painful. There is extensive experience for palliation of obstructing esophageal cancer and for ablation of rectosigmoid villus adenomas with Nd:YAG laser. However, the role of endoscopic laser therapy in the management of stenotic lesions of the hollow organ gastrointestinal tract remains unsettled because there are other less expensive, simpler, and equally efficacious methods of treating these lesions.

The passage of high-frequency electrical current (400 to 1000 kHz) can also produce thermal energy capable of tissue destruction. The BICAP tumor probe is a bipolar device that uses high-frequency electrical current to produce tissue destruction. The BICAP tumor probe is a

60-cm-long flexible wand with a sized bulb and flexible spring tip on one end. The flexible wand portion of the device is marked with 1-cm calibrations. The sized bulb is circumferentially lined with metal strips separated by insulating material. The bulb portion comes in 6-, 9-, 12-, and 15-mm diameters. An additional probe with a 15-mm diameter bulb with metal conducting strips covering only half of the circumference of the bulb is available for use in noncircumferential tumors. The entire tumor probe assembly can be passed over a guidewire. A connecting cord supplies current from the generator to the tumor probe.

The use of the BICAP tumor probe for treatment of malignant strictures requires stricture dilation, surveillance endoscopy, and either endoscopic or fluoroscopic monitoring of the tumor probe during application. The malignant stricture must be dilated to a diameter large enough to permit passage of an endoscope. After dilation, surveillance endoscopy is performed and the distance of the proximal and distal tumor margins from the incisors (or other landmark) is carefully measured. External markers may be placed over the tumor margins with fluoroscopic guidance. Finally, the endoscope is used to position a guidewire through the tumor. A tumor probe that will pass snugly, yet easily, through the stricture is selected (usually the 12- or 15-mm probe). Depending on whether fluoroscopic or endoscopic guidance is used, the sized bulb of the tumor probe is either pushed or pulled through the stricture using a station technique.

Use of the BICAP tumor probe for palliation of obstructing esophageal cancer is being investigated. Its advantages appear to be low cost, portability, and the ability to treat submucosal tumors. Its disadvantages include the inability to treat noncircumferential tumors because of the danger of coagulating normal tissue, the difficulty in treating tortuous malignant strictures because of the rigidity of the instrument, and the difficulty guiding the instrument when an endoscope is present for observation.

The Nd:YAG laser and the BICAP tumor probe represent methods of creating destructive amounts of thermal energy under endoscopic guidance within malignant tissue. The Nd:YAG laser is particularly useful for treating exophytic noncircumferential tumors, whereas the BICAP tumor probe is useful for treating circumferential submucosal tumors. Thus the BICAP tumor probe and the Nd:YAG laser appear to be complementary techniques for palliation of esophageal cancer in humans.

## THE FUTURE OF BLEEDING LESION THERAPY

Endoscopic coagulation of bleeding vessels in the gastrointestinal tract can be achieved by application of radiant energy (laser), electrical energy (bipolar and monopolar electrocoagulation systems), and thermal energy (thermocoagulation systems). The creation of thermal energy or heat in the target tissue is the final common mechanism with application of any of the three energy forms. Heat denatures tissue protein, resulting in solidification of liquid protein constituents and polymeric binding of other tissue constituents and surrounding material. Creation of sufficient thermal energy at a bleeding site results in a congealed (or cooked) mass of tissue constituents that form a hemostatic plug.

Rapid bleeding from a ruptured vessel can carry enough heat away from the target area to prevent heat-induced coagulation. Mechanical compression (coaptation) of the vessel before energy application prevents auto cooling of the target area. Touch techniques such as electrocoagulation and thermocoagulation permit vessel coaptation before energy application. Laser is a no-touch technique. Therefore when radiant energy from a laser is applied to a target area, heat dissipation can only be dealt with by increasing the energy density at the target. Either the power setting of the laser device must be increased or the beam guide tip must be moved closer to the target.

These maneuvers, however, tend to create tissue vaporization rather than coagulation and thus increase bleeding by destroying indigenous coagulum rather than creating more. The use of ruby contact tips with the laser beam guide permits vessel coaptation before energy delivery. Even with the ruby contact tips, the laser remains an unattractive method for achieving hemostasis because of its high cost and lack of portability.

A major problem with the physical contact method of energy delivery is the sticking of the coagulum to the probe. When the probe is withdrawn, the freshly created coagulum comes with it and bleeding resumes. The metallic conducting surfaces of the various electrocoagulation systems are areas where troublesome coagulum adherence occurs. Provision of powerful water jets at the probe tip helps diminish problems with sticking by permitting the endoscopist to wash free adherent coagulum before withdrawing the probe. In addition to water jets, the bipolar Gold Probe (Microvasive, Milford, Mass) uses gold conducting strips to diminish sticking. The Olympus Heater Probe Unit (Olympus Corporation, Lake Success, NY) does not depend on transmission of electrical current through tissue to generate heat. Therefore the entire probe tip is made of Teflon. The Teflon significantly diminishes sticking, but does not eliminate the problem. The heater probe also has coaxial water jets, which help to further diminish sticking.

There is debate about which method of energy application is most effective for prevention of rebleeding from human hemorrhagic gastrointestinal tract lesions. Results with the Nd:YAG laser are contradictory with some indications that the Nd:YAG laser is no better than conservative management and others indicating substantial benefit. When compared with multipolar coagulation

and the heater probe, Nd:YAG laser appears equally efficacious. Differences among the participating endoscopists' level of experience with Nd:YAG laser equipment and differences in the patients' studies probably explain the disparate results. Similar problems exist with evaluation of the heater probe and multipolar electrocoagulation techniques. In general, all three methods of energy application are effective, but it is unclear which is most effective. Convenience and theoretical considerations are supporting a trend away from the use of laser. More controlled studies with stringent entrance criteria are needed.

## COMPUTERIZATION OF ENDOSCOPY

The steady decrease in the price of computer hardware has made powerful computers available at nominal cost for use with endoscopy. Computers are used for endoscopic report generation and database management. Some endoscopic computer-based report generation systems are voice triggered with the endoscopist dictating directly to the computer, which instantaneously produces a typewritten report and enters the report variables into a database. In those facilities equipped with video endoscopy, digitized endoscopic images may be included along with the procedure report in the patient database.

Digital images obtained through a video endoscope may be manipulated using computer technology. For instance, colors may be changed, added, or subtracted from images. Such manipulation may enhance subtle image detail and aid in diagnosis.

Endoscopic autofluorescent tissue spectroscopy is another imaging innovation whose technology is based on computers and CCDs. Most biological tissue fluoresces when stimulated by light of certain wavelengths. The fluoresced light is always of the same or lower energy (longer wavelength) than the incident light. By using monochromatic (single wavelength) light from a laser as incident light, a filtering system, CCD, and computer technology, fluorescence patterns unique to various tissues can be detected. It has been demonstrated that endoscopic autofluorescent tissue spectroscopy can differentiate normal colon tissue from adenomatous colon tissue. Further development of this technology may permit the endoscopist, in essence, to obtain a histologic diagnosis at the moment of initial endoscopic lesion visualization.

Acquiring endoscopic skills by "practicing" on patients has long been recognized as a suboptimal situation. To address this problem, a vigorous effort is under way by various groups to develop training simulators for endoscopy. The basic concepts upon which successful endoscopic simulators will be based are listed in Box 16-3. The creation of a realistic internal landscape with seamless image motion has become one of the major problems in developing endoscopy simulators. Currently, videographic, computer graphic, and computer polygon mapping techniques are being investigated as methods of seamless image motion simulation. Various prototype simulators employ these technologies. The recreation of tactile sensation also poses a difficult problem for endoscopy simulators. Nonetheless, the prototype devices have been developed to the point where they are being evaluated for their impact on endoscopy training.

**Box 16-3 Basic Concepts for Development of Endoscopy Simulators**

Simulation must be a participatory experience.
A realistic tactile and visual experience must be created.
Recreation of "internal landscape" must accurately mimic the mosaic of views in motion seen during endoscopy.
Image appearance must occur in real time.
Images should be seamless.
The simulation system should be open and free of regimentation and subjective rules.

## CONCLUSIONS

The future of endoscopy is bright. Advances in video endoscopy will make access to and management of endoscopic images easier. New imaging modalities, such as endoscopic ultrasonography, will allow the endoscopist to look beyond the wall of the gastrointestinal tract with great precision. Laser tissue spectroscopy techniques may allow the endoscopist to perform on-the-spot histologic analysis of observed lesions by obtaining laser photospectrograms. Undoubtedly, the "superscope" equipped with electronic imaging for visual examination, an ultrasound transducer for beyond-the-wall examinations, quartz fibers incorporated into the light and image guide bundles for laser spectrometric histologic tissue analysis, and a computer to analyze and store the data collected during a procedure is not too far off. Advances in therapeutic endoscopy will continue to expand the list of disease treated first by the endoscopist rather than the surgeon. Advances in the application of robotics, computers, and video endoscopy will soon make practical endoscopy simulators available. The difficulty of obtaining endoscopic skills will decrease, and the trend toward viewing diagnostic endoscopy as an extension of routine physical examination will accelerate.

## DEDICATION

Dedicated to the memory of my grandfather, James H. Johnson, DVM, 1890-1981.

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