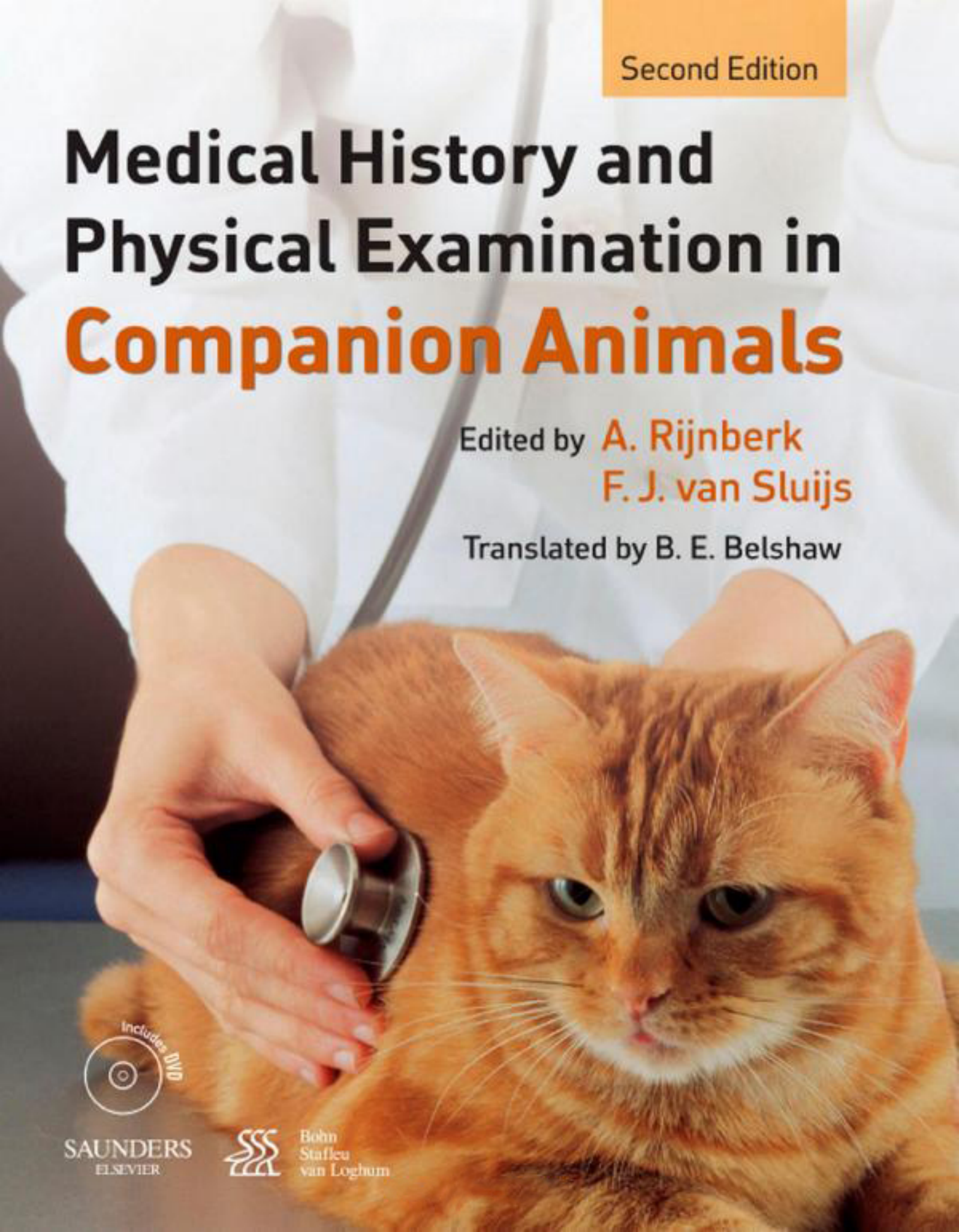
Second Edition

Medical History and Physical Examination in Companion Animals

Edited by A. Rijnberk
F. J. van Sluijs

Translated by B. E. Belshaw



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Prefaces

Preface to the first edition

The history and the physical examination are the most important pillars of clinical work, but a detailed description of these methods for application to companion animals has been lacking thus far. With this book an attempt has been made to fill the lacuna.

The approach is based on the methods used in the faculties of veterinary medicine of two Dutch-language universities, at Utrecht in the Netherlands and at Ghent in Belgium, and it illustrates the alliance between these universities. The book follows a line which has become more emphatically delineated in the past decade: an undertaking of the examination that is as problem-oriented as possible. The examiner is shown how to proceed from a limited examination to further definition of the problems presented by the owner, and is asked to make choices in order to increase efficiency. Directing the examination in this way makes it possible to use the available time principally for problem solving.

The description of methods in various chapters is based on this selective approach. At the end of many chapters there is a form which facilitates rapid orientation in the relevant examination. Some of the forms are the fruit of many years of use. Others have been developed only recently and have not been tested extensively in practice and hence they will be subject to changes.

The editors gratefully acknowledge the contributions of the authors of the individual chapters and their willingness to allow adaptation of their contributions to the general organization of the book. Although already mentioned on the copyright page, E.M. Klaasen-van Slobbe, BA (editorial assistant), Bert Janssen (drawings), and R.N. van Blokland, DVM (forms), deserve a special word of thanks for their dedicated and expert contributions. We hope that this book will find its way to those who can use it and will contribute to the quality of veterinary care of companion animals.

Spring 1990

A. Rijnberk and H.W. de Vries

Preface to the second edition

The first edition of the book *Medical History and Physical Examination in Companion Animals* has clearly filled a need. Following publication of the Dutch first edition in 1990, there have been five additional printings. Although the book was originally intended for Dutch-speaking regions, it soon became apparent that there was also an interest in other languages for this detailed description of the 'tools' of veterinarians for companion animals. This has resulted in the publication of translations in German, English, Spanish, and Japanese.

The authors of the first edition created the philosophy of the book, which is also the basis for the second edition. This includes not only those who have contributed to the second edition as well, but also those who for a variety of reasons have not: H.W. de Vries (editor), B.E. Belshaw, W.J. Biewenga, J.E. Gajentaan, R.P. Happé, H. Hoogenkamp, D.E. Mattheeuws, F.J. Meutstege, P.G. van Ooijen, R.A. A. van Oosterom, J. De Schepper, R.J. Slappendel, and G. C. van der Weijden. We are also grateful to Sylvie Daminet of Ghent University for reviewing Chapter 11.

We remain grateful for the work of A.R. Janssen, graphic designer, Utrecht. Many of the illustrations he made for the first edition continue to shine in the second edition. The forms, which were initially designed by R.N. van Blokland and adapted by Yvonne W.E.A. Pollak, are no longer to be found in the book but rather on the DVD as pdf files.

All of the chapters in this new edition have been revised and a completely new chapter on reptiles has been added. In addition, two chapters have been divided and the resulting parts have been expanded. Color photographs by J. Fama and the DVD compiled by M.J.A. Mudde have helped to modernize the book. We hope readers will find that these additions make it enjoyable to read as well as an effective companion to learning.

As for the previous edition we hope that this book will find its way to its intended users, thereby contributing to the improvement of the quality of veterinary care of companion animals.

Autumn 2004

A. Rijnberk and F.J. van Sluijs

Translator's preface

Translation of the first edition

Visitors from veterinary faculties in other countries have expressed admiration for the way in which Utrecht students undertake the physical examination of patients. What the students are taught is contained in this book. Though taking part in the teaching, I myself am also impressed week after week by its results: the way in which students working in the clinic are able to perform physical examinations, by their often remarkably secure knowledge of what to do and how to do it.

They are taught how to do this, about a dozen students at a time, during nine afternoon laboratories. Using the methods described in this book, a teacher first explains and then demonstrates all aspects of the examination being considered that day. Then the students work in pairs, each pair with an animal (dog, cat, bird, small mammal), to practice what they have been shown. The teacher observes, correcting technique, explaining, demonstrating again and again.

The translation of this book into English was begun because of the interest of visitors from another faculty who wished to learn this approach to physical examination for their own use and to be able to teach it to their students. The translation was encouraged by the interest of other visitors and by my own high regard for what the book teaches and how it does so.

The translation of each chapter has been reviewed and corrected by its author or authors. In this way we have tried to convey as accurately as possible what each author intends, in an English that we hope will also welcome those for whom it is a second language.

Spring 1994

B.E. Belshaw

Translation of the second edition

As for the first edition, the translated texts of the second edition were reviewed and corrected by one or more of the authors of each chapter. Ineke Westerhof kindly provided the initial translation of Chapter 30. Translation of the audio portions of the DVD, to which Carla Rijnberk contributed, was verified by the authors of the scripts and brought to life by the voice of Ed Schaefers.

Autumn 2008

B.E. Belshaw, A. Rijnberk, and F.J. van Sluijs

01 Introduction

A. Rijnberk

The history and physical examination are the methods by which a veterinarian in the exercise of his or her profession first handles a problem that is presented by the owner of an animal. The information thus obtained is the main determinant of the approach to the problem and it is also the main guide for further clinical management. This is not just the experience-based opinion of clinicians. It has also been documented in a recent observational study in human medicine. In 26 of 100 patients a thorough physical examination by an attending physician resulted in important changes in diagnosis and treatment.[1]

Specific applications of biochemical and biophysical principles have considerably enlarged the possibilities for laboratory diagnostics and diagnostic imaging. Nevertheless, the history and physical examination remain the most important guides for further examination and for monitoring treatment. The yield of screening laboratory examinations is small in comparison with selective laboratory examinations based on indications derived from the history and physical examination.[2]

In this book methods applicable to companion animals are described in such a way that they may also be taught to students. Veterinary education is generally considered to be training in a scientific profession.[3] The extent to which this can be considered to be science may be questioned but before answering this we should first consider what science is understood to mean.

It is especially through the work of the science philosopher Popper[4,5] that a clear distinction has been made between science and nonscience (pseudoscience, myth, and metaphysics). The critical rationalism of Popper is a rational problem-solving method[6] which essentially comes down to the following method of proceeding: A problem is recognized. For the purpose of explaining this problem, a theory (hypothesis) is created. From this theory the most 'hazardous' possible proposals are derived by deduction and are tested by observation and experimentation. If the results agree with the predictions then the theory is provisionally accepted as the best approximation of the objective truth. If the results do not agree with the predictions then the theory is not good (= challenged and found false) and it must be discarded. Then once again the problem must be defined and a new theory must be developed. Figure 1.1 is a schematic representation of this process.

The central question in science is thus not how the probable truth can best be found but how untruth can best be revealed and eliminated. It is a process of the survival of the strongest theory. The surviving theory will at that particular moment most closely approximate the truth. This is then 'to the best of our knowledge', which for practical purposes is—for the time being—taken to be the truth. The theories should be formulated in as clear a manner as possible, in order that they can be exposed in the most unambiguous way to refutation (falsification). In this manner one can indicate which experiment delivers such a result that the theory must be discarded. In this way we come at the same time to the border between science and nonscience: a theory is scientific if it is falsifiable. It is thus not scientific to bring additional evidence to bear in vindication of the theory; the theory would thereby take on the character of an unchallengeable certainty of belief ('religion').

Following Popper, others such as Kuhn, with his paradigm theory, have considerably extended the range of thought over what is scientific and what is not. Kuhn has among other things shown that developments in science over the long term are not purely rational but are influenced by external factors of a social, economic, cultural, political, or religious nature. Somewhat later Lakatos again placed theory

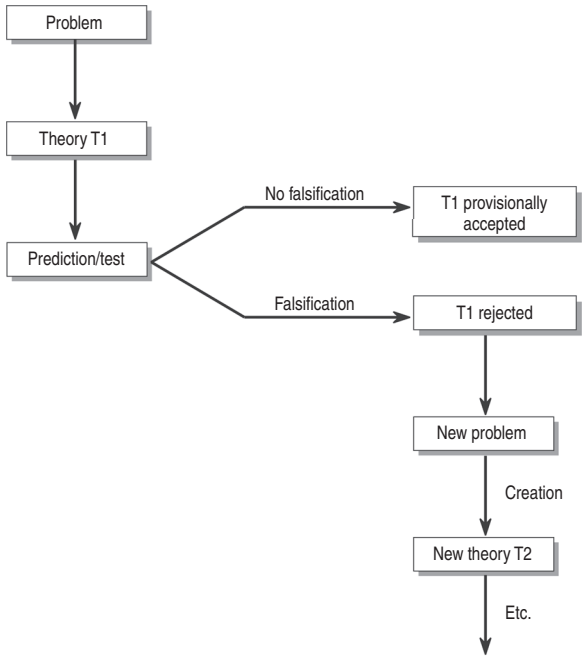


Fig. 1.1

formation or theory choice in the center, with science as a rational activity defended against irrational elements of Kuhn's paradigm theory.[7] The so-called sophisticated or refined falsifiability of Lakatos can be seen as an extension of Popper's rational procedure for theory elimination.

Popper's naive falsifiability knows only one way, the elimination of what is weak. The sophisticated falsifiability, in contrast, knows only elimination in combination with the acceptance of an alternative. According to sophisticated falsifiability, a scientific theory T_1 is only abandoned if its place is taken by another theory T_2 which has the following three characteristics:

1. T_2 has more empirical content than T_1; the new theory predicts new facts, facts that according to T_1 are improbable or even prohibited;
2. T_2 explains the previous success of T_1; all of the unrefutable content of T_1 is taken up in T_2;
3. a part of the additional content of T_2 will be confirmed by the results of experiments.

Another characteristic of Lakatos' refined falsifiability is the simultaneous generation of different alternative theories. For a certain period differing theories can sometimes exist side by side. The decision concerning elimination or acceptance cannot always be made immediately. Between the proposing of a theory and the finding of new facts can take some time. As a scientific measure, Lakatos does not use the separate theory but the manner in which the central theories follow each other by mutual comparison against the background of newly obtained factual material.

The refined falsifiability appears to form a good basis for the methodology of making clinical decisions. In Chapter 3 we will return to this. However, even now it should be noted that not all diagnoses grow out of a pure deductive manner of reasoning.[8] There is often some degree of pattern recognition, based on knowledge and experience.[9] As a result of this, ideas will again be generated and will then be tested.[10]

At first sight it is not very likely that the description of methods for physical examination contains elements which deserve to be called scientific. There is at yet no mention of problem solving, yet small excursions are made to clinical problems.

This book itself deserves to be studied in a scientific manner. The carefully prepared material and statements which it contains are based on 'our best knowledge', on that which at present is taken to be the truth because it is the least uncertain foundation at out disposal. In principle, however, all statements are to be considered highly suitable for falsification. This approach is especially important in the present case because much of what is presented here rests on the foundation transmitted by clinicians without having been systematically tested, testing which in the coming years may take place.

The content of this book is offered as a 'tool' that is necessary in order to resolve problems which owners of companion animals present to veterinarians. In order to make the best possible use of the available time in the scientific solving of these problems, we have chosen an approach to physical examination in which one can work in a strongly problem-oriented way. The tool can be used in an efficient manner in order to further define the presented problems, after which attention can be concentrated on the scientific solution of these problems.

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02 The rationale for this approach

A. Rijnberk and F.J. van Sluijs

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2.1 The intended readers

This book is intended for students in veterinary medicine and for veterinarians whose interests lie in the direction of the diseases of companion animals. It is attuned to the professional profile of the veterinarian for companion animals. This profile is further defined as first-line veterinary medicine in a practice in which one or more veterinarians are chiefly involved in treatment of companion animals.[1] Hence the description of the methods of examination in this book are confined to the methods which a veterinarian—principally involved with companion animals—is expected to use. Methods which belong to the practice of companion animal medicine on a specialist level are mentioned briefly in this book only to indicate what possibilities exist for further diagnostic studies by specialists.

2.2 The animal species

The book is in the first place directed to the history and physical examination of the dog and cat. In general the methods for the dog and cat are also applicable to other species. The species-specific aspects of the history and physical examination of birds, small mammals, and reptiles are dealt with in separate chapters.

2.3 The title

The title of the book was chosen to more closely indicate the contents than do terms which have been used in the past, such as 'clinical diagnosis' or 'clinical examination', terms that actually only indicate that the topic is diagnosis or examination in a clinical setting. This can, however, include other forms of examination such as laboratory examination or radiographic examination.

2.4 Why history and physical examination?

This book is based on the assumption that the veterinarian is concerned with the taking of the history and the performance of the physical examination for the following two reasons:

1. in order to determine the background of a problem that the owner of the animal has observed. With this background (diagnosis) the owner's expectations of the veterinarian can be met, namely, that the veterinarian obtains insight into the nature and the severity of the disorder and if possible prescribes a treatment;
2. in order to adequately meet the requirements of a specific request by the owner such as for a vaccination, a health certificate, or examination for the possible presence of breed-related abnormalities.

Although this would appear to be sufficient, an important reservation is still included. With the approach described under *1* the veterinarian does not presume to detect abnormalities at a time when they still have not led to any indication of symptoms which can be observed by the owner. For such a purpose, periodic health examinations are more suitable than an examination that is initiated for a specific reason.

The examination is thus strongly directed by the owner's reason for seeking veterinary consultation. Moreover, with the following approach an attempt is

made to only perform examinations which have a sufficiently large chance of success relevant to the problem presented by the owner.

2.5 Setup of the examination

When one turns to books about physical examination of human or animal patients, one observes that most authors lay strong emphasis on a thorough and complete examination, which must serve as the basis for further management.[2] In practice, however, a complete physical examination is seldom or never carried out. Always on the basis of the history and the first observations the examination is limited to that part that will probably lead most quickly to a further definition of the problem.[3]

Thus many choices are made to increase the efficiency of the examination. With increased experience the choices can be made more specific, which usually leads to a very efficient series of procedures. This method of working does not, however, lend itself to teaching, which is a reason why a search has been made for models for a more selective approach to the physical examination. There do not appear to be suitable models, although occasionally a start has been made.[4] Even in the literature on the problem-oriented approach to the patient, the physical examination is described as an essential basis without the explanation that this examination can differ according to the information obtained from the history and the first observation.[5] Some authors also do not favor a slightly more selective approach and are of the opinion that the veterinarian should develop a routine for adequate examination of all organ systems. It has even been remarked that 'an experienced clinician can easily examine an animal thoroughly in less that ten minutes'[6] and 'a complete physical examination should not require more than 5 to 8 minutes'.[7] It should be clear that this approach leads to an examination that is not careful or, conforming to the usual practice, that it finally results in limitation of the examination. The misunderstanding seems to have arisen with the term 'routine physical examination', which is also commonly used in medical education. Routine physical examination does not exist. The physical examination always has a particular reason, a certain aim.[8]

Since 1971, in the Utrecht Faculty of Veterinary Medicine's teaching of physical examination there is a point at which, after the general examination, a choice can be made to limit further examination to one or only a few organ systems.[9] We have continued to adhere to this idea. In combination with the problem-oriented approach this has led to a setup for the examination such as shown in Figure 2.1.

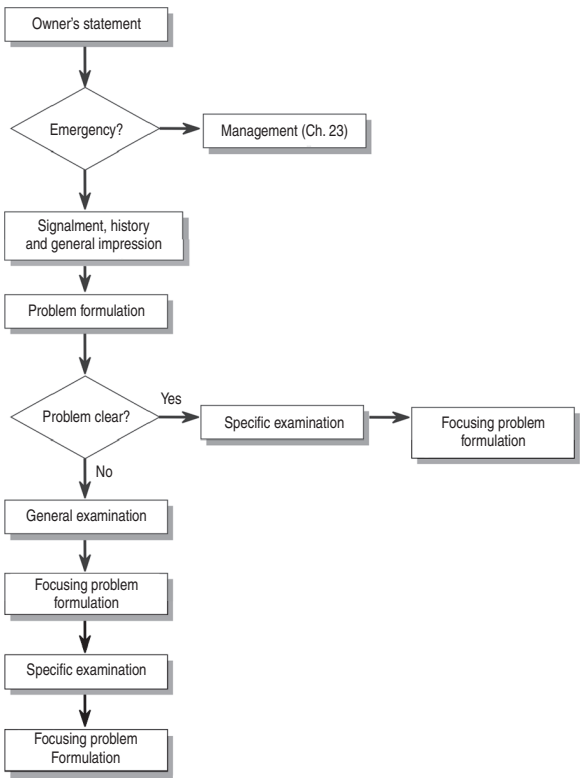


Fig. 2.1 Scheme for the setup of the history and physical examination.

With this approach two important questions must be answered:

1 Does the examination concern an emergency?
If the impression exists that there is an organ-threatening or life-threatening situation, then the examination should proceed completely as described in Chapter 23. If there is not an emergency situation, then—if it is the first encounter with the patient—some initial information from the owner and the signalment of the patient are recorded (Chapter 5). Following this the history is taken (Chapter 6) and then a general impression (Chapter 7) of the patient is recorded.

2 Is the problem formulation so well completed by the history and general impression that the further specific examination can (following guidelines) be carried out?
This question will be answered affirmatively if a specific request by the owner is involved: for example, a vaccination or an examination for a health certificate (Chapter 27). It will also usually be the case when there are localized signs or abnormalities, such as changes involving the ears and eyes, lameness, or superficial lesions and swellings. In other cases the problem formulation can sometimes be completed at this stage such that a specific examination can be carried out, whether according to a specific 'guideline' or not.

If, after the history and general impression, one or more problems cannot be clearly formulated and/or there are signs of a general illness, then the examination is extended with a general examination (Chapter 8). With this general examination an attempt is made to detect abnormalities which were not apparent in the 'general impression' and by which the problem formulation can be sharpened.

Depending on the formulated problems a choice is then made for examination of one or more, or parts of, organ systems (Chapter 9 and subsequent chapters).

In figure 2.1 it is clear that the setup of the examination is largely determined by the problems. In this context, a problem is understood to mean everything that must be examined and/or treated.[10] With this design, problems are already formulated at an early stage and as more information becomes available they can be more sharply defined. The recording of findings (notation) is considered in Chapter 5.

Sometimes there will be a problem for which a 'guideline' is available (see § 2.6), so that a specific examination can be carried out according to such a guideline. In this examination new problems can come to light and can be added to the problem list and thereafter can be pursued following a guideline or not. It will be clear that in cases in which the problem formulation is already possible after the general impression, the specific examination can sometimes include elements that also occur in the general examination.

The examination may lead to a proposal for surgical intervention or to further examination for which anesthesia is necessary. For this a preanesthetic examination should be performed, as described in Chapter 26.

With this system an attempt is thus made to limit the examination in such a way that the available time is used as much as possible for the solving of problems for which the owner has presented the patient. An effort is made to obtain the best diagnostic return by a limited examination that is performed well. Preference must be given to this over a 'complete physical examination', which usually comes down to searching the patient for gross abnormalities.

This approach is open to discussion. It can be said that limitation of the examination is not justified because the choices are not based on appropriate information. For the compilers of this book this idea played a role in deciding upon the content of the chapter on the General Examination (Chapter 8). Consideration was given to the inclusion of other components of the physical examination in order that as many organ systems as possible be examined. The examination has, however, remained restricted to the content given in Chapter 8 because the proposed additions (e.g., abdominal palpation) are not appropriate to a screening examination, which should be an examination requiring little time but having great sensitivity. If well performed, these additions would instead require much time which is usually not adequately provided for or which is obtained at the cost of other parts of the general examination.

2.6 Guides

As shown in Figure 2.1, this approach may lead to 'specific examinations'. It will not be necessary in each patient to carry out a specific examination point by point. In the approach to many problems a certain consensus has developed. The resulting guides are usually presented as texts or as flow charts (algorithms).

In Chapter 3 under the heading of Diagnostic process (§ 3.2) this topic will be discussed in more detail. This approach, which has been described as protocol medicine, tries to give the veterinarian a guide to follow in diagnosis and/or treatment. In addition the 'guides' could serve as the basis for intercollegial testing. Here it should be added with emphasis that such 'guides' only arise from information in the literature, theoretical considerations, and clinical experience; they have not been tested systematically.

In consensus discussions, 'to the best of our knowledge' is used as the guide and this implies that modifications will often be needed in the future. In recent years there has been a strong effort to rely as much as possible on scientific evidence in the making

of decisions on diagnosis and treatment. For example, in 2002 a new journal appeared in human medicine concentrating completely on the publication of standardized protocols, heavily based upon information acquired through research.[11] This 'evidence-based medicine' is discussed briefly at the end of Chapter 3.

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03 A few concepts and an introduction to the diagnostic process

A. Rijnberk and E. Teske

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3.1 Concepts

There has been as yet no standardization of the terminology used in physical examination.[1] On the contrary, the terms for describing observations vary from textbook to textbook. A few of the clinically important concepts, about which there are occasional misunderstandings, are discussed below.

3.1.1 Symptoms and signs

In veterinary medicine the terms 'symptoms', 'complaints', and 'signs' are sometimes used interchangeably. Because our patients generally do not complain, the term 'complaint' seems out of place in veterinary medicine. In human medicine the term 'symptoms' is used to denote the observations and sensations of the patient concerning his or her body and its products. 'Signs' comprise the observations made by the doctor during physical examination.[1] In pediatrics it is not the baby that presents the history, but usually the parent. Similarly, in veterinary medicine it is the owner or handler who presents the (hetero)anamnesis. Consequently, and without losing ourselves in detailed semantics, we can agree that in general in veterinary medicine a distinction can be made between:

1. *symptoms*, which are the changes observed by the owner, and
2. *signs*, which are abnormal findings of the veterinarian during the physical examination.

The owner may observe a great many symptoms but only a few may cause him to consult the veterinarian. The latter are called *iatrotropic* symptoms (from the Greek: iatros = physician, tropein = seeking).

Iatrotropic problems are important because they usually form the problem that—in the eyes of the owner—must be solved by the veterinarian. The iatrotropic symptoms will not always be caused by the principal problem of the patient. Sometimes the most important problem of the patient is associated with symptoms which do not yet rise above the iatrotropic threshold.

3.1.2 Scales of measurement

Observation plays a large role in physical examination. In many cases the observations also have a quantitative character, so that they can be described as measurements. In principle this measurement involves comparison with a quantity of the same kind (standard). If it concerns length, we make use of an *interval scale*,[2] which is based on a standard length and in which the width of each interval of the scale (the calibration) indicates how accurately measurements can be made with the measuring instrument. If it concerns mass, then we compare with a standard mass. In physical examination, however, it is not always adequate to record quantitative information by means of an interval scale.

For example: a nodule or mass could be described by its size and consistency. The size can be given by measuring it as carefully as possible (depending on its accessibility) in three dimensions in the metric system.

The consistency can be described by comparison with the consistency of some object or material. Hence it might be described as having 'the consistency of modeling clay'.

Such a description is not quantitative. Yet we can place the information semiquantitatively in a rank by use of an *ordinal scale*.[2] A scale for describing consistency could be as follows:

The consistency is reminiscent of (1) water in a thin plastic sack, (2) putty, (3) soft rubber, (4) hard rubber, or (5) stone.

This example shows at the same time the problem in using ordinal scales: the exact definition of the classes. Such scales are still not commonly used in human or veterinary medicine. In this book an ordinal scale is used when it is thought to be appropriate. For example, in § 17.3.2 an ordinal scale is given for grading lameness.

In addition to an ordinal scale, which gives a semiquantitative standardization to the ranking of a particular characteristic, we can also use a *nominal scale*,[2] in which the name also contains recognition. It is applicable, for example, to the tones in percussion: (1) hollow tone, and (2) dull tone. This is comparable to a scale for sounds of different musical instruments: (1) piccolo, (2) flute, (3) oboe, and (4) clarinet. The use of such a scale depends on a number of conditions, the most important being that the classification must be unique so that no observation can be put in more than one category. This immediately raises problems for the findings in physical examination, so the application is limited. The nominal description of observations thus usually consists of no more than the recording of present or absent (a scale with two categories = a dichotomous scale). Summarizing in reverse order, the classification and evaluation of findings can be recorded by means of a nominal scale, an ordinal scale, and an interval scale. An ordinal scale can be used to rank nominal observations, so that a certain characteristic could be given a score (for example, 4 for consistency). If the differences between the scores are equal, then an interval scale is obtained.

The measurement of symptoms and signs is called *clinimetrics*.[3] It is an approach that affords documentation of the course of disease and the effects of treatment. Also, when care of the patient is transferred or referred to someone else, that person's effectiveness in diagnosis and treatment will benefit from data that have been quantified as much as possible.

3.1.3 Measurement errors

Even more than for other pillars of the clinical examination, such as laboratory diagnosis, the measurements in physical examination have a rather limited accuracy. One can divide measurement errors into (1) accidental (chance) and (2) systematic mistakes. As an example, a cat has been hospitalized and its body temperature is measured daily. On six successive days the temperature varies between 37.6°C and 37.8°C. On the seventh day the temperature is measured by a different person, who uses the thermometer correctly (introducing it far enough) and a temperature of 38.2°C is found. Hence there has been a series of measurements with a small variation and thus a fairly great *precision* (= high reproducibility), but with a systematic error, so that the results of these measurements on an interval scale have a poor *accuracy*.

The same concepts apply to observations on a nominal scale. As an example, several observers are asked independently to identify a percussion tone. All of the observers appear to be in agreement that the tone is a dull tone. This is precise observation. However, each observer was able to reproduce the result of the other; in other words, there was no *inter-observer variability*. If, however, in reality it was a hollow tone that had been presented to the observers, their precise observations would have been *inaccurate*. It should also be clear that an inaccurate observation on an ordinal or nominal scale usually means a serious error.

Inter-observer variability plays a role in everyday clinical work. This was illustrated by a study in which 6 veterinarians were asked to auscultate the hearts of 57 dogs of a breed with a high prevalence of valvular defects. The presence or absence of a leaking valve was confirmed by ultrasonography and phonocardiography. The percentage of defective valves signified by murmurs detected by the veterinarians ranged from 63 to 88 percent. The most experienced examiners had the best results.[4]

3.1.4 Occurrence and incidence

In dogs, vomiting is sometimes due to a gastric carcinoma. In a group of 200 consecutive dogs presented for chronic vomiting, examinations eventually revealed that 30 had a gastric carcinoma. This amounts to an *occurrence* (prevalence) in this population of 30/200 = 0.15 or 15%. In terms of probability analysis, the probability (P) (the a priori chance or 'advance chance') that any given dog in this population has the disease (D)—gastric carcinoma—is expressed as P(D) = 0.15. The occurrence of a disorder should be clearly distinguished from the concept of *incidence*, which is defined as the number of new cases of a disease that are registered in a population in a given period (e.g., a year). In a population chronic disorders can be quite prevalent although their incidence is low. On the other hand, disorders of short duration such as respiratory infections can have a low occurrence in a population but a high incidence.

3.1.5 Sensitivity, specificity, and predictive value

Of the 200 dogs mentioned above, presented because of chronic vomiting, 40 had a history of sometimes vomiting blood. This is a strong indication of the presence of a gastric carcinoma. In order to obtain insight into the meaning of this characteristic, a Venn diagram is constructed (Fig. 3.1). In this diagram, U represents the 'universe', that is, the total population of chronically vomiting dogs. The group of patients with the disease (gastric carcinoma) is represented by D. The group of patients with the nosographic (= distinguishing or disease indicating) character of 'vomiting blood' is represented by C. Now we can see to what extent we can say something about D with the help of C.

The diagram consists of four subgroups.

1. $C \cap D$: the animals that 'vomited blood' and had a gastric carcinoma. Here the question in the history about 'vomiting blood' had a *real positive* result.
2. $C \cap \bar{D}$: the animals which had a 'positive history' but were found not to have a gastric carcinoma. These are so-called *false positives*.
3. $\bar{C} \cap D$: patients which did not have a history of 'vomiting blood' but which did have a gastric carcinoma: the *false negatives*.
4. $\bar{C} \cap \bar{D}$: patients which did not have a history of 'vomiting blood' and did not have a gastric carcinoma. The history thus provided a *real negative* finding in these cases.

From these groups and subgroups several unconditional and conditional probabilities can be calculated (see also Table 3.1). The *unconditional probability* P(D) is the probability that a vomiting dog has a gastric carcinoma. P(C) is the unconditional probability that any patient selected at random will be 'vomiting blood'. A marginal note should be made by the term 'unconditional' because a condition in the selection was that the patient vomited. P(D) and P(C) are only unconditional within the chosen 'universe' (vomiting). In large epidemiological investigations one can more closely approximate the real unconditional probabilities, but they can never be fully achieved.

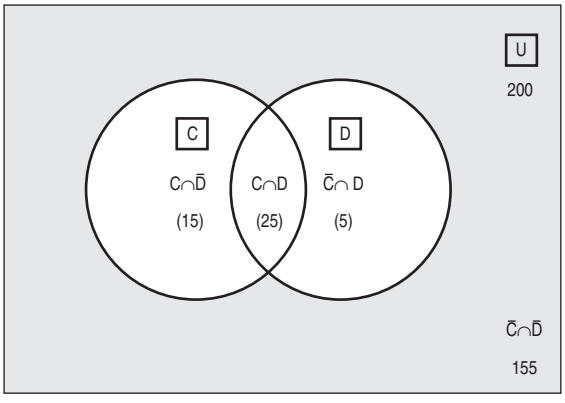


Fig. 3.1 Venn diagram for the illustration of subgroups in a population (U) of vomiting dogs. Circle D = having the disease (gastric carcinoma); circle C = having the character 'vomiting blood'. The symbols $\bar{D}$ and $\bar{C}$ indicate that the disease or character is absent. With the overlapping of the circles four subgroups are formed ($C \cap D$; $C \cap \bar{D}$; $\bar{C} \cap D$; and $\bar{C} \cap \bar{D}$).

By *conditional probability* is meant probability under the condition of a certain situation. Here for example the condition 'vomiting blood' is brought into question; what then are the probabilities? In addition a distinction is made between diagnostic probabilities and nosological probabilities.

The *nosological probabilities* are the probabilities that a patient vomits blood or does not, *provided that* it does or does not have a gastric carcinoma. This probability can be represented as P(C/D). A nosological (= inherent in the disease) conditional probability thus concerns textbook information. In essence it is the frequency with which a sign is seen in a given disorder. This information is of little direct importance when the clinician is faced with a diagnostic problem in an individual patient.

The clinician is then faced with another problem. His help is sought by a client for an animal that vomits and he must then assess the probability that the patient has a gastric carcinoma. The clinician thus has more interest in the reverse probability P(D/C). This *diagnostic probability* represents the probability that a patient has a gastric carcinoma if there is evidence of 'vomiting of blood'.

In Table 3.1 the unconditional and conditional probabilities for the previously given case example are worked out. The most current terminology is given after each of the conditional probabilities.

Careful study of the table together with the previously shown Venn diagram will make much of this clear. Insight is given into two characteristics of a distinguishing sign or abnormality, namely, *sensitivity* and *specificity*.[1,5] The sensitivity P(C/D) indicates what percentage of the patients with the disease are detected by use of a given diagnostic test. The specificity $P(\bar{C}/\bar{D})$ indicates what percentage of patients not having the disease are also shown to be free of it. In the example shown the character has a reasonable sensitivity (0.83) and also a fairly good specificity (0.91).

The *predictive value* of the presence of 'vomiting blood' is, however, only moderate (0.63). In contrast, the predictive value of the absence of 'vomiting blood' is very high (0.97). This means that a question in the history about the occurrence of 'vomiting blood' has a high screening value for exclusion of a gastric carcinoma, but much less for the diagnosis of a gastric carcinoma.

In much of the literature about this material only the nosological approach is discussed, which—as already explained above—is of only limited clinical importance.

Table 3.1

unconditional probabilities	
$P(D) = \frac{D}{U} = \frac{30}{200} = 0.15$	occurrence of the disease (prevalence)
$^{*}P(\bar{D}) = \frac{\bar{D}}{U} = \frac{170}{200} = 0.85$	absence of the disease
$P(C) = \frac{C}{U} = \frac{40}{200} = 0.20$	occurrence of the character
$^{*}P(\bar{C}) = \frac{\bar{C}}{U} = \frac{160}{200} = 0.80$	absence of the character
nosological conditional probabilities	
$P(C/D) = \frac{C \cap D}{D} = \frac{25}{30} = 0.83$	sensitivity of character or test
$^{*}P(\bar{C}/D) = \frac{\bar{C} \cap D}{D} = \frac{5}{30} = 0.17$	nosological false negative
$P(\bar{C}/\bar{D}) = \frac{\bar{C} \cap \bar{D}}{\bar{D}} = \frac{155}{170} = 0.91$	specificity
$^{*}P(C/\bar{D}) = \frac{C \cap \bar{D}}{\bar{D}} = \frac{15}{170} = 0.09$	nosological false positive
diagnostic conditional probabilities	
$P(D/C) = \frac{C \cap D}{C} = \frac{25}{40} = 0.63$	predictive values of presence of character/positive test result
$^{*}P(\bar{D}/C) = \frac{C \cap \bar{D}}{C} = \frac{15}{40} = 0.37$	diagnostic false positive
$P(\bar{D}/\bar{C}) = \frac{\bar{C} \cap \bar{D}}{\bar{C}} = \frac{155}{160} = 0.97$	predictive values of absence of character/negative test result
$^{*}P(D/\bar{C}) = \frac{\bar{C} \cap \bar{D}}{\bar{C}} = \frac{5}{160} = 0.03$	diagnostic false negative

**Each probability marked with an asterisk is complementary to the one directly above, for example P(C/D) = 1 – P ($\bar{C}$/D).*

In addition, there is the possibility of two explanations of the terms *false-positive* and *false-negative*. In the example, using the nosological approach 'vomiting blood' gives false-positive information in 9% of the patients without gastric carcinoma, while using the diagnostic approach gives false-positive information in 37%. Both percentages are indicated as being false positive, a term which causes much misunderstanding.

For the sake of simplicity the statistic is not shown in the example, but we should not forget that the probabilities concern rather small numbers of patients. Extrapolation of these observations (the random sample) to future patients (the population) presupposes the introduction of confidence limits.[6] By use of the appropriate tables[7] we find, for example, that the predictive value of P(D/C) = 25/40 can vary, with 95% confidence, from 0.46 to 0.77.

In this figurative example a decision was first taken about the nosographic characteristic (vomiting) of the random sample which could be considered. Then consideration was given to the predictive value of the occurrence of a character ('vomiting blood') for the presence of gastric carcinoma. In this example a choice was made for a characteristic symptom in the history, but of course it could also have been a test such as examination of vomitus for blood pigment or examination of feces for blood pigment or even the hematocrit value in the circulating blood.

In the above described *direct method* for determining the predictive values of a characteristic symptom or a diagnostic test, the results depend on the indication and thus on the composition of the random sample. If, for example, a choice is made for a group of patients with vomiting in the history in place of a group in which chronic vomiting forms the iatrotropic problem, then different predictive values would almost certainly be found. It is clear that in the direct method a choice can always be made for the most relevant group of patients.

Sometimes a more conventional approach is taken and the *indirect* or *nosological method* is chosen. First, a group of patients with an irrefutable diagnosis is chosen and then a control group is collected which mostly consists of healthy animals. Both groups are or will be examined with a certain test, after which the

percentages of positive and negative results in both groups will be calculated. In case of, for example, 90% positive results in the patient group and 95% negative results in the control group, the sensitivity and specificity can be represented as P(C/D) = 0.90 and P($\bar{C}/\bar{D}$) = 0.95, respectively.

These are nosological probabilities that allow the clinician to predict how great the chances are of a positive or negative test result in the patient which has the disease in question. This information is of little importance when one is confronted with a patient in which just the opposite is of importance, namely, the diagnostic probabilities P(D/C) and P($\bar{D}/\bar{C}$). By studying textbooks the clinician has learned nosological probabilities which in daily practice are turned around into diagnostic probabilities. This (often unconscious) process of reversal is part of the concept of 'clinical experience'. This reversal can also proceed in a more exact manner, namely, with the help of Bayes' theorem.* In its most simple form and focused on the present material this can be represented as follows:

$$P(D/C) = P(C/D)\frac{P(D)}{P(C)} \text{ and}$$

$$P(\bar{D}/\bar{C}) = P(\bar{C}/\bar{D})\frac{P(\bar{D})}{P(\bar{C})},$$

this meaning that a conditional probability can be calculated from the reversed conditional probability and the two unconditional probabilities. By a few algebraic manipulations it can be shown that:

$$P(C) = P(C/D)PD + \{1 - P(\bar{C}/\bar{D})\}\{1 - P(D)\},$$

so that in a test for which the sensitivity and specificity are known, the predictive value can be calculated if nothing more than the occurrence of the disorder in the population is known. As has already been noted for the direct method, the predictive value of the test is highly dependent on the composition of the random sample and thus on the prevalence of the disease P(D). This is illustrated in Table 3.2 by the results of an imaginary investigation of the usefulness of palpation of the peripheral pulse for detecting an arrhythmia (revealed by ECG).

From this it is easy to show that the sensitivity of the method P(C/D) = 90/100 = 0.90 and the specificity P($\bar{C}/\bar{D}$) = 80/100 = 0.80. The predictive value of palpation of the peripheral pulse for the presence of an arrhythmia P(D/C) = 90/110 = 0.82.

If the composition of the groups was such that the control group (no arrhythmia) was twice as great, the table would have a different appearance: Table 3.3.

Sensitivity and specificity are, just like the chance of a false-negative result, unchanged (think about this!). In contrast, the predictive value of the abnormal sign for the presence of an arrhythmia is lowered considerably: P(D/C) = 90/130 = 0.69, while the predictive value of the absence of the character for the presence of an arrhythmia is instead increased: P($\bar{D}/\bar{C}$) = 160/170 = 0.94 in place of 80/90 = 0.89.

These examples clearly show that the nosological probabilities are of little worth if the unconditional probability that the patient has the disease P(D) is unknown. It is also clear that in a large clinic, where many patients in a given category are presented, the predictive value of a test can be high, and that it can be lower in a private practice where this type of patient is fairly infrequent. In the latter situation such a test is mainly of value in excluding the disorder in question.

There is another objection to the indirect nosological method. This concerns the composition of the groups. The selected group of patients sometimes contains rather pronounced cases in which a positive test result may be found earlier than in less severe cases. The control group is no more realistic if healthy animals are chosen for it. It may also be that the diagnostic test

Table 3.2

palpation	*arrhythmia*	*no arrhythmia*	*total*
abnormal	90	20	110
not abnormal	10	80	90
total	100	100	200

Table 3.3

palpation	*arrhythmia*	*no arrhythmia*	*total*
abnormal	90	40	130
not abnormal	10	160	170
total	100	200	300

*Thomas Bayes (1702–1761), Presbyterian minister in England. His writings concerned mathematical and religious topics.

has a rather invasive character (e.g., a kidney biopsy), which makes one unwilling to use it in healthy animals. Such a control group is unnecessary if one uses the direct diagnostic method, in which a test is performed on the basis of a specific indication. Nevertheless, the nosological approach must still be used sometimes, especially in the first investigation in a new area. In diseases that are very infrequent, it may not even be possible to use the direct method.

The above is also intended to improve the critical reading of articles in veterinary and medical journals, in which, especially when new methods are presented, only nosological probabilities are presented. It has been explained above how these can be turned around into diagnostic probabilities and it has been shown that the direct method for determining the predictive value of a diagnostic method usually deserves preference. The calculation appears to be somewhat complicated. Also, the information necessary for the calculation of these objective probabilities is often not or not yet available. Yet this is not essential. It is more important that the clinician acquires insight into the background of certain results. It should be obvious that in a situation in which many individuals do not have the disorder, it must be anticipated that relatively many false-positive results will be obtained. If on the other hand a large number of patients have the disease, a negative test result will be less reliable and the number of false-negative results will increase. From this it follows that the type of test can differ according to the conditions. In the latter case (a university clinic) a test with great sensitivity will be satisfactory. In the first case (a veterinary practice) the greatest need will be for a test with high specificity, a rapid screening test with a great ability to exclude. Thus far attention has only been given to the diagnostic importance of a single nosographic sign, but this is an all too simple representation of the clinical decision process. Almost always there must be a decision on the basis of various nosographic characteristics, a process in which Bayes' theorem is applied unconsciously in a subjective way and a conclusion is made. After this more information may become available (e.g., radiographic findings or the histopathology of a biopsy), which also contains some uncertainty and must be integrated with the earlier findings. Probability analysis may also be involved here.[8-11] For a patient with a swelling, the clinician thinks: inflammation, benign tumor, or malignant tumor. Yet the age of the patient, its gender, and several features of the swelling could cause the clinician to estimate the probability of these three diagnoses as 0.65, 0.30, and 0.05, respectively. The clinician thus made an integrated estimation of three complex diagnostic probabilities (= P(D/C)). The pathologist works in a different way in evaluating the biopsy. He makes use of the archives or his own memory to decide how closely the histologic picture approximates each of the differential diagnoses under consideration (= P(C/D). Then the a priori probability (or opinion) of the clinician can be multiplied by the nosological probabilities of the pathologist (Table 3.4). Thus the original opinion is adapted ('weighed') by the contribution of the pathologist and the results are the a posteriori probabilities. The surprising thing in this, as the example has shown, is that the end result is sometimes a probability that neither party had expected. It is an approach which can greatly benefit the diagnostic process.

3.2 Diagnostic process

The diagnostic decision process rests on the following three pillars:[1]

1. *Pattern recognition*, in which the clinician, with knowledge from textbooks, recognizes the clinical picture of known diseases. So, for example, canine distemper can be recognized on the basis of the presence of a group of characteristic symptoms.
2. *Causal approach*, in which logical thinking and knowledge of pathophysiology are of central importance. The cause of edema can, for example, be found by an analysis on the basis of knowledge of the pathophysiology of this abnormality.
3. *Probabilistic diagnosis*, in which the diagnosis is based on estimation of probabilities. This 'Bayes diagnosis' has been described above.

Often the diagnosis is made by an interaction of these three pillars, in which the following sequence of steps[12] (also see Chapter 2) is followed:

- assembly of the findings, leading to
- problem formulation

Table 3.4

	P (clinician) %	*P (pathologist)* %	*Product* %	*P (a posteriori)* % *(Product × 100/Σ)*
inflammation	65	5	325	25
benign tumor	30	20	600	46
malignant tumor	5	75	375	29
			Σ = 1300	

- making (insofar as possible in a pathophysiologic way) a list of possible causes of the problem
- thinning of the list, a process in which against the background of the clinical manifestations of the problem the probability (P(D/C)) of a given cause is considered. The causes with a very small probability are excluded or temporarily removed from consideration (parked).
- forming a diagnostic plan in order to choose among the remaining differential diagnoses. This diagnostic plan rests upon the pathophysiologic possibilities, yet in the sequence in which the plan is developed many other factors (including the level of development of the veterinary practice and financial limitations) play a role.
- deciding whether all of the signs in the patient can be explained by the final diagnosis. If they cannot, a new problem is formulated and the above process is repeated.

In essence this is the problem-solving method, briefly described in Chapter 1. Translated to the clinical decision process, the scheme given in Chapter 1 (Fig. 1.1) can be expanded into the scheme shown in Figure 3.2.

A great difference between this approach and the scheme given in Chapter 1 is the presentation of various theories which could explain the problem and which usually will be tested at the same time. However, for each possible cause usually (by deduction) a certain phenomenon is predicted and is then tested. For example, for the problem of polyuria, one can theoretically consider, among other things, osmotic diuresis due to renal insufficiency or diabetes mellitus. In that case it can be predicted that either isosthenuria (urine SG of 1.010) or glucosuria is present, and both of these possibilities can then be tested.

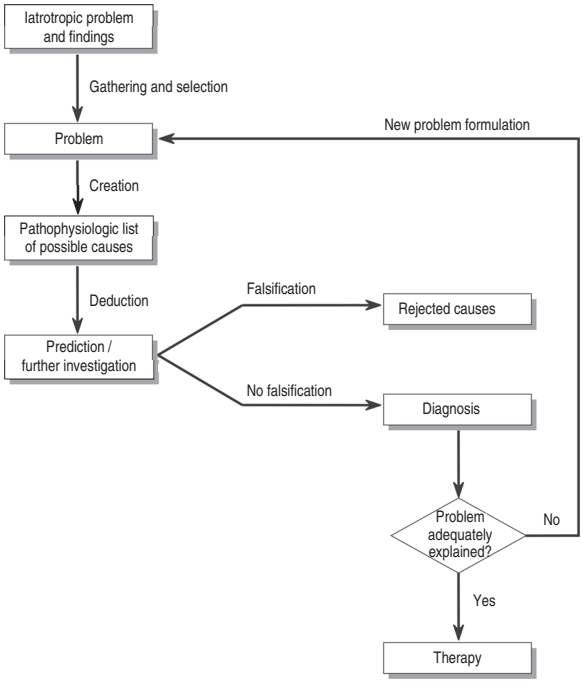


Fig. 3.2 Clinical decision process shown schematically.

Another difference from the situation described in Chapter 1 is that usually various problems are distilled from the findings. Furthermore, after the diagnostic decision another step (relating back to the problem) is introduced, which can lead to new problem formulation.

This gives a picture of the complicated character of the problem-solving method with which the clinician must work. As explained above, the quality of the diagnostic procedure can in principle be improved by making use of probability calculations. Usually, however, the necessary probabilities are not known. In the entire procedure there are also often small intermediate decisions to be made. All of this means that sometimes the diagnosis might seem to be reached by a vague brainstorm rather than via logical reasoning.

Until recently the clinician also scarcely had the means to express the thought process, which has been called scientific aphasia.[13]

Chemists and physicists have long represented their thought patterns in the form of chemical and mathematical formulas, while the clinician usually tries to set down the rationality of the thought process in a written description. With the stimulus provided by the computer a change has come about in recent years. Not so much by use of the computer itself but by application of notations necessitating use of the computer, the clinician can now specify the reasoning process. For this purpose use is made of so-called *algorithms*, systematic representations of a series of steps that must be carried out and/or decisions that must be taken in order to solve a problem. In order to give an idea of this, such a flow chart for the problem of mammary tumor in the dog is presented (Fig. 3.3). These *guides* are intended to help the clinician in the formation of a diagnostic plan, after—as shown in the procedure—the problem formulation has taken place. With the outlined procedure and the guides the approach to the patient is strongly heuristic. This heuristic support seems to anticipate shortcomings in the clinically thinking mind, such as have come forth from scientific research. A few results of research into the psychology of clinical analysis[14] are summarized briefly here:

- In contrast to what students have long been taught is the right approach, the clinician already begins forming a hypothesis at a very early stage.

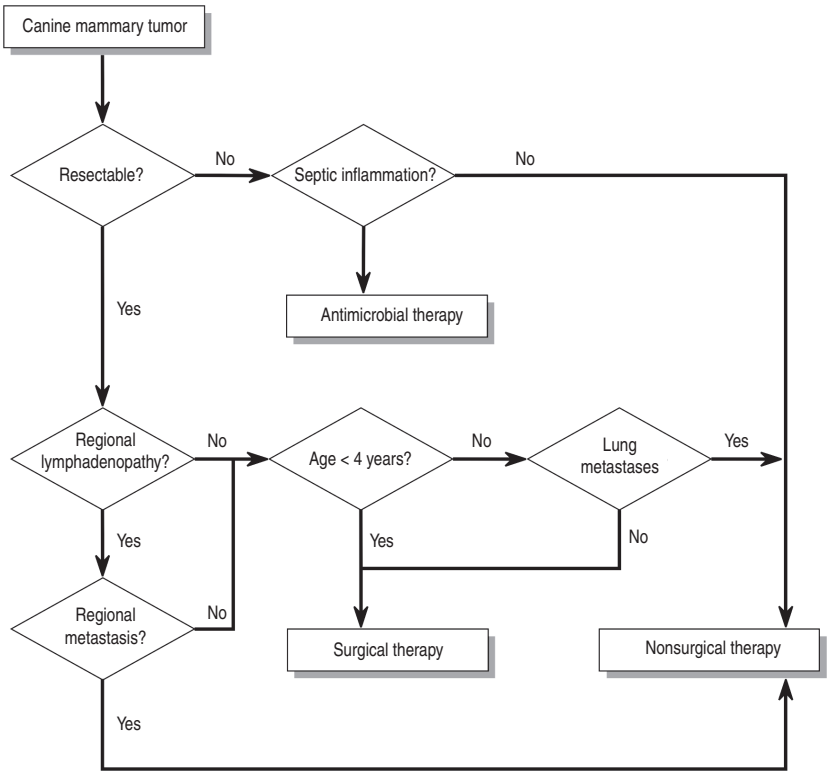


Fig. 3.3 Algorithm for mammary tumor in the dog.

- The number of hypotheses that a clinician considers simultaneously is usually small, seldom more than five. In this limited scope of thinking, the following phenomena could still occur:
  - The hypotheses could be somewhat vaguely formulated in an attempt to also include inconsistent findings.
  - Some findings could be set aside in order to avoid having to form new hypotheses.
  - Great importance will be attached to some findings to further substantiate the hypothesis that is being considered.
- There is a strong inclination to allow information which does not in fact support the hypothesis to predominate nevertheless, instead of creating a new hypothesis. This appears to rest on a need of the human intellect to look at disagreeable problems in a way that makes them seem less complicated.
- There is a fairly great variation in capability among clinicians, depending on the nature of the problem. One way of describing the capacities of a clinician is in terms of capability profiles with specific competencies for certain problems in certain situations.
- The capability of the clinician is to a very great degree dependent on knowledge and experience. In addition to knowledge there must above all be broad experience with related problems in order to determine which symptoms and signs are of importance to the diagnostic process. The meaning of experience in the solution of complicated problems was already shown in the 1960s by the classical research of De Groot.[15] His research on chess players showed that grand masters do not differ from less capable players in their ability to think far ahead but in their memory. The quality of chess playing appears above all to depend on the long-term ability to remember chess board patterns.
- In seriously ill patients physicians are inclined to present a prognosis that is too optimistic.[16] This attitude has not been studied in veterinary medicine, but since the threshold for euthanasia is somewhat lower than in human medicine, the outcome of such a study might be different.

The procedure which has been outlined here for problem solving via guides is no panacea for all clinical questions. It is intended as a guideline with—against the

background of the above—the following supporting possibilities:

- The approach to the physical examination and the procedure for making diagnostic decisions give opportunity for early forming of hypotheses.
- The algorithms (guides) provide a large number of alternatives, which limits the danger of a too narrow range of thinking.
- A clinician with a somewhat less developed capability for a given problem can fall back on a clear guideline.

It is appropriate to conclude this chapter with a few remarks about the algorithms that have just been discussed. The algorithms are at first glance usually attractive; they seem to offer a very rational approach to the problems. Yet as already mentioned in the previous chapter, they are for the time being at best the fruit of consensus discussions, i.e., discussions among clinicians with expertise in the field concerned. In recent years there has been a strong movement towards basing the diagnostic decision-making process on scientific evidence. This evidence-based medicine represents the integration of the best scientific information and clinical expertise with the preferences, concerns, and expectations of the patient (in human medicine) or client (in veterinary medicine).[17,18]

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04 Methods and instruments

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Physical examination depends on our sensory perceptions and sometimes our perception is increased by the use of instruments. In this chapter some basic information is given about the methods used in these sensory observations.

In principle the senses of taste, smell, hearing, touch, and sight can be used. The time in which taste played a role (the sweet taste of diabetic urine) lies far in the past. The sense of smell has not acquired a permanent place in the physical examination. Only in examination of the skin or the mouth may a special odor be noted which can aid in recognition of a specific illness.

At present the physical examination is performed primarily with the aid of the senses of sight, touch, and hearing. The use of the sense of sight is called *inspection*, by which shape, color, and movement can be observed. The sense of touch can obtain information about the shape, consistency, and temperature of the object being examined. The use of touch is called *palpation*. Except for perception of sounds that are recognizable at a distance, the sense of hearing is used primarily to observe sounds occurring in the thoracic cavity. This *auscultation* can be accomplished by pressing one's ear against the animal's body, but it is almost always done by use of an instrument that transmits the sound to the ear of the examiner. Instruments are also sometimes used in inspection and palpation. Body temperature is not measured by palpation but by use of a thermometer. Sometimes we evoke responses that require visual or auditory evaluation, such as the patellar reflex or the tone that is produced by tapping over a body cavity (*percussion*).

What follows is a discussion of the methods and a description of the instruments and other materials used in these examinations.

4.1 Methods

4.1.1 Inspection

Inspection can be either general or local. The general inspection is a visual evaluation of the entire animal or of large parts of it (see Chapter 7). Inspection should always be carried out in good illumination.

In several of the following chapters local inspection is also mentioned. Sometimes the method for doing this is described, such as by opening the animal's mouth. In other cases an instrument is used to obtain access to the part of the body to be examined, such as forceps to lift the hair in order to examine the skin (§ 8.3.4).

For local inspection it is also sometimes necessary to use a focal light source, usually a small penlight. Some cavities or passages are inspected with the aid of an instrument especially designed for the purpose, such as an otoscope or vaginoscope.

Through its partly transparent structures the eye lends itself to internal inspection with instruments such as the slit lamp (§ 19.4.9). Its slit-shaped light beam makes as it were a slice through the eye so that optically dense parts or surfaces are illuminated by

reflection or scattering in the light beam (*Tyndall effect*). The deeper parts of the eye can be inspected with an ophthalmoscope, the accessibility being increased by dilating the pupil.

4.1.2 Palpation

Palpation is used in many ways and in many places. It involves utilizing the sense of touch as well as possible and this requires touching carefully. If palpation is done with too much pressure, the tips of the fingers lose their sensitivity and also part of the structures to be palpated (e.g., in the abdomen) may be pushed away by the palpating hand.

In addition to pure sensory pressure there are other ways to extend observations by using additional manipulations. One of these is what is called the undulation test, in which the palpating hand is placed as a detector on the lateral surface of the abdomen in order to detect the presence or absence of transmission of vibrations produced on the opposite side (§ 10.2.3 and 11.2.3).

If a mass is palpated, it can be described by its size, shape, consistency, painfulness, and moveability in relation to its surroundings. Sometimes the mass is partly visible, so that inspection can also contribute to the description. Since the description of a mass by inspection and palpation is not dealt with in subsequent chapters, we describe it here. These are the aspects that are of most importance in the characterization of a mass.

- *Location.* The localization of the mass should be described as exactly as possible. It is often possible to indicate its anatomical origin.
- *Size.* The size of a mass should be given in three dimensions in metric units, subtracting the contribution of overlying structures as well as possible. Sometimes the measurements must be estimated, but in many cases the mass is so located that a ruler or tape measure can be used. Describing the size by comparison with other objects such as an egg or an orange or a pea is too inexact.
- *Shape.* Many masses have a characteristic shape. Sometimes the mass is the result of the diffuse enlargement of an organ and the original shape is retained. In other cases the shape of the mass is in no way related to that of the organ from which it arose. It is very useful to record the size and shape of a mass (with dimensions!) in a sketch so that subsequent changes, as the result of treatment or otherwise, can be compared objectively.
- *Consistency.* The consistency of a mass can vary from soft and fluctuating to rock-hard and it can be recorded by use of the ordinal scale mentioned in Chapter 3.
- *Painfulness.* Palpation of tumors does not usually elicit pain. This is because tumors seldom have a nerve supply and because they can arise in locations in which they cause no pressure on other structures. However, tumors that lead to destruction of bone or grow into nerves can cause much pain. Inflammatory processes are also usually very painful because of the acute swelling of innervated tissue.
- *Moveability.* The moveability of a mass is examined in order to determine whether it is attached to adjacent structures such as bone or skin. In case of doubt with regard to the skin, a small fold of skin over the mass can be lifted up and the ease with which this can be done can be compared with that for skin in the area around the mass.
- *Borders and surface.* An indistinctly circumscribed mass could be an infiltrating malignant tumor. Benign tumors are usually clearly circumscribed. Apart from whether or not a mass has a regular shape or is clearly circumscribed, it can be useful to record whether the surface is irregular or smooth.
- *Color and temperature.* In an acute inflammation the overlying skin is often red and warm because of the increased blood flow. If the swelling is associated with leakage of blood from the vessels, its color can vary from red to bluish-purple and yellow, depending on the amount of reduced hemoglobin and the presence of breakdown products of hemoglobin. Depositions of melanin can be the cause of a brown-black color.
- *Related masses.* Sometimes the presence of other masses contributes to the identification, because some neoplasms tend to occur in multiple sites and sometimes because the presence of multiple masses indicates involvement of regional lymph nodes.

It is worth mentioning here that the results of inspection and palpation are greatly dependent upon the time and attention given to them. This is true for all examinations. It was shown in a study among physicians who were tested for their ability to palpate a mass in a silicone model.[1] The results showed that the frequency of detection was positively correlated with the time spent on palpation.

4.1.3 Percussion

Strictly speaking, percussion only means tapping. Sometimes a specific area is percussed to localize pain (§ 17.6). In general, however, the term percussion is intended to mean *acoustic percussion*.

In percussion an attempt is made to set tissue into motion in order to create sound waves. These are longitudinal vibrations corresponding to density fluctuations in the medium. There is a pressure wave corresponding to the changes in density, because where the medium becomes more dense, the pressure

increases. The intensity of the sound generated by tapping is greatest for the frequencies corresponding to the natural vibration frequency of the object, i.e., its resonance. This occurs, for example, during percussion of the thorax, in which a great variation in sound frequencies is generated. In healthy large dogs the maximum amplitude is observed at a frequency of about 200 Hz, which corresponds to the natural vibration frequency of the thorax in one of the many possible forms of vibration. In small dogs the frequency of the tone generated by percussion is higher than 200 Hz. Hence there is a selective amplification by resonance and the frequency selection depends upon several of the properties of the thorax. In general the resonance frequency of an object is determined by its geometric properties (shape and size) and by physical properties of the material (stiffness and density). The smaller and more rigid the object, the higher the frequency. During percussion of an organ, each component, such as the wall and the contents (which could be gas), can in principle resonate independently. In addition, a damping effect can be exerted on the resonance by both the contents of the organ (depending on the gas content, for example) and the surrounding tissues. Hence there can be great variations in the percussion sound.

The method was introduced by the Viennese physician Leopold Auenbrugger in 1761.[2] He tapped with the finger directly on the thorax, which we now call direct percussion and which does not produce a very clear percussion tone. It is said that he borrowed his method of percussion from the method his father, an innkeeper, used to determine the level of wine in wine casks.

Piorry made important improvements in the method in 1827.[3] He tapped not with the finger directly on the thorax but on an ivory plate which he called a *plessimeter*. This gave a clearer percussion tone and thus the percussion became much more accurate. During the 19th century there was a great deal of experimentation with plessimeters and percussion hammers. In small animals the indirect method of *finger-finger percussion* is generally used, although in large dogs clearer percussion tones can be created by use of a percussion hammer and plessimeter. Right-handed persons use finger-finger percussion by striking with the middle finger of the right hand on the middle phalanx (close to its articulation with phalanx III) of the left hand (Fig. 4.1). The left hand rests against the animal so that the middle finger remains held against the skin with moderate pressure. The pressure that is applied with the middle finger must be constant, since a change in the pressure leads to a change in the percussion tone.

The right hand is used to generate the percussion tone. The middle finger is bent to make a half-circle starting at the wrist (Fig. 4.1). All taps should be the same. The best results are obtained by repeatedly

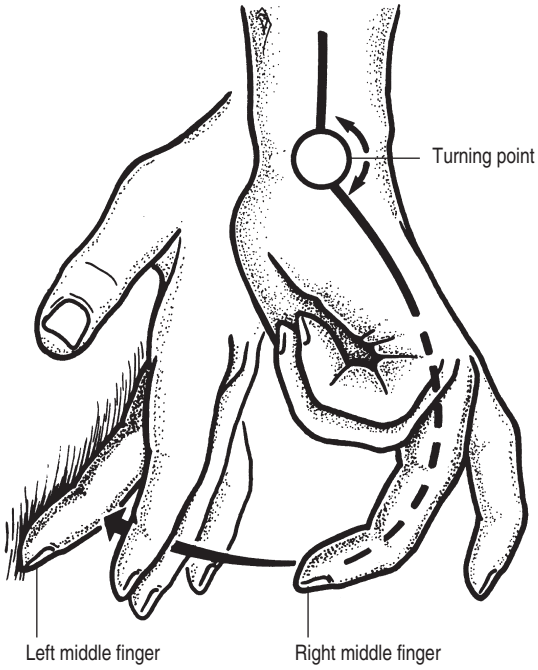


Fig. 4.1 Finger-finger percussion by a right-handed person.

giving a single tap and then waiting to hear and evaluate the resonance sound before giving the next tap. A tap that is too heavy leads to a long resonance and a tap that is too light does not penetrate adequately. The strength of the tap giving optimal results depends on the thickness of the thoracic wall and must be determined for each individual. In some cases it will be clear that a percussion hammer and plessimeter must be used for good results.

For accurate definition of the borders of two areas with differing resonances, it is often necessary to go back and forth a few times at the level where the border is presumed to be. Acoustic percussion does not penetrate beyond 7 cm into the thorax,[4] and hence deeper lesions will not be revealed by this method. In addition, consolidated lesions (tumor or fluid) must be at least 5 cm in diameter in order to produce damping that can be detected.

In percussion of the trunk (thorax and abdomen), three main percussion sounds can be distinguished:

1. Sonorous percussion tone. This is the fairly low, strongly resonant tone that is heard by percussion of gas-containing lung tissue.
2. Damped percussion tone. This can be heard over any part of the body that does not contain gas, such as muscles or liver. It is a short (cut-off) sound of low intensity.
3. Tympanic percussion tone. This tone contains more sound and is a little higher than the sonorous percussion tone. A good example of this tone is

that from the gas-filled stomach. It occurs in smaller cavities (stomach, intestines) than does the sonorous percussion tone and is therefore higher in pitch. In addition to the size of the cavity, the tension of the wall (hence its stiffness) probably plays a role in formation of the tone.

4.1.4 Auscultation

Sounds can be generated in the body by rapid fluctuations in gas pressure or by tissue vibrations. They will only be heard if the frequencies are in the audible range. Usually a sound consists of a combination of vibrations with different frequencies. When there is no special underlying relation among the frequencies, the sound is described as noise. This kind of sound also has no periodic character. A sound that does is described as having a certain pitch. The height of the pitch is determined by the lowest frequency of the associated vibration (the basic pitch). The tone color (timbre) is associated with the higher frequencies (the so-called upper tones or higher harmonic tones in the frequency spectrum). The intensity is proportional to the square of the amplitudes of the related vibrations.

Of the various processes in the body via which sounds can be generated and heard (auscultated), we will discuss four in detail.

1 In the displacement of gas (respiration) and fluid (circulation), two types of flow can occur:
   a *laminar flow*: The particles move in the direction of the flow but not all at the same velocity. The flow of fluid through a tube can be described as consisting of layers of different velocity, increasing toward the center.
   b *turbulent flow*: If the velocity exceeds a certain limit, orderly flow ceases. The particles move across or against the direction of flow. In this turbulence there is transfer of energy via collisions, resulting in short-term changes in pressure. Thus tissue can be caused to vibrate with a great many frequencies so that sound is generated with the characteristics of noise.

      In addition to the velocity (v) of the flow, the occurrence of turbulence is also determined by the viscosity (η) and the density (ρ) of the material. Moreover, vortices do not develop easily in a tube having a small radius (r). The probability of turbulence is contained in the *Reynolds formula* (Re):

$$\mathrm{Re} = \frac{v\rho r}{\eta}$$

      In a cylindrical tube with a smooth inner surface, rotational (vortical) flow occurs when Re >1000. Narrowing of the tube or abruptly changing the direction of flow readily leads to changes that increase the numerator of the quotient.

      The above remarks apply to the flow of both fluid (circulation) and gas (respiration). The hemodynamic processes in the heart and the respiratory processes in the upper airways are especially subject to turbulence and hence are sources of sound.

2 Bronchi can become so narrowed that the opposite walls almost make contact and so begin to vibrate. These pathologic sounds (peeps) have more to do with the *Venturi effect*, which concerns narrowing in flow tubes (Fig. 4.2). According to the law of conservation of energy, when there are no frictional effects the sum of the internal energy (the pressure, P) and the kinetic energy ($\frac{1}{2}\rho v^2$) has the same total value and is thus a constant (H). Before the point of narrowing, $H_1 = P_1 + \frac{1}{2}\rho v_1^2$ and in the narrowed segment, $H_2 = P_2 + \frac{1}{2}\rho v_2^2$. It is presumed that there is no loss of energy via internal friction and thus $H_1 = H_2$, but in the narrowed segment, $v_2 > v_1$, and hence $\frac{1}{2}\rho v_2^2 > \frac{1}{2}\rho v_1^2$. Hence $H_1 = H_2$ only if $P_2 < P_1$. This means that when a segment of a bronchus (or a blood vessel) is narrowed, the decrease in pressure can cause it to become narrowed even more or even occluded. When there is occlusion the Venturi effect ceases, the passageway is restored, and then the Venturi effect can recur. These recurring self-perpetuating pressure changes are accompanied by rapid vibrations of the tissue and are a means by which musical sounds can occur in the airways (Chapter 9). The pitch of the sound is determined by the properties of the material, as is the case for a vibrating reed in the mouthpiece of many wind instruments.

3 When air is forced out of the lungs during respiration, the velocity of the flow increases because the total cross-section of the bronchial flow decreases from the periphery toward the center. The term $\frac{1}{2}\rho v^2$ in the law of conservation of energy thus increases at the expense of the pressure P. Hence there is an increasing loss of

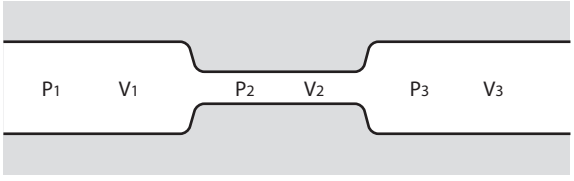


Fig. 4.2 Narrowing in a tube illustrating the Venturi effect.

pressure, which at high flow velocities can be magnified by the additional loss of energy resulting from internal friction. At certain places, even without the presence of a morphologic abnormality (as in the Venturi effect), P can become so low that the bronchus is closed by the surrounding tissue pressure. At that moment the value of v becomes zero, the pressure shoots up and the bronchus opens again. Completely analogous to the Venturi effect, this process can recur and become a source of sound.

4 As soon as the separation between two gas-filled spaces with different pressures is removed, the pressure is equalized. This occurs so quickly that the total mass of gas can resonate and even the walls can resonate. The frequency of the resonation depends on the dimensions of the spaces. If the walls are highly absorbent, the effect of explosive redistribution of gas can be of such short duration (a few milliseconds) that the pitch of the sound is above the range of hearing. Under certain circumstances the examiner can hear this explosive pressure equalization as a kind of 'click', without being able to ascertain its pitch. This mechanism occurs in the lungs when an air passage that has been closed by lowering of the pressure on its walls is suddenly opened by sufficient pressure during inspiration or expiration. Equalization of pressure then occurs in the bronchioli. This is discussed further in Chapter 9.

The extent to which these sounds and possibly sounds from other sources can be noticed externally depends not only on the intensity of the source but on at least two other factors:

1 Reduction in the intensity I of the sound during passage through tissue, as a result of loss of energy. In many cases this reduction has an exponential behavior according to Beer's law, which is familiar in radiation physics: $I = I_o e^{-\alpha x}$, where x is the distance traveled in tissue and α is the characteristic absorption coefficient for the tissue. The value of α is higher for solid than for gas-containing tissues. Furthermore, α is strongly dependent on the frequency, higher frequencies being more strongly reduced. Thus the lung behaves as an acoustic filter that greatly restricts the transmission of frequencies above about 200 Hz. In addition to the loss of intensity there is also, due to the frequency-dependency of α, a loss of timbre during its passage through the tissue.
2 Reflection of sound waves. When sound waves traveling through a medium encounter another medium with other acoustic properties, part of their energy is reflected from the interface. The relation between the arriving intensity (I_0) and the reflected (echo) intensity (I_t) is:

$$\frac{I_t}{I_o} = \left(\frac{Z_1 - Z_2}{Z_1 + Z_2}\right)^2, \text{ in which } Z = \rho v$$

This product Z of density (ρ) and sound velocity (v) is called the *acoustic impedance*. If the impedance is very similar in both media, as in the case of a lung infiltrate and the thoracic wall, little sound is reflected (I_t/I_o is small) and the majority of the sound is transmitted.

At the interface between air-containing lung tissue and the thoracic wall, however, a large part of the sound is reflected back against the pleural surface. (For air $\rho = 1.05\ \text{kgm}^{-3}$ and $v = 340\ \text{ms}^{-1}$ and for water $\rho = 1000\ \text{kgm}^{-3}$ and $v = 1480\ \text{ms}^{-1}$). Incidentally, it is the occurrence of differences in acoustic impedance that allows us to make use of ultrasonography.

In spite of the above factors influencing the transmission of sound, enough of the sounds in the thorax and abdomen reach the body wall to allow important information to be obtained by auscultation. Initially (at the beginning of the 19th century) the ear was pressed against the body for this purpose. Laennec first described indirect auscultation in 1819.[5] He called his instrument, which consisted of a simple wooden tube, the stethoscope. This word is derived from the Greek 'stethos' (chest). Since not only the chest is auscultated, we prefer the term phonendoscope (the Greek 'phonein' means sounding), which is commonly used in veterinary medicine in the Netherlands. Laennec made his discovery at a moment of embarrassment, when the age and gender of the patient did not permit him to place his ear directly against the chest. He has described this as follows:

'Je fus consulté, en 1816, pour une jeune personne qui présentait des symptômes généraux de maladie du cœur, et chez laquelle l'application de la main et la percussion donnaient peu de résultat à raison de l'embonpoint. L'âge et le sexe de la malade m'interdisant l'expèce d'examen dont je viens de parler, je vins à me rappeler un phénomène d'acoustique fort connu: si l'on applique l'oreille à l'extrémité d'une poutre, on entend très distinctement un coup d'épingle donné à l'autre bout. J'imaginai que l'on pouvait peut-être tirer parti, dans le cas dont il s'agissait, de cette propriété des corps. Je pris un cahier de papier, j'en formai un rouleau fortement serré dont j'appliquai une extrémité sur la région précordiale, et posant l'oreille à l'autre bout, je fus aussi surpris que satisfait d'entendre les battements du cœur d'une manière beaucoup plus nette et plus distincte que je ne l'avais jamais fait par l'application immédiate de l'oreille.'

Following the introduction of indirect auscultation by Laennec, many attempts were made to improve the instrument as well as to give it another name.[6] The

models with a membrane (or diaphragm) on the listening piece were called phonendoscope or 'resonating stethoscope'. Studies of the optimal length and diameter of the connections between the listening piece and the ear pieces led to the biauricular instrument introduced by Littman in 1961, which will be discussed further below. The monaural stethoscope is now only used in human medicine by obstetricians to listen to the heart sounds of the fetus.

4.2 Instruments and diagnostic materials

The instruments and diagnostic materials which a veterinarian needs for the routine physical examination of companion animals are shown in Figures 4.3 to 4.8. A few specifications of some of the instruments and a few directions for their use are given here.

Percussion hammer and plessimeter

To perform percussion with instruments it is necessary to have both a hammer with a rubber head and a plessimeter, which is a metal plate with wings by which it can be held. The hammer is held loosely between the thumb and forefinger. Percussion is performed by loosely swinging the hammer against the plessimeter, which is pressed firmly against the body wall. Holding the hammer too stiffly and swinging from the wrist or elbow prevents a good rebound by the hammer and this distorts the resonance.

Reflex hammer

The Taylor reflex hammer is preferred because of its size, weight, and shape. The shape of the rubber head is triangular. The base of the triangle is used to test the patellar reflex and the tip is used for the muscle reflexes.

Effective use of the reflex hammer requires administering a short, abrupt tap on the tendon or muscle. Learning this skill requires practice. The way in which the hammer should be held is shown in Figure 4.9. The quick, circular movement of the head of the hammer depends on two turning points: the wrist and the place where the thumb and middle finger hold

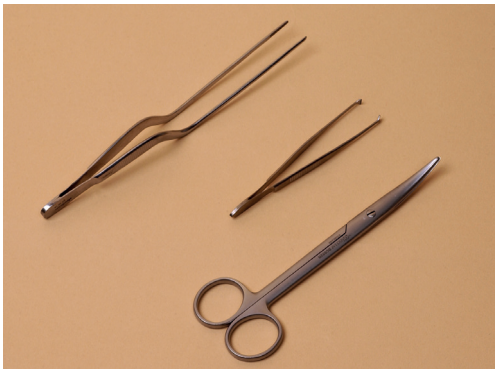


Fig. 4.4 Instruments for visualizing underlying structures: scissors for removing hair, forceps with offset blades for lifting hair, and Von Graefe fixation forceps for inspecting the eyelids and conjunctivae.

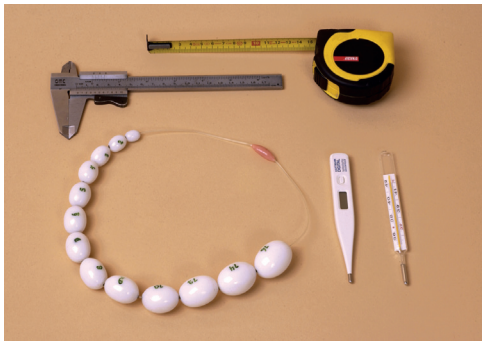


Fig. 4.5 Measuring instruments: measuring tape, vernier caliper, string of calibrated ovoids for estimating volumes, mercury thermometer, and digital thermometer utilizing a thermistor.

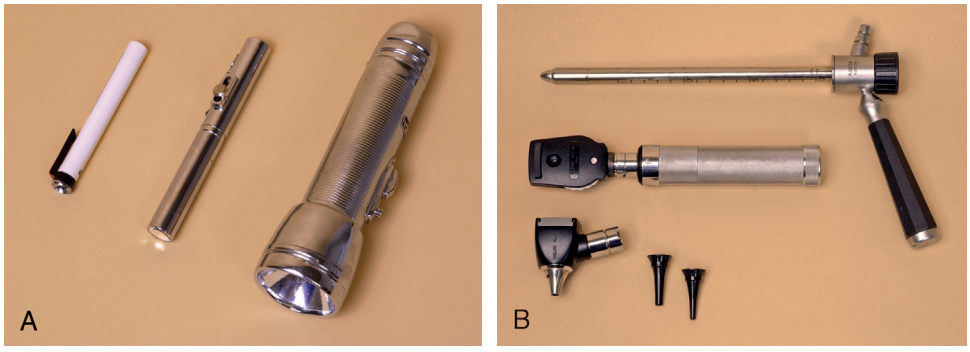


Fig. 4.3 Aids for inspection.
A Local illumination: penlight, slit lamp, and flashlight.
B Local illumination + optics: otoscope, ophthalmoscope, and vaginoscope.

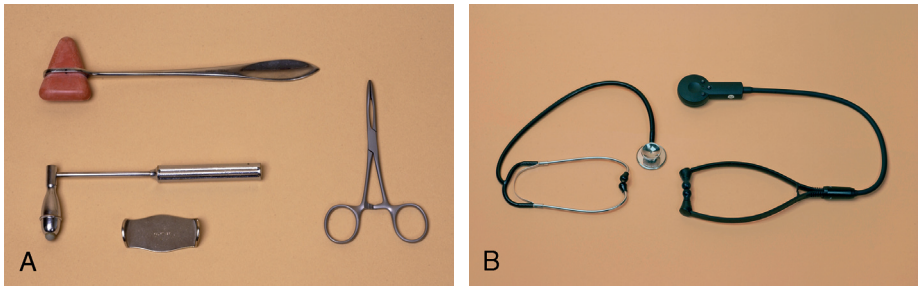


Fig. 4.6 Instruments for palpation, percussion, and auscultation:
A Wide-jawed forceps (for testing pain perception), percussion hammer, plessimeter, and reflex hammer.
B Littmann phonendoscope and electronic phonendoscope that allows amplification and selection of sound frequencies.

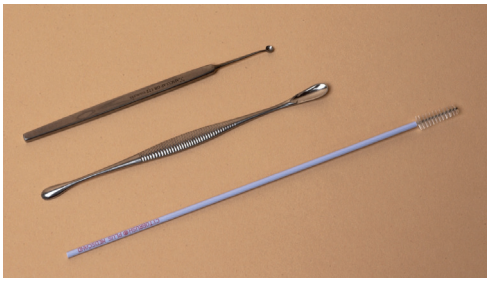


Fig. 4.7 Instruments for collecting material for examination: curette for collecting skin material, eye curette, and a small brush for collecting cells for cytological examination from the cornea and conjunctiva (cytobrush).



Fig. 4.8 Diagnostic aids for ophthalmologic examination: Schirmer tear test, fluorescein-impregnated paper strips, local anesthetic, and short-acting mydriatic.

the handle. The movement is begun by giving the handle a push with the forefinger in the direction of the palm.

Phonendoscope

The ear pieces should be large enough to fit well and completely occlude the external ear canals. Phonendoscopes whose two tubes are connected by a flexible metal brace often close off the external ear canal better than instruments with loose tubes. The disk-shaped listening piece or cup is usually covered with a plastic diaphragm. This increases the possibility of hearing high-pitched sounds, because the low frequencies are filtered out.

In choosing a phonendoscope, attention should be given to two properties:

1. good transmission of sounds to the ear
2. no distortion of sound and no additional sound or noise

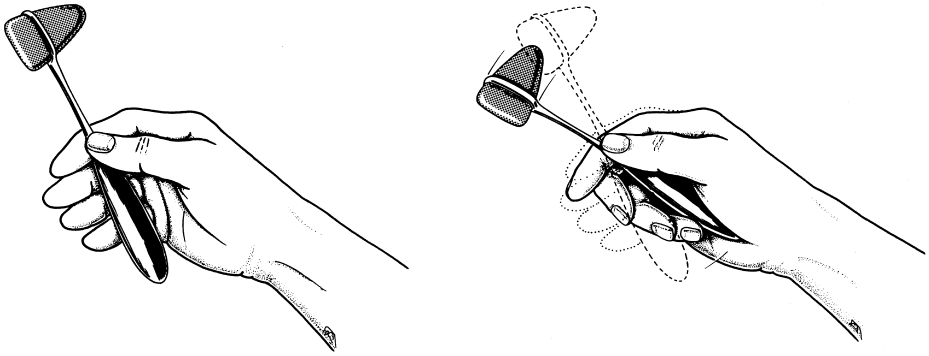


Fig. 4.9 How to hold the reflex hammer.

In practice these two properties are not well related. The better that sound is transmitted, the more noise will be heard. This is especially noticeable with battery-powered microphones that are available for use as a phonendoscope. In such an instrument the sensitivity can be greatly increased, but the result is that much more noise is also heard. The Littman phonendoscope provides a good compromise between the two properties mentioned above. This instrument has a thin disk-shaped cup with a plastic diaphragm and a smaller and slightly cone-shaped open cup for selective auscultation. There are now battery-powered phonendoscopes that not only amplify but also allow the user to select the range of sound frequencies. This enables better evaluation cardiac sounds, which are of low-frequency, by suppressing high-frequency noise.

Probably more important than the type of phonendoscope is continuing practice with the same phonendoscope in order to learn to selectively recognize the sounds that are of importance in the diagnostic process. Those beginning to learn auscultation tend to hear too much rather than too little. They have not yet learned to find the way through the auscultated sounds and thus to disregard the sounds that are of no diagnostic importance. Here are a few guidelines for use of the phonendoscope.

- The cup should be placed firmly and flatly against the body wall. If contact is inadequate, a soft sighing or rustling is heard, just as when a sea shell is held to the ear. A similar sound may occur as a result of poor fitting of the ear plugs.
- The sound that is produced by moving the cup over hair can strongly resemble the short crackling sound (nonmusical rhonchi) that can come from the lungs under pathologic conditions (see Chapter 9). These disturbing sounds generally disappear when the phonendoscope cup is pressed more firmly. If necessary, the hair over the area to be auscultated can be moistened.
- Sounds from muscles, tendons, and joints can also lead to confusion. A nervous animal with tense and trembling muscles can produce an interrupted, damped sound from its muscles. This will be heard especially during auscultation over the thorax at the level of the trapezius, serratus dorsalis, and latissimus dorsi muscles. Sometimes it is necessary to wait until the animal is more relaxed.

Thermometer

The measuring tape and the thermometer are the only instruments in this overview with which quantitative measurements can be made. The thermometer is an important example of a large class of instruments having the common characteristic that some time is needed to obtain the correct indication. The slowness of such measuring instruments is related to the specific properties of each. For the mercury thermometer the heat capacity and thermal resistance of the glass wall of the mercury reservoir play a large role. The slowness is often characterized by means of the indication time: the time necessary to indicate 95% of the difference between the initial and final values when there is an abrupt change of signal (e.g., for the thermometer, a jump from 20°C to around 38°C) (Fig. 4.10). Disregarding the indication time, which is to say reading the temperature too quickly, thus gives an incorrect value. For a mercury thermometer in good contact with its surroundings an indication time of 10 to 20 seconds is expected. If the contact between the mercury reservoir and the heat source is poor, as result of the presence of a poor heat conductor such as air or because the reservoir itself cools the local area around it, then the indication time may be much longer. One must realize that after 95% of a change from 20°C there is still an error of 1°C in the temperature to be measured, which is not acceptable for measurements of body temperature for clinical purposes. Reading the thermometer after doubling the indication time reduces the underestimation to less than 0.1°C. Hence a mercury thermometer should not be read too quickly: reading after not less than one minute is a good rule of thumb.

Increasingly measurements with the mercury thermometer are being replaced by measurements by means of transducer techniques (transducer: converter). The variable, in this case the temperature, is converted into an electrical and easily measured signal. Temperature-dependent resistors (called thermistors) are used: from the resistance value, with appropriate calibration, the temperature can be obtained. Such thermometers usually have a shorter indication time than conventional mercury thermometers (less than five seconds) and have a digital readout.

Both types of thermometer are introduced rectally (§ 8.3.3), for rectal temperature is generally regarded as a good measure of central body temperature. Because this procedure can be unpleasant, for the patient as well as for the examiner, in human medicine

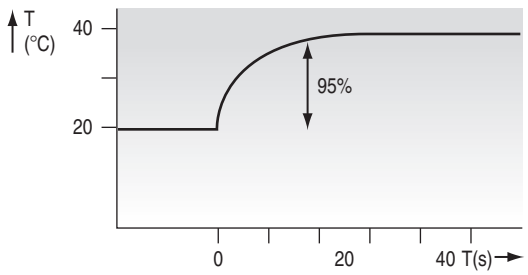


Fig. 4.10 Illustration of the indication time of a thermometer.

temperature is often measured orally (under the tongue) or in the axilla. In these locations the temperature is 0.5 and 1.5°C, respectively, lower than the rectal temperature.[8]

Another option is the ear thermometer, which has been tested in dogs as well as in humans. Its use rests on the detection of infrared radiation (warmth) from blood vessels behind the ear drum. In human medicine some regard this as a good alternative to rectal measurement.[9] However, it has been demonstrated recently that there is only a moderate correlation between the two (r=0.77) and in patients with fever the lower temperature registered by an ear thermometer can lead to underestimation of the problem.[10]

In dogs the use of an ear thermometer is further hampered by the morphology of the ear canal (Chapter 20). Because the ear canal is partly vertical, it is difficult to point the thermometer toward the ear drum. The results of comparisons between ear and rectal temperature measurements in dogs are similar to those in people. There has been a positive report[11] and another with a clearly negative conclusion.[12] A comparative study at the Utrecht University Clinic for Companion Animals also revealed that measurements with an ear thermometer were not consistent enough to justify routine use.

Techniques of arterial blood pressure measurement

The above-mentioned use of transducers (also called sensors) to measure physiological phenomena has expanded enormously, in part due to advancements in miniaturization and digital signal processing. Two important examples are in the field of noninvasive measurement of arterial blood pressure, which will be discussed in this section.

For noninvasive measurement of arterial blood pressure, an inflatable elastic cuff is wrapped around a body part (limb or tail) and is then inflated until the pressure completely occludes the artery.* The pressure is then gradually reduced by deflating the cuff and at the moment when it passes below the systolic pressure, the vessel reopens and flow resumes. Continued lowering of the cuff pressure allows the artery to open further until, at the diastolic pressure, the flow is completely unhampered again.

The physical changes occurring when blood reenters the artery and then when its flow is completely unhampered allow measurement of the systolic and then the diastolic pressure, by the following methods:

Auscultation. A phonendoscope is placed over the artery just distal to the cuff. Initially, when the cuff pressure is high, there are no sounds. When the cuff pressure is lowered to the level of the systolic pressure, a sound is heard that is synchronous with the heart beats. It is the result of turbulence associated with the resumption of blood flow, as the Reynolds number is exceeded. (see § 4.1.4). As the cuff pressure is lowered further, the sound becomes continuous and then it stops abruptly when the diastolic blood pressure is reached.[7] The sounds heard with this technique are called Korotkoff sounds† and this is the method commonly used for noninvasive measurement of blood pressure in adult humans. In babies this auscultatory measurement poses problems[7] and in companion animals the Korotkoff sounds cannot be heard clearly enough for blood pressure measurement.[14]

Oscillometry. With lowering of the cuff pressure, the reentry of blood also causes pulsating movements of the arterial wall. These small oscillations are transmitted through the tissues to the surface, where they can be detected by sensors in the cuff. The cuff pressure at which the oscillations begin to increase is interpreted as the systolic pressure. The amplitude of the oscillations increases to a maximum which corresponds to the mean arterial pressure. Then there is a decline to a constant level which corresponds to the diastolic pressure. The main problem with this method is the difficulty in accurately determining the beginning and the end of the oscillation patterns. Oscillometric measurements give lower values than direct (invasive) measurements of blood pressure in hypertensive animals and somewhat higher values in those with hypotension.[14]

Doppler effect. The resumption of blood flow can also be detected by means of the Doppler effect.‡ This phenomenon is the change in observed frequency of a signal source when the distance between the source and the observer changes. This change in frequency is proportional to the speed of the movement. The effect can be observed in the change in pitch of a passing siren or a passing train. Qualitatively this phenomenon can easily be understood. If a source is emitting 100 pulses per second—this is by definition 100 Hz—then the time between the first and the last pulse observed by a stationary person will also be one second. However, if the observer moves away from the source between the first and the last pulse, the last pulses will not reach the observer until after one second. Consequently, the number of pulses reaching the

* This principle was introduced in 1896 by the Italian physician Scipione Riva-Rocci (1863–1937) for use in people. The cuff was placed around the upper arm and inflated until the pulse could no longer be palpated.[13]

† In 1905, during a presentation at the Imperial Military Academy in St. Petersburg, the Russian military physician Nicolai Segejewitsj Korotkoff (1874–1920) first described this auscultatory measurement of blood pressure.[13]

‡ The Austrian physicist Christian Johann Doppler (1803–1853) discovered the effect named after him on the basis of the change in color of the light of moving stars. A star moving toward the earth looks more blue, while one moving away from the earth looks more red. In 1842 Doppler found that similar changes of wave length occur with moving sound.

observer during just one second will be less than 100 and so the observed frequency will be less than 100 Hz.

For blood pressure measurements using the Doppler effect, a source emitting sound pulses is placed on the skin distal to the cuff. The sound waves will be reflected by several tissues, including blood cells (mainly erythrocytes). The acoustic impedance (see § 4.1.4) of erythrocytes is different from that of plasma. The movement of the erythrocytes induces the Doppler effect. The sound frequency reflected by the moving erythrocytes is different from that of the source. A sensor detects the shift in sound frequency. Electronic comparison of the original and the reflected frequency provides a measure of the rate of flow in the vessel. Doppler systems make use of ultrasound (often about 8 MHz). The frequency difference can be made audible and can also be visualized on a monitor.

As soon as the occluded vessel opens and the erythrocytes begin to move again, a signal is generated. This identifies the systolic pressure, often more accurately than by oscillometry. However, in contrast to this positive aspect, diastolic and mean pressures cannot be measured well in Doppler systems.

The frequency difference is a very small fraction of the source frequency. In order to obtain a usable (audible) signal, the source frequency needs to be sufficiently high, i.e., in MHz range. This ultrasound can be induced by using materials that exhibit the piezoelectric effect. Introduction of an electric current causes the dimensions of the material to change, by compression and decompression. An alternating current induces an alternating effect, thus vibration of the surface of the material. The phenomenon also occurs at very high frequencies. This is an example of a transducer converting an electrical signal into a mechanical signal. The piezoelectric effect also occurs in reverse: placed under mechanical pressure, the material generates an electric current, which can be detected. In this way the transducer acts as a sensor.

The results of both the oscillometry and the Doppler system are sensitive to external factors such as the type of cuff and the rate of deflation. The commonly accepted guideline for the width of the cuff is 40–60% of the circumference of the body part. Wider cuffs can result in low values and narrower cuffs can result in values that are too high.[14]

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05 Medical records

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5.1 Introduction

In every practice there should be an administrative system for collection of information about the patient and the owner, organized in such a way that this information is at the disposal of the veterinarian(s) and others who have a justified interest.

The era in which the administration of a practice only concerned financial information, while the medical information about the patient depended on the memory of the veterinarian and the owner, is long past. The necessity for good medical registration has become quite clear in the past decades. The arsenal of diagnostic and therapeutic possibilities and the number of specific diagnoses have increased considerably, and the average lifetime of our patients has also increased. The memory capacity of the human intellect is no longer sufficient to retain the relevant information about all patients in one practice. The necessity for professional communication about patients has also increased greatly. The frequent use of replacement veterinarians on weekends and during vacations, the increasing number of group practices, the trend toward formation of larger group practices with internal specialization, and the coming into vogue of referral clinics and veterinary hospitals have greatly increased the number of veterinarians that can be involved in the treatment of one patient. Hence the accurate transferal of patient information has become an urgent necessity.

Good patient care is impossible without good medical records. The design, application, and supervision of the system should be proportional to the level of patient care. Conversely, the quality of the record keeping generally reflects the level of veterinary practice. Especially in veterinary hospitals, the keeping of records must meet high standards.

The need for good medical record keeping is well recognized in our profession. This is apparent in the minimal requirements and guidelines concerning medical records in veterinary practices as formulated by the Royal Netherlands Veterinary Association and the Federation of Veterinarians in Europe.[1,2]

In this chapter the requirements that a system of medical records must satisfy will be explained. Particular attention will be given, by use of examples, to the problem-oriented medical record devised by Weed.[2]

5.2 Function of medical records

The most important functions of medical records are:

1. *memory:* They serve the veterinarian caring for the patient, concerning earlier observations, diagnoses, and treatments.
2. *communication:* They benefit associates in the practice, part-time replacements, transfer of the practice, and referral of patients.
3. *keeping order:* The record system can provide an overview of relevant information, which aids efficient and accurate work.

4 *guidance:* A medical record system based on protocols can aid working efficiency and improve the completeness of records, for example by using printed forms for the collection of information. Protocols play an increasing role in disciplinary jurisdiction.*
5 *documentation:* The need for documentation may involve referral of patients, questions of purchase, insurance claims, and legal prosecution.

Information from the medical record can also be used for the benefit of such financial aspects as the printing of bills and giving estimates.

In university clinics medical registration also has an important function in support of teaching and research.

5.3 Determining the content of medical records

The extent of a medical record system will be partly determined by economic factors and is thus dependent on the size of the practice, the type of practice, and the way the practice is arranged. At least as important is the interest of the veterinarian(s) who must supervise and use the system and the determination to achieve good patient care and a good level of practice.[5]

A simple card system, hand-written and entirely according to individual insight, gives the users great freedom with regard to the information that they will record. Its maintenance costs little time and the storage of the information is the ultimate in compactness. Such a system also excels in incompleteness and lack of functionality.

A medical record system that adequately fulfils all of the functions mentioned in the preceding section should contain the following information:

1 personal information about the owner
2 identification of the patient
3 information concerning vaccinations, treatments for parasites, and health certificates
4 information about previous diseases and treatments, including the nature of the disease and the date
5 the reason for consultation: the iatrotropic problem (see § 3.1.1)
6 the history relevant to this consultation
7 results of physical examination
8 results of other examinations (radiology, laboratory, histopathology, etc.)
9 conclusions or diagnoses
10 diagnostic and therapeutic substances, with method of administration, dose, and date
11 surgical and anesthesia records
12 autopsy report, if applicable
13 explanation given to the owner
14 referral (to whom and why)
15 financial consequences of what has been done

Most of these subjects are self-explanatory or are explained in more detail in this or later chapters. Only points *1* and *2* require some explanation here.

1. Personal information about the owner. This should include not only the name and address but also telephone numbers where the owner can be reached during the day as well as in the evening. Thus the owner can be contacted as soon as possible if urgent situations arise concerning the patient (e.g., as a result of the receipt of laboratory reports or in acute problems occurring in hospitalized patients).

2. Identification of the patient. This consists of the name of the patient and the signalment (characteristics such as breed, gender [including whether or not neutered], date of birth, color and type of coat, drawings, anatomical abnormalities, scars, tattoo, and pedigree number). Occasionally it happens that the date of birth is unknown and the owners or handler can provide no helpful information to determine it. The veterinarian must then make an estimate of the age of the patient (see § 11.2.1).

Increasing numbers of dogs and cats are provided with an identification chip (transponder) implanted between the shoulder blades. The unique bar code can be read out with a detector, enabling the owner to be identified through the European pet network (EUROPETNET).† The patients of many veterinary clinics and practices for companion animals are also given unique registration numbers.

In the patient record the patient identification information serves the following purposes:

1 Making the patient recognizable. Mixing up patients is one of the worst mistakes that can occur in human or veterinary medicine. Mistaken identity is a real danger with small animals, especially hospitalized patients, which in behavior and outward appearance can strongly resemble each other and cannot make their own identity known. Careful recording of the identification information reduces this risk. The chance of mixing up patients or of not being able to find patients that have gotten away can also be reduced by using a collar with identification information. Accurate identification is also needed for health certificates, vaccination certificates, and legal procedures in which companion animals are involved.

   The recognizability of a patient based on the presence of a unique mark or characteristic is ideal. Since these are rare, recognizability usually rests upon a combination of less specific characteristics.

* This concerns not only compliance with existing protocols but also whether protocols are available where needed.[4]

† EUROPETNET is a group of national and local associations throughout Europe which register owner information about pets that have been uniquely identified by means of a transponder (www.europetnet.com). Every year Europetnet helps to return thousands of lost animals to their owners throughout Europe. The website provides information on the registering bodies in the associated countries.

The chance of erroneous identification is reduced as the number of such characteristics increases. Usually a rather small amount of information provides adequate identification (e.g., five-year-old Doberman, male, called Bobby). There are conceivable situations, however, in which the addition of something like 'has a scar from a laparotomy incision' would be very welcome. The signalment should thus in the first place give as unique a description as possible.

Tattoo numbers are naturally unique and should always be recorded. Unfortunately, they are sometimes unreadable, especially in older animals. Implanted transponders are accessible lifelong and this, in combination with the possibility of retrieval through the internet, makes them a real improvement.

2 The identification of samples from the patient. Blood, urine, or fecal samples, tissue aspirates, etc., are usually identified with the owner's last name. When the name is a common one, this easily leads to mistakes. Adding the name of the animal or the breed reduces the chance of a mistake considerably. Adding the unique patient record number is the best guarantee against mixing up of samples. However, use of the record number alone, or some other number, can also easily lead to mistakes because numbers can easily be misread or copied incorrectly. The chance of such mistakes increases with the number of digits in the number.

Mixing up of samples can have serious consequences for the patient. It is one of the most frequently occurring mistakes in hospitals and laboratories.

3 Diagnosis. The signalment of the patient can play an important role in the process of reaching the diagnosis, i.e., in the conditional probabilities (§ 3.1.5). Many examples can be given of diseases that can be considered unlikely or can even be excluded from consideration on the basis of age, breed, or gender.

5.4 Setting up a medical record system

The following aspects are important in the setup of a medical record system:

- clarity of organization of the record
- completeness of the record
- accessibility of the record
- effort required and costs

5.4.1 Clarity

Clarity is essential for functioning of a medical record system. Clarity requires both good readability and a logical order in the recording of the information.

Forms, both printed and on screen, are an aid to readability, especially if they make use of multiple-choice questions which can be answered by marking appropriate boxes. The amount of handwriting is thereby reduced to a minimum. This type of form also makes it easier to retrieve information because each part of the information has a fixed place in the form. This place can be chosen consciously when the form is designed. A good layout contributes to readability and also makes possible the easy recognition of information with a 'signal' function by, for example, arranging this in a separate column (see § 6.2 Notation, and the associated form on the DVD).

In general it is true that the greater the use of printed forms the greater the clarity of the records. There are limits, however, because this does not hold for patients for which there is little information.

If information is to be retrieved easily it must be documented uniformly and organized logically. Uniformity in recording information can be improved by employing lists of terms from which to choose at relevant places in the record. Choosing from a list avoids typing errors and inconsistencies in terminology. These advantages are particularly important when data (e.g., signalment, problems, or diagnoses) are retrieved, either by hand or electronically.

Medical information can in principle be organized in three ways: chronological, source oriented, or problem oriented. In a strict chronological organization the information is only sorted according to the date of entry. This method does not offer much clarity because the location of the information in the record is not predictable. In a strictly source-oriented retrieval the information is sorted according to origin (e.g., diagnostic imaging, clinical chemistry, histology). This leads to the occurrence in the record of independent packages of information within which a chronological order is followed. With this method the information is usually quite easy to retrieve but the motivation for gathering it, the underlying relationships, and the thereby associated conclusions can be difficult to reconstruct in a large package of information.

Some of these problems can be prevented somewhat by using forms of different colors for different information and always arranging these in the same order in the record. This improves clarity. The use of forms of different formats is generally inadvisable.

Rapidly-changing information that is collected regularly and often should be recorded on flow sheets (Fig. 5.1). Graphic presentation makes it considerably easier to follow the course of an abnormality. Curves representing variables plotted against time, such as pulse rate, temperature, respiration, or blood urea, are familiar examples of this.

Making a list in which all of the problems of the patient are given in a compact way and in chronological order provides an integrated overview of

Clinical progress

Date	2 Apr		3 Apr		4 Apr		
Time	0800	1630	0800	1700	0800	1630	
Appetite	–	–	±	–	+	++	
remarks							
Vomiting	+	–	–	–	–	–	
remarks	foam						
Feces	–	–	+	–	+	–	
remarks			strains		thin		
Drinking	80 ml	50 ml	75 ml	–	90 ml	20 ml	
remarks							
Urination	+	+	+	+	+	+	
remarks	red	red		red			
Pulse	120	100	112	120	80	96	
Respiration	24	26	22	32	30	panting	
Temperature	39.8	39.9	38.7		38.4		
Mucosae	pale	pale	pink	pink	pink		
CRT	?	?	<1	<1	<1		

Fig. 5.1 Example of notation on a progress sheet.

the clinical status of the patient and prevents relevant information from being overlooked. The composition of such a 'problem list' will be described in more detail later in this chapter. It constitutes an essential component of the problem-oriented medical record, but it can also be valuable in the source-oriented or chronological record.

In the problem-oriented record the information is sorted according to the problem to which it is related. Information from various sources (e.g., diagnostic imaging, laboratory) is always transferred from the original report to a daily progress sheet on which it is recorded under the problem for which it was obtained. The original report is discarded or added as a supplement to the record folder. This method allows easy retrieval of information, provided that the problem for which it was acquired is known.

Since a compulsion to interpret is inherent in the system, going back to the record to look for information provides at the same time insight into the thoughts that have led to the conclusions or plans. Figure 5.4 shows an example.

5.4.2 Completeness

A medical record can only function well if it contains all of the available relevant information and it is worked up. New information must always be added to the record as soon as possible. Direct recording of examination and treatment information must be considered a routine part of each visit or consultation and may only be postponed under exceptional circumstances.

The completeness of the information depends naturally on the completeness of the examination itself. This can be helped by working within an established routine. The use of forms (on paper or on screen) for the history, examination, and treatment facilitates working in such a manner. These forms can also be used as the template for a report. It is even possible to work up different problems on one form. If after completing a given part of the examination another problem must be taken up, that point of decision can be indicated on the form by referring to a continuation page which may or may not be included in the same form (for an example see the form for Chapter 23 on the DVD).

5.4.3 Accessibility of the record

Records must always be readily available and thus a good storage system is the first requirement. This can consist of a card box or a system of hanging folders in which the records are stored in alphabetical or numerical order. If storage is in numerical order, the

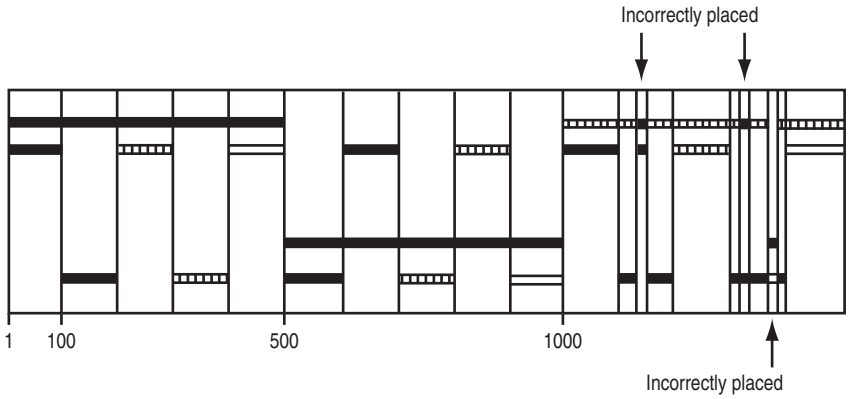


Fig. 5.2 Use of color codes for a filing system. Example of the use of three colors and two 'alleles' per color, suitable for the filing of 3000 records. Incorrectly placed records are immediately noticeable or in any case can be located in a group of 100 sequential numbers.

chance of erroneous placement can be reduced by placing on the spine of each record a color-coded label on which the number is partly or completely readable (Fig. 5.2).

Records should always remain in their places in the storage system or remain with the patient when the patient is being treated. They should never drift through the practice and should certainly never leave it.

5.4.4 Computerized medical registration

Systematic data storage can be improved greatly by the use of a computer system and a program for medical registration. Computerized medical records have important advantages over paper records: they are not misplaced or lost, they facilitate retrieval of data, and they allow the data to be consulted on any computer connected to the system. Almost all hospitals for companion animals now use computer programs for finances and billing and these programs usually provide the option of simple forms for medical registration. These are usually nonstructured, source-oriented records. For more options one may choose a program designed for human patients or a custom-made program. However, both are very expensive and much attention must be given to restructuring the database and designing the forms. In any case, the paperless practice for companion animals has been introduced and will surely be developed further.[6]

In some veterinary clinics, medical registration is now completely computerized. Although the change has usually been made by taking over systems used in human medicine,[7] much programming is needed to make such a system suitable for veterinary medicine. In addition, users must go through a learning curve. When these difficulties have been overcome, the main advantages appear to be that the record is always retrievable(!) and is (almost always) complete. Additional advantages over the paper record system include partly automated compilation of discharge letters, access to the internet, and inclusion of digitalized pictures. Improved access to clinical data is also beneficial to education and the computerized record allows thought processes during examination and treatment to be analyzed.[7]

A few examples of electronic medical registration, which was begun in 2003 in the Utrecht University Clinic for Companion Animals (Vetware Utrecht), are given in Figs 5.3–5.6. These show computer screens for the example of an examination of the ear. The registration form takes up the largest part of the screen. The column on the left is the toolbar containing the action buttons. One button calls up the problem list. Another, 'Invoerverrichtingen' (actions), calls up the billing form. At the top of each form are given the identification of the owner, the patient, the referring veterinarian, and the veterinarian in charge.

5.4.5 Effort and costs

The amount of work invested in the development and maintenance of a medical record system must in principle be economically accountable. The 'profit' of keeping medical records is difficult to express in monetary terms because it is chiefly expressed in the quality of the patient care. Although quality is a readily understood term, its value in economic terms cannot be determined unambiguously. Furthermore, it fluctuates with the economic situation.

Good medical records can save time in the practice. There is, however, an optimal relation between the time invested and the time gained thereby. The recording of too little information raises the risk that many procedures will be repeatedly or needlessly or even incorrectly carried out. If a great deal of information is recorded, it will be unavoidable that

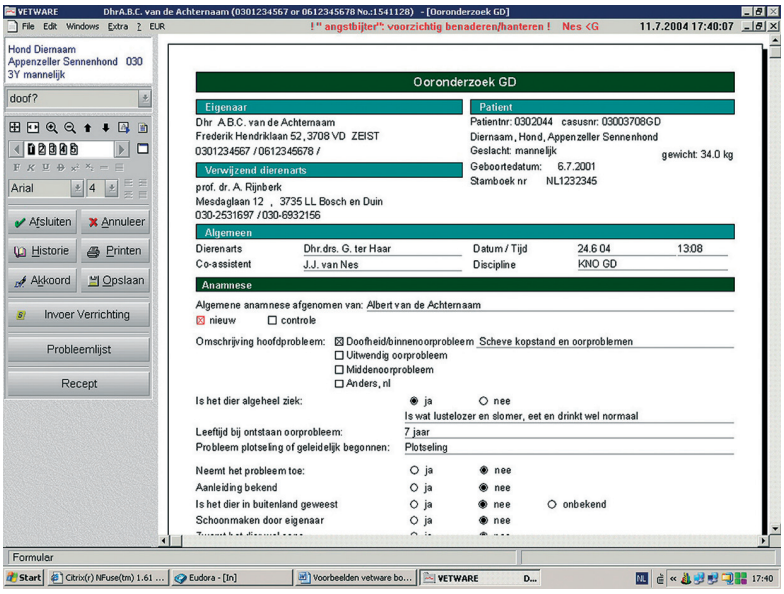


Fig. 5.3 The content of the form changes according to the choices made. When 'ja' (yes) is given in reply to the question 'does the animal have a general (systemic) illness', a field for free text appears. Clicking on 'nieuw' (new) produces a list of questions for the first consultation. Clicking on 'controle' (follow-up) opens a different package of information and questions.

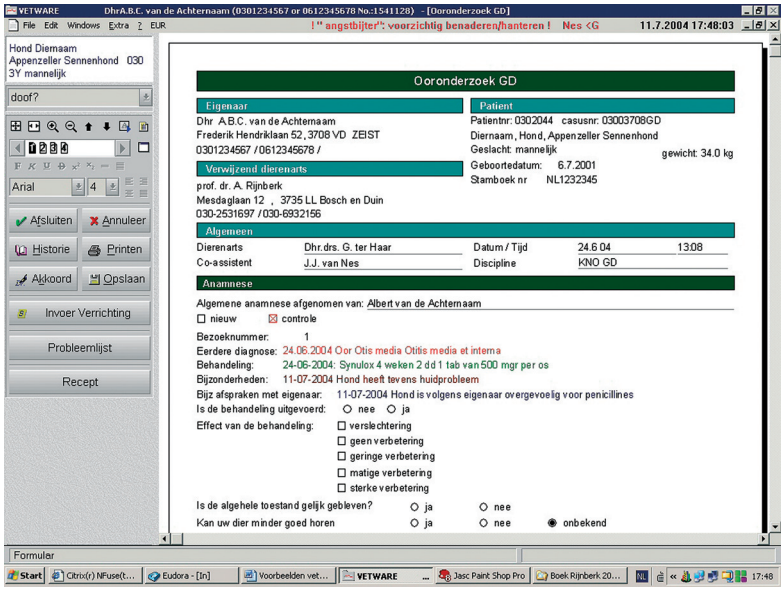


Fig. 5.4 Clicking 'controle' (follow-up) produces a summary of the first consultation, with questions about the course of the disease.

some of the information will never be used, for example because the patient never comes back.

Among the systems mentioned in § 5.4.1 the problem-oriented is the most extensive and laborious and thus the most expensive. The source-oriented system is simpler and less expensive but less accessible and less complete. The way in which the practice is carried out, the financial possibilities, and the desired quality of patient care determine the extent and type of the system to be applied.

Of course, the choice between a paper record and a computerized database also has financial consequences. Both the hardware and the software represent considerable financial investment and this has to be related to the wishes and possibilities of the user.

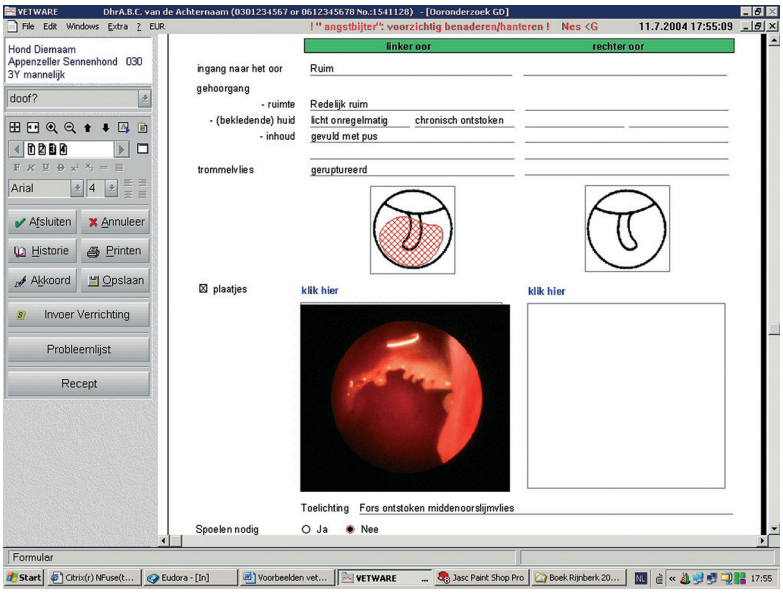


Fig. 5.5 Digital registration also offers the possibility of sketching in abnormalities in figures provided on the forms (hatched area, in red, on this diagram of the eardrum). Also, files can be imported into the record, such as the digital photograph shown here.

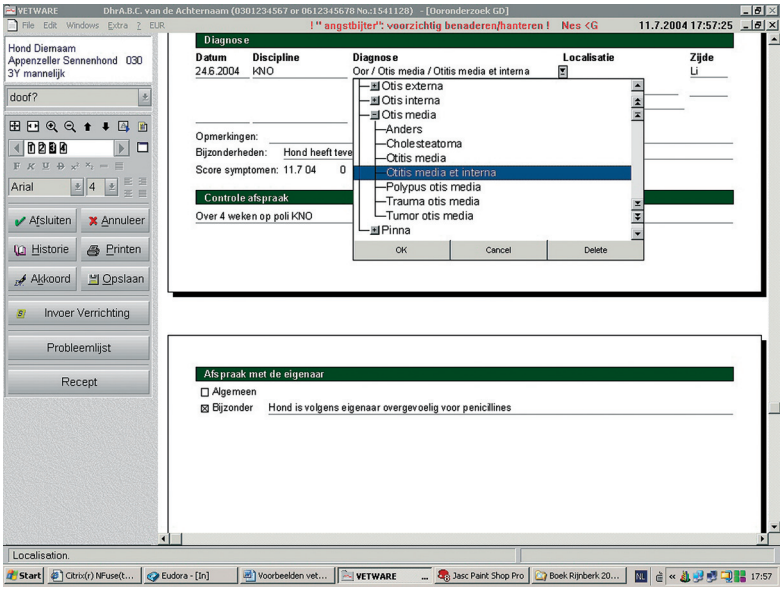


Fig. 5.6 The diagnosis can be chosen from a menu with a hierarchical catalog of all possible diagnoses in this field. Standardized recording of information makes it possible to use key words to generate reports. For example, the records of all cats with external otitis can be collected, showing breed, sex, and age.

5.5 The problem-oriented medical record system

The classical medical record is source-oriented. The advantage of the source-oriented record is that adding information costs little time. It also allows the veterinarian a great degree of freedom in determining the format and extent of notes made in the record.

The great disadvantage of the source-oriented system is that the reconstruction of the history of an illness usually costs a great deal of time because related pieces of information, originating from different sources, are not brought into connection. Because of the lack of a systematic approach—the record hardly lends itself to systematic collection of information—information is often later found to be missing. In addition, each

veterinarian must think again about which examination is indicated for the patient, which doesn't benefit selectivity and judgment. The lack of a systematic approach to the collection and recording of information leads to loss of uniformity. This can cause problems in communication when the patient is handled by more than one veterinarian. This may also be detrimental in cases involving damage claims or disciplinary jurisdiction, where the quality of the medical record usually plays an important role.[4]

Out of dissatisfaction with these shortcomings the American physician Weed developed an alternative record that has since become known as the problem-oriented medical record (POMR). The POMR is so constructed that *all* recorded information is visibly related to one or more defined problems. The core of the system is thus formed by the 'problem list', on which all problems of the patient are listed. In this context the term 'problem' has been defined by Weed as everything that requires examination or treatment.[3] The reason why the owner comes (the iatrotropic problem) can be recorded as a problem just as can an abnormality discovered in the course of the examination.

The definition of the problems is one of the most important steps in the management of the patient because it determines the choice of diagnostic and therapeutic techniques to be applied. Careless or erroneous formulation of the problems introduces the risk that medical procedures will be undertaken from the wrong starting point. In the most unfortunate case this can lead to costly examinations that produce no useful information; radical treatments may be undertaken that do not improve the patient's health or even make it worse.

Problem definition begins at an early stage of the examination. After the medical history has been obtained, the examiner usually has a clear picture of the reason for the consultation. This is the iatrotropic problem (§ 3.1.1), which is always noted on the problem list. As the examination progresses, more information becomes available and may result in the addition of other problems to the list.

The way problems are defined is important for the accessibility of the record. For example, it is possible to list every observation as a problem. While this has the advantage that nothing is overlooked, it results in problem lists that are too long and complex. The problem list is made more clear by limiting the number of problems as much as possible. This can be achieved by bringing separate observations together in nosological entities that point the way to diagnostic procedures, e.g., 'polyuria/polydipsia' or 'fever of unknown origin'. Lists of standardized descriptions of frequently occurring problems can facilitate the compilation of a problem list. In addition, these standard problem definitions can be linked to diagnostic and/or therapeutic scenarios. An extra advantage is that the use of standardized terminology reduces the number of terms without forfeiting the accuracy of the problem description.[6,9]

A constant component of a diagnostic scenario is the basic record for the problem under consideration. Herein is indicated the data which need to be collected to achieve the next stage of refinement. The basic record may be restricted to physical examination, but it may also include further examinations such as laboratory examinations or diagnostic imaging. The extensiveness of the basic record depends on the problem as well as on possibilities and limitations of the practice.

In some cases it is not possible to clearly define a problem from the medical history. In those cases a general basic record can be used. This contains a number of aspecific examinations that may reveal data leading to problem definition. This approach is rarely needed because almost always the iatrotropic problem can be defined in such a way that the appropriate diagnostic scenario can be chosen.

One of the advantages of the POMR is that the user is compelled at an early stage to formulate the problem as simply as possible. This resists the inclination to make a specific diagnosis prematurely and causes the veterinarian to describe the problem at a level at which it can actually be defined (e.g., 'vomiting' in place of 'pancreatitis'). On the other hand, the POMR also compels the user to put together the problems and symptoms as logically as possible and to leave aside irrelevant items. Unnecessary writing and the danger of a too extensive approach are thereby prevented. The POMR also helps the veterinarian to recognize at an early stage whether his own ready knowledge is adequate to resolve the problem or whether other sources must be tapped (journals, books, consultation with colleagues, the help of a specialist).

The extended pause in the definition of the problems costs extra time but the time is well spent. A problem that is well defined is already partly resolved. When a problem is badly or even wrongly described, there is a risk of undertaking a series of inappropriate diagnostic procedures. It is not always easy to correctly define the problem from the medical history. As an illustration, patients in a family practice interviewed by an independent investigator disagreed with 12% of the problems defined by their physician.[10] This example indicates that it may be useful to discuss the definition of the problems with the client, prior to adding it to the record.

The problems placed on the problem list are given numbers in sequence that are carried over to the other parts of the record to indicate where information will be found concerning the given problem (Fig. 5.7). The problem list also contains certain dates for each problem. The date on which the owner observed

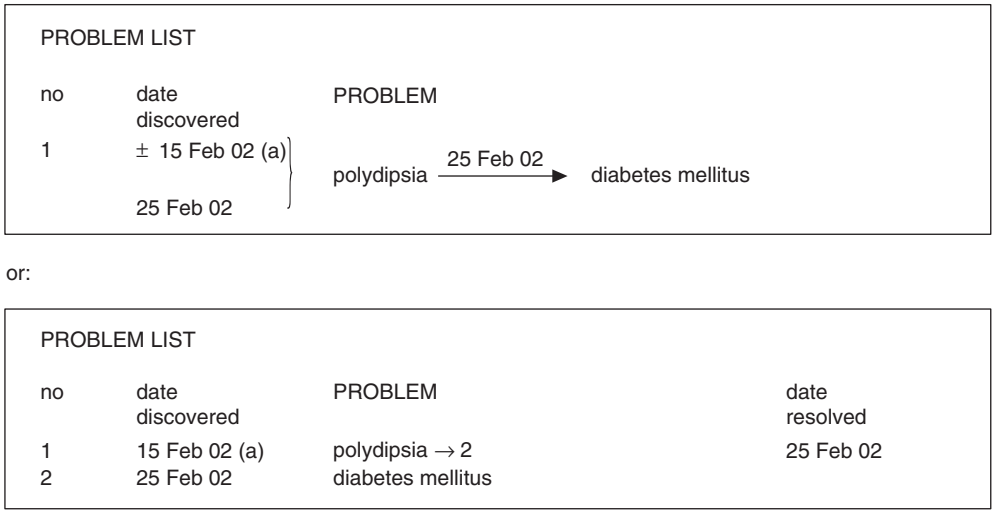


Fig. 5.7 Alternatives for setting up a problem list.

the problem can be given first. The letter (a) can be placed after this date to indicate that it is from the anamnesis. The second date is that on which the veterinarian observed the problem. Finally, the date on which the problem is resolved is also given.

The term 'resolved' requires some explanation here because in this connection it has a slightly different meaning than in general use. In the POMR a problem is considered to be resolved when it has been worked out to a *diagnosis*. This can mean that the problem ceases to exist, but that is not necessary. It does mean that a prognosis can be given and that the most appropriate therapy can be started.

The progression from a problem to a diagnosis is indicated in the problem list by a horizontal arrow. The problem is placed at the left of the arrow and the diagnosis is eventually placed at the right. When nothing has been written at the right of the arrow, the implication is that the problem has not yet been resolved.

The problem list fills a double function in the record:

- It provides at a glance an overview of all of the problems of the patient and the degree to which each diagnosis has been worked out.
- It indicates via the problem numbers the places in the record where information concerning the problem is to be found.

In order for the latter to be possible, results or findings which are collected in the examination must be directed to the problem to which they are related. This means that the findings for each problem can be summarized. For this purpose, all of the relevant information added to the record is placed on a form for progress notes.

The progress notes form a continuing report of the progress being made with diagnosis and therapy for the problems given in the problem list. The progress notes (Fig. 5.8) are written in a fixed format in which they are divided into three sections: *observations**, *assessment, and plan.*[8] On the form for progress notes these three sections are indicated by the letters O, A, and P, placed in the margin after the date on which the notations are made and the number of the problem to which they refer. The clarity of the record is generally increased if the problem is also indicated by name and not only by number.

The section 'observations' includes all information collected on the given date in connection with the given problem. The section 'assessment' gives the conclusions which the veterinarian has drawn from these observations with regard to the severity and presumptive cause (to the extent that this has not yet been clarified) of the observed abnormalities. At this stage hypotheses which could explain the observations are also created (see § 3.2).

The section 'plan' consists of three separate parts:

- (P_d) the *diagnostic* plan
- (P_t) the *treatment* plan
- (P_i) the *informing* of the owner

The diagnostic plan indicates (1) what examinations(s) will be made to test the hypotheses proposed under A, and (2) when the examination(s) will be performed. The therapeutic plan indicates the treatment that will be started and how long it will last. The informing of the owner consists of an explanation of the diagnostic and therapeutic plans, including when the specified plans must be accomplished and why.

At the first examination the observations are recorded in the data base and the assessment consists

* In the original design of Weed, a distinction was made between subjective and objective observations. Subjective observations are made by the patient, objective observations by the physician and nurses. In veterinary medicine one can only guess at what the patient experiences in its illness, so a comparable distinction is not applicable.

PROGRESS NOTES

date	no	
26 Feb 02	2	(diabetes mellitus)
	O	Drinks about 70 ml water/kg/day Glucosuria, urine SG = 1.035 Blood glucose (15.30) = 11 mmol/l
	A	Diabetes still inadequately regulated.
	P	*d* Repeat blood glucose on 29 Feb 02 *t* Increase insulin from 13 to 15 units. Send home. *i* Appointment made with owner for 29 Feb 02, printed instructions with treatment scheme provided.

Fig. 5.8 Example of the recording of progress notes.

in the first place of the summarization of abnormal observations into one or a few problems, which are noted on the problem list. Theories about the cause of these problems (differential diagnosis) should be written under a heading 'assessment' on the progress record. Arguments for and against can be added to each differential diagnosis.

The diagnostic plans consist of two kinds of program: diagnostic programs and monitoring programs. The diagnostic programs are aimed at testing the differential diagnoses. They follow diagnostic scenarios, insofar as these are available.

The monitoring programs allow abnormal values to be followed and are mainly determined by the severity of the abnormalities. The form for progress notes described previously can be of considerable use here. It is indispensable in the POMR because findings are always collected which are not clearly related to a single problem (e.g., body weight).

The therapeutic plans can be symptomatic or specific. Informing of the owner can include a request for permission to carry out a certain treatment.

Carrying out the above method fully results in a great deal of writing, part of which may be superfluous. A very extensive list of problems can occur, to each of which the OAP procedure must be applied and written up (Fig. 5.9). It is therefore advisable in making the problem list to combine observations into clinical syndromes as much as possible, so that there is little or no overlap of the diagnostic programs.

PROBLEM LIST

no	date discovered	PROBLEM	
1	2 Dec 01 (a)	vomiting	5 Dec 01 → 9
2	4 Dec 01	poor turgor	4 Dec 01 → 10
3	4 Dec 01	prolonged capillary refill time	4 Dec 01 → 10
4	4 Dec 01	high hematocrit	4 Dec 01 → 10
5	5 Dec 01	hyperproteinemia	5 Dec 01 → 10
6	5 Dec 01	hyponatremia	5 Dec 01 → 1
7	5 Dec 01	hypokalemia	5 Dec 01 → 1 and 8
8	5 Dec 01	metabolic acidosis	5 Dec 01 → 1 and 7
9	5 Dec 01	ileus	
10	5 Dec 01	hypotonic dehydration	5 Dec 01 → 1, 6 and 9

Fig. 5.9 Example of a problem list.

Poor turgor, a prolonged CRT, an increased Ht, and hyperproteinemia all indicate dehydration, so that the progress notes on problems 2, 3, 4, and 5 will be almost identical. In addition, the pH and the potassium level in the blood influence each other, so the progress notes on problems 7 and 8 will also partly overlap. Such duplications can be avoided by combining these observations (Figs 5.10 and 5.11).

It can be seen that condensing a number of observations into a few problems becomes easier in proportion to the growth of insight into the clinical situation. What information is relevant and what is not is also not immediately clear. Some authors thus advise setting the problem list aside in the first phase of the examination and filling it in only at a later stage.[11]

The problem always remains in the record of the patient and is reviewed at each succeeding examination and, if necessary, it is expanded by the addition of new problems. It is clear that a problem list, composed according to the above examples, can become extremely long, especially if the patient has many problems and a long life. The problem list will soon become less useful in providing an overview. This can be resolved by rewriting the list from time to time. For example, all problems in the existing problem list could, once they belong to the past, be condensed as in Figure 5.12.

If problem lists are to be revised occasionally, the reference to problem numbers may cause mistakes when the numbering changes. Therefore it is better to mention the problem each time (see Figure 5.9).

One of the disadvantages of the POMR is that it limits the user's freedom to decide upon the nature and extent of the notes. This is a consequence of the use of printed forms as well as being inherent in the method. Freedom remains nevertheless in an essential component of the notes: the assessment.

PROBLEM LIST

no	date discovered	PROBLEM
1	2 Dec 01 (a)	vomiting → (5 Dec 01) ileus
2	5 Dec 01	hypotonic dehydration → (5 Dec 01) 1
3	5 Dec 01	hypokalemic metabolic acidosis → (5 Dec 01) 1

Fig. 5.10 Condensation of the problem list in Figure 5.9.

PROBLEM LIST

no	date discovered	PROBLEM
1	5 Dec 01	ileus (vomiting, hypotonic dehydration, hypokalemic alkalosis)

Fig. 5.11 Problem list in Figure 5.9 reduced to one problem.

PROBLEM LIST

no	date discovered	PROBLEM
1	5 Dec 01	ileus → (6 Dec 01) intestinal resection
2	5 Jul 02	wound on tail

Fig. 5.12 The problem list in Figure 5.11 at a later stage. The first problem is summarized and a new problem is added to the list.

In small animal practice, teaching and research do not often play a role and the value of a medical record is mainly determined by its quality in the area of the recording of information and the communication between clinicians. Although the POMR is better in both respects than the traditional record, the laboriousness of its use on a large scale is an obstacle. Yet even when record keeping is set up on a system other than the POMR, the selective addition of some elements from the POMR is still worthwhile. As an example, the filling in of a problem list makes the reconstruction of the medical history easier for the veterinarian handling the patient as well as for colleagues, and so professional communication is improved.

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Supplements on the DVD

For most of the chapters of this book there is a form on the DVD. The purpose of these forms is to aid in recording as completely as possible the relevant medical findings in the history and physical examination. In general, the forms are divided as follows:

- identification, name, address, etc.
- history, including the iatrotropic problem
- physical examination
- formulation of the problem(s)

History

On the general history form the owner can answer a number of questions in advance, for example in the waiting room or even at home if the referring veterinarian provides the form. In the left column are the answers which require the attention of the veterinarian.

The forms of various specialties begin with an additional history.

Physical examination

Beside each component of the physical examination a number of possible findings are given. These can be checked off on the form.

The following is an example from the form for the 'General examination'.

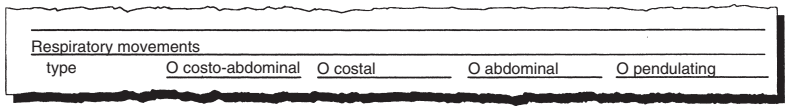


Fig. 5.13

In other cases, such as in the following example from the form 'Behavior', there is a place for the addition of a not yet specified possibility or finding.

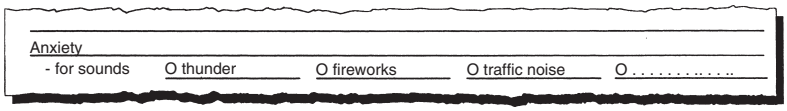


Fig. 5.14

On some forms, such as 'Nervous system' or 'Locomotor system', there are columns with boxes in which the findings can be filled in, for example with a number as in the case of the reflexes: 0 = absent, 1 = present, 2 = exaggerated, 3 = clonus.

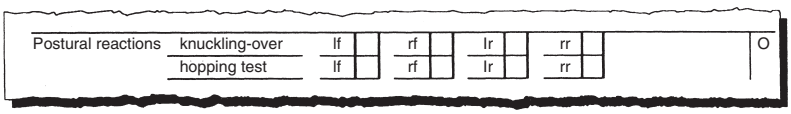


Fig. 5.15

The column at the far right of the forms provides the possibility for indicating 'no abnormalities'. There is a small circle which can be marked for each line or each group of related findings. Marking this circle indicates that a given part of the physical examination has been carried out but that no abnormalities were found. An example is shown below from the form 'Skin, hair and nails'.

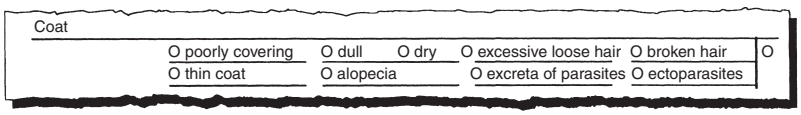


Fig. 5.16

On a few forms certain findings can be sketched in on a drawing provided for this purpose, an example of which is shown here.

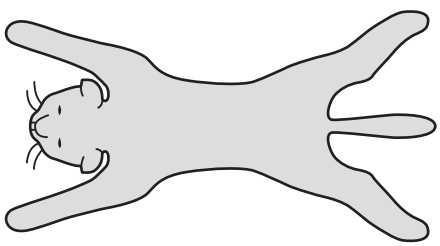


Fig. 5.17

06 The history

A. Rijnberk

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6.1 History

6.1.1 Introduction

The medical history is obtained by an interview with the owner or handler of the patient. The objective of the interview is not only to obtain specific information about the reason for the visit (*the iatrotropic problem*) but also more general information about the functioning of the patient, about the conditions in which it lives, and about its past medical history.

There is usually close contact between a companion animal and its owner, so the history can often provide much information that is valuable in formulating the problem. In the problem-oriented approach, questions often quickly proceed to a specific problem. However, the information required for this purpose is not discussed in this chapter but rather in later chapters on the organ systems. This is because of its connections with the anatomy, pathophysiology, and techniques of examination, which are taken up in those chapters.

This may at first seem a slightly illogical way of discussing the history, but it happens now and then that something found by physical examination raises new questions. Then it again becomes necessary to gather information about the functioning of part or all of an organ system. Both the history and the physical examination are used for this purpose, which emphasizes how much they are interwoven, most certainly with regard to the individual organ system.

6.1.2 The approach to the client and the patient

In order to achieve our objective as well as possible, we must create the right conditions for a good interview. Very often the first few minutes of the meeting between the veterinarian and the client shape the nature of their future contacts. First, greet the client quietly (not in a hurry!) and with interest. At the first examination you are making your first acquaintance with each other. Although social habits are changing, it is desirable in these professional contacts to greet clients with 'Good morning, Mr.…' or 'Good afternoon, Miss (or Mrs.)…' and not to be on first-name terms. Children and adolescents can be addressed less formally by their first names. When the pronunciation of the name poses a problem, one should not hesitate to ask for the correct pronunciation.[1] Careful pronunciation and spelling of the name (including the use of initials, if applicable) is highly appreciated by many people.

Nonverbal communication plays an important role in initial contacts. To greet the client, stand up, take a few steps in his or her direction, and shake hands. A handshake is a form of nonverbal communication with a reassuring effect, especially when it is accompanied by a friendly expression. In this way the veterinarian conveys the impression that the patient is being received with fresh interest and energy.[2]

The first contact should be maintained for a few minutes. Also at subsequent examinations the meeting of the client should also not be immediately interrupted by, for example, reading the patient's record, which is something that should if at all possible

have taken place in advance. Good contact requires a quiet setting. The conversation should not be disturbed by noise, by others walking in and out, or by a repeatedly ringing telephone. The client should not have the impression that your time and attention are under pressure.

By offering the client a chair and also sitting down yourself, you create the opening for a good interview. You and the client then face each other at eye level and in general you should look at the client while he or she is speaking. However, the subject of your conversation may sometimes be such a burden for the client that eye contact should be avoided. Also, while you are talking, continuous eye contact can be worrying for the client.

There are two styles of carrying on a consultation: (1) the directing style, in which the veterinarian leads the conversation, and (2) the sharing style, in which the client largely determines the course of the conversation. In general practice in human medicine, the handling of small problems was found to be more satisfying to the patient when the physician used a directive approach, while in long consultations there was no difference in patient satisfaction between the two styles.[3] As discussed in § 6.1.3, one needs to find a balance between the two styles of consultation.

It is not necessary to immediately seek contact with the patient. It is better to let the animal become a little more familiar with the surroundings. This gives you the opportunity to evaluate your general impression of the patient (Chapter 7). It is certainly appropriate to show the client your interest in the patient by a positive remark about the patient's appearance or behavior. Interest may also be shown by a question like: 'Did the cat appear comfortable in the waiting room?' In many cases the patient makes some exploratory approach to the veterinarian while the history is being taken, which is a good moment to make contact with the patient, verbally and manually.

6.1.3 The interview

The actual interview begins with the question: 'What is the problem?' or 'What can I do for you?'. We do not ask 'What is the complaint?', because animals cannot make complaints (§ 3.1.1). The client needs to have a chance to tell the story without interruption. Contrary to what might be assumed, these first statements do not usually last long. Studies in human medicine have shown that 70% of patients take less than two minutes to describe the problem and 95% take less than 5 minutes.[4]

If this is a follow-up examination for which an appointment was given, its continuity with the previous examination should be shown. For example: 'The last time there were severe skin problems. We began treatment then. How has it gone since then?' The client must have the opportunity to answer the first question without interruption, for he or she may have gone through quite an experience and may need to let that out. One client will want to explain in detail, another may not. It can be useful to repeat an important remark which the client has made and to follow by asking for more details. For example:

Client: '...especially painful when she tries to stand up.'

Veterinarian: 'When she stands up? Just how does she do that?'

By repeating part of what the client has said, you show your interest in what has been said and at the same time can give direction to the interview. When the client has come to the end of the first part of the story, you should sum this up in a few words and ask whether the client agrees with this summary. Then you should explain to the client how the examination is going to proceed (completion of the history, physical examination, and possible additional examinations). The interview then continues according to the plan described below. In completing this plan the client is given somewhat less free rein than in the discussion of the iatrotropic problem. The following guidelines are followed:

1 Ask questions that are open-ended as well as questions that can only be answered with yes or no (closed questions). Since the reply to an open question has something of story-telling in it, it reveals useful information about the relation between the client and the animal, in addition to factual information about the animal. Sometimes we discover that the client describes everything in the worst terms (aggravation), which may reflect a wish to make a decision about euthanasia. Another client may minimize or deny problems (dissimulation), because of anxiety about the possibility of a malignancy or the need for surgery. It is often helpful to begin with open questions and then to gradually change over to closed questions. For example:

   'How are things going for him at home?'
   'How many animals have you at home?'
   'Is there a cat at home?'

   If only closed questions are asked, important information may remain unspoken.

2 Avoid asking different questions at the time, such as:

   'Do you want a litter from the dog or are you considering spaying?'

   Such questions can suggest that there are no other possibilities. In addition, they make it difficult for the client to adequately express his or her meaning or intentions.

3 Do not 'bombard' the client with questions, such as:
'What have you observed about the dog's eating, drinking, and defecation?'

4 Avoid questions with an accusatory character, such as:
'Are you certain that the dog has really received the medicine?'

5 Try to bring an over-talkative client back to the point with an interruption, such as:
'Pardon me, Mr. . . ., I understand that you have had a lot of trouble trying to prevent Astrid from vomiting, but I would now like to hear a little more about how the vomiting occurs', or 'Since I have not seen your cat before the illness, you could help me a great deal by describing what is now different from before.'
The difficulty here is of course that a choice must be made between the advantage of shortening excessive information and the possible disadvantage that certain useful information will be missed.

6 In case of an external interruption (e.g., the telephone) always try to remember two rules:
– apologize for this interruption
– do not forget what you were discussing when you were interrupted, so that you can immediately continue. For example:
'You had just told me that you first found the swelling in the mammary gland 4 weeks ago.'

7 Avoid categorical answers about the cause of the problem. At this stage of the history it is often impossible to give a yes or no answer to a question such as 'Doctor, do you think that it is cancer?' Such a question clearly reveals concern and sometimes this can be handled with a question in return, such as:
'Why do you think that it could be cancer?'
This kind of question in reply acknowledges the client's concern. When the client has replied, you can explain why it is not possible at this stage to give an answer.

Several of the above suggestions come down to elementary politeness or courtesy. They may be regarded as excessive but are meant to emphasize the importance of maintaining a feeling of discussion in the interview and not letting it turn into an interrogation.

6.1.4 Program for the history

1 The iatrotropic problem or problems.
2 General information about the animal:
– maintenance of homeostasis
– interactions with people and animals
3 Living conditions
– animal husbandry aspects
– exposure to harmful agents/materials
4 Past history
– illnesses, medications, vaccinations
– family history.

Point 1. As mentioned at the beginning of this chapter, the first question should be 'What is the problem?' or 'What is the reason for coming?' Once the problem has been described, questions are asked about its duration and progress, whether treatment has been given, and what the present situation is. At the same time, it is important to know what the client has observed personally and what has only been observed by others (family members or neighbors).

Point 2. The maintenance of homeostasis includes food intake, drinking, respiration, urination, and defecation. Hence questions must be asked about:
– food and water intake, problems in swallowing, vomiting
– shortness of breath, panting, abnormal respiratory sounds, coughing
– changes in urination or in the urine
– changes in defecation or in the feces

In the interaction with people and other animals, the following could play a role or come to attention: activity, locomotion, reproductive function (and consequences), response to visual and auditory stimuli, appearance, and behavior. Thus questions must be asked about:
– changes in the amount of sleeping, interests, reactions to stimuli
– how the animal walks: easy, painful, lame, strong, well-coordinated
– female animal:
regular estrus/estrus prevention
time and character of last estrus
pregnancies
– male animal:
interest in females
castration
– vision and hearing
– changes in appearance: body proportions, coat, various parts of the body such as head, feet, ears, eyes
– changes in habits, unusual actions (fainting, convulsions, scratching)

Point 3. Questions about living conditions concern how the animal is kept by the client (how long and for what purpose) and how the animal is housed (in the home, kennel, outdoors). Questions are also asked to determine the type and amount of exercise, the amount of contact with other animals, and whether the animal has been in any other area or country (for diseases not endemic here).

Questions about the animal's food are mainly concerned with the composition of the food. It should be made clear how much use is made of industrially-prepared food and what is given in addition, particularly vitamin and calcium preparations. If an industrially-prepared food is not used, the nature and amounts of the ingredients of the menu should be defined.

The possibility of intoxication can be examined by asking about the use of toxic materials in the animal's surroundings (e.g., against parasites or rodents). Can the animal go outside without observation or supervision?

Point 4. One asks whether the animal has had any previous illness and whether this has led to veterinary treatment. If so, the date of the illness and the name of the veterinarian should also be obtained. It should then be determined whether the animal has had any previous surgery. The relevant information about vaccination can be summarized by asking whether a dog has been vaccinated in the preceding 12 months against distemper, infectious hepatitis, leptospirosis, and parvo-enteritis, and whether a cat has been vaccinated against feline viral enteritis/panleukopenia and feline infectious respiratory disease. Any current or recent medications should be noted, with the dose and frequency if possible. Sometimes the color and form of a tablet or markings on a capsule allow a medication to be identified. Treatment for prevention of estrus should also be noted, as well as the administration of such home remedies as aspirin.

For the family history, the client is asked whether anything is known about illnesses in littermates or other close relatives of the patient. Finally, the client is asked for any relevant information about the health or illness of offspring of the patient, or other animals or people in regular contact with the patient.

6.2 Notation

While the above questions are being discussed with the client, notes must be made. A history that is not written down has a good chance of being incomplete. The completeness of the history is of the greatest importance because, among other reasons, an important question can arise during analysis of the findings or during treatment based on the findings, when the client is no longer available.

This problem can largely be avoided by the use of printed forms that can be filled in by the client while waiting before the examination. By use of the form shown on the DVD, it is possible to quickly sift through the history. A glance at the form that has been filled in by the client will clearly indicate which points need to be examined by additional questions. With this form time is saved and a great degree of completeness is achieved.

On the form entitled History 1, *Point 2* is worked out in detail. These questions about the functioning of the animal provide a picture of the situation at the moment. The questions arising from *Points 3* and *4* are combined on the History 2 form. It is sometimes necessary in a later stage of the examination to return to these more fixed aspects of the animal's history. At a follow-up examination, the History 1 form (*Point 2*) is sufficient, together with the question of whether there have been any changes under *Points 3* and *4*.

6.3 Procedure

When the forms are used, the history proceeds as follows. After the greeting in the examination room, the iatrotropic problem is discussed with the client as described above. The information about the iatrotropic problem is recorded by the veterinarian on History form 3. Then the veterinarian reviews the forms that have been filled in by the owner and asks any additional questions that are needed about items that have been checked in the first or third columns. This additional information is also noted on the History form 3.

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07 General impression

A. Rijnberk

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7.1 Objective

The general impression is formed by looking at and listening to the patient from a slight distance. The objective is to collect in a reasonably short time information that—in combination with the history—allows one to decide how to proceed, that is, to decide whether the problem is defined sufficiently for specific examinations to be undertaken (Fig. 2.1).

7.2 The meaning of 'general impression'

The general impression includes a number of readily observed signs of general illness.

7.2.1 Level of consciousness

A healthy animal in the examination room of the veterinarian is alert and usually shows an obvious interest in the surroundings. Depending on the severity and the nature of the illness, this may be replaced by sopor (sleepiness), stupor (only aroused by strong stimuli), or coma (cannot be aroused).

7.2.2 Behavior

Most of our patients are calm and cooperative, but sometimes in the examination room an animal is nervous and tense, and occasionally there is pronounced anxiety and restlessness. In rare cases this leads to defiance in the form of biting or scratching. Restraint may be required (§ 24.2).

Apart from these physiologic variations in behavior, pathologic behavior can occur in such forms as self-mutilation, compulsive actions (head-pressing, walking in a circle), convulsions, or aggression.

7.2.3 Posture

Sometimes malaise is so great that the patient can no longer stand but must be carried into the room. In very severe conditions it remains lying on its side and in less severe conditions it lies on its sternum. Because of problems in the rear limbs the animal may only adopt a sitting position. When an animal is standing, it may be seen to bear less weight on one leg or its legs may not be adequately extended or may be overextended. The position of the spinal column can be abnormal (arched or sagging back or stiffly extended neck).

7.2.4 Locomotion

An abnormal posture is often accompanied by abnormal locomotion. Usually the defects in posture become more obvious when the animal begins to move. Some animals assume a normal posture at rest but when they move there is an abnormal use of one or more extremities as a result of lack of strength, disturbed coordination, or

mechanical limitation with or without pain. For the present we are interested in an overall impression of locomotion. In the examination of the locomotor system (Chapter 17), locomotion is examined in more detail.

7.2.5 Body shape

Because of the great variations in body shape among different breeds, especially in the dog, evaluation of body shape must always take the breed into account. This causes some special problems in crossings of two breeds of markedly different body shape. The crossing of a fox terrier with an achondroplastic breed such as a dachshund produces an animal that resembles a fox terrier but has disproportionately short legs. Other parts of the body can also be out of proportion. Sometimes the abdomen seems too large or the head too massive. An alteration in the relation between muscles and skeleton can also occur.

7.2.6 Nutritional condition

The nutritional condition can range from obesity to extreme emaciation (cachexia). Most of the patients we see fall between these extremes. To evaluate the course of some illnesses or kinds of therapy, it is also desirable to measure body weight accurately. Fat accumulates chiefly on the trunk and sometimes there is an extra accumulation bilaterally in the lumbar area. After marked loss of weight the ribs and the vertebral processes can become clearly visible. The eyes can be sunken because of the loss of retrobulbar fat and as a result the nictitating membrane can protrude.

The animal's nutritional condition can be described on a scale midway between a nominal and an ordinal scale (see § 3.1.2): cachectic, skinny, slim, optimal, overweight, and obese.[1] Overweight and obesity are associated with health risks. Compared with cats of optimal weight, overweight cats are 2.9 times as likely to be taken to veterinarians because of lameness. Obese cats are 3.9 times more likely to develop diabetes mellitus than are cats of optimal weight.[1]

7.2.7 Coat

We are concerned here with the coat as a whole. It can become dull and dry when the animal's general condition becomes poor. Skin disorders may lead to hair loss, a change in the color of the coat, and finally to localized or generalized alopecia with pigmentation of the skin.

7.2.8 Abnormal sounds

At the usual distances in the examination room, no sounds are heard from an animal at rest. The loud respiratory sounds in some of the brachycephalic breeds reflect deficiencies of these breeds. Eructation and flatulence do not occur often in healthy carnivores, and flatulence is more often detected by odor than by sound. Under pathologic conditions respiratory or intestinal sounds may be so loud that they are heard at some distance from the animal. Disorders of the joints can cause snapping sounds during walking.

7.2.9 Abnormalities that stand out

These include such things as a thickened pinna, swelling of one of the legs, or pumping respiration.

7.3 Technique

Body weight is usually measured before the examination begins, at the instruction of the receptionist.

As was explained in the previous chapter, the general impression can be recorded in the course of the interview, for the patient is often busy investigating the room, and this gives a good opportunity for observation of consciousness, behavior, posture, and locomotion. Sometimes the length of the coat prevents a good visual evaluation of the nutritional condition and it is necessary to palpate along the spine. This is usually easiest as an extension of the first contact in greeting the patient.

The observations for the general impression must not disturb the progress of the interview and if necessary should be delayed until after the interview. If the animal is brought in a box or carrier, it is best to ask the owner not to remove the animal until after the interview. The locomotion of some cats cannot be adequately assessed because, once they are removed from the carrier, they remain where they are placed on the table and refuse to move.

If the general impression is delayed until after the history has been taken, it will form the first step in the examination. The examination is in principle always performed on a table. Small mammals and birds are usually placed on the table by the owner spontaneously. Also medium-sized dogs are usually placed on the table so that they can be observed at eye level. Very large dogs such as the Great Dane and St. Bernard are difficult to place on a table and difficult to persuade to stand up on a table, so are better examined standing on the floor.

If the general examination is followed by examination of one or more organ systems, it may then

be necessary to place even very large dogs on the table, lying on the side or sternum.

7.4 Notation

The findings of the general impression are noted on a form, an example of which is given on the DVD. On this form a nominal scale is provided for each component of the general impression and space is provided for remarks. The form also contains a section in which the problems can be recorded and on the basis of which a decision is made about the nature of further examination.

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08 General examination

A. Rijnberk and A.A. Stokhof

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8.1 Objective

The general examination is a visual and manual examination to collect, in a reasonably short time, information that—in combination with the signalment, history, and general impression—can guide the problem formulation and give direction to further examination. The symptoms and signs that are recorded will be translated into problems and on the basis of these the subsequent examination can be directed to the appropriate organ system or part of an organ system so that the problems can be better defined and, hopefully, resolved.

8.2 Handling of the patient

While the physical examination is being performed, the animal should be as free as possible from restlessness, tension, inconvenience, and pain, not only for humane reasons but also because restlessness and tension can greatly hinder the examination. As already noted in Chapters 6 and 7, the patient should first be allowed to become acquainted with the unfamiliar surroundings of the examination room to help it to relax. A dog that stands pulling on its leash can be showing that it wants to explore the room and should be given the opportunity to do so. Observation of this spontaneous action can reveal useful information (Chapter 6) and sometimes also provide just the right starting point for a relaxed discussion with the client.

A cat should usually be left in its box or carrier while the history is being taken. When the examination is started, the client should be asked to take the animal out of the box or carrier. This is not always necessary, for sometimes if the door of the carrier is opened the cat comes out of its own curiosity. Once the cat appears in the doorway of the carrier, the other end can be tilted up carefully so that the cat spontaneously steps onto the table. The carrier should then be removed from the table, for otherwise if the cat finds the examination unpleasant it may escape to the safety of the carrier and will not so easily let itself be taken out again.

Large dogs are most easily examined if allowed to remain standing on the floor. Sometimes it is necessary to place them on the table for orthopedic examination of the extremities (Chapter 17). Small dogs can usually be placed upon the table by the owner but if help is required to lift the animal onto the table, the owner should be the one by the animal's head. The owner is then asked to remain standing by the table to hold the animal during the examination. This usually reassures the animal and has a calming effect.

Some owners encourage the dog to jump onto the table by itself or to jump from the table when the examination is finished. Although some dogs are able to do so without any problem, this should always be discouraged because the risk of an injury, however small, is quite unnecessary.

If cats are approached in a relaxed way and are held loosely, they often allow considerable manipulation without difficulty. Most cats can also be distracted from unpleasant aspects of the examination by continuous and fairly vigorous rubbing and scratching behind the ears. This only succeeds, however, if the owner or assistant does it with full attention to its purpose of distracting the cat. It is unusual that the physical examination cannot be performed with this approach.

If, with gentle persistence, the intended examination cannot be performed at all or not with the necessary thoroughness, the cat must be restrained by an experienced assistant (see Chapter 24). Inadequate restraint, such as by the owner, is very undesirable, for it can lead to suddenly increasing resistance by the cat, which may be dangerous to those involved as well as to the cat itself.

8.3 The concept of 'general examination'

The general examination includes examination of:

1. respiratory movements
2. pulse
3. body temperature
4. coat and skin
5. mucous membranes
6. peripheral lymph nodes
7. other notable abnormalities

By proceeding in this order, we avoid disturbing the respiratory movements and pulse by other parts of the examination.

8.3.1 Respiratory movements

Introduction

The respiratory movements are of great importance for two homeostatic functions:

Respiration. By this we mean the sum of all chemical and physical processes that maintain and regulate oxidative metabolism in the cells. In this sequence of events (ventilation, diffusion, transport, and tissue respiration), the respiratory movements bring about ventilation of the lungs. The movements are regulated by respiratory centers which receive impulses from peripheral and central chemoreceptors and from mechanoreceptors in the lungs and thoracic wall.

Thermoregulation[1]. When their body temperature rises, dogs and cats increase the loss of heat by increasing the *frequency* of respiratory movements. By means of this superficial respiratory movement (panting, thermal polypnea), the inspired air in the upper airways is 100% saturated with moisture. The heat for vaporization is drawn from the mucous membranes of the nose, mouth, and throat. Although this has also been called ventilation of the dead space, it still results in a slight respiratory alkalosis, from which we can conclude that the alveolar ventilation is also slightly increased.

The respiratory movements are also under the influence of behavior. Fright can lead to sudden apnea, and tension can be associated with nervous panting. In something as complex as barking, the respiratory muscles come into action with great precision, so that a sound of the desired volume and tone is produced.

The *object* of the examination of respiratory movements is to obtain an impression of the functioning of respiration. Disturbances in one or more of the

processes of respiration can be reflected in abnormal respiratory movements. Unfortunately, this examination is sometimes made difficult by respiratory movements arising from behavior (sniffing, barking) or thermoregulation (panting). The observation of respiratory movements consists of evaluating their depth, type, rhythm, and frequency.

Depth

When the need for gas exchange increases, ventilation is first increased by deeper respiratory movements. Even under resting conditions deeper breaths are also sometimes seen, in the form of a sigh. This single deep respiratory movement prevents collapse or atelectasis by release of sufactants.

If the respiratory movements are deepened to the extent that they give the impression of forced movements, or if the movements are clearly difficult, then we speak of *dyspnea*. If the difficulty arises chiefly during exercise, we speak of *dyspnea of exertion*. During dyspnea, auxiliary respiratory muscles come into function in addition to the usual respiratory muscles. The most important of these are the scalenus and the sternocephalicus muscles and the muscles of the nasal alae (wings of the nose). The first two pull the ribs and sternum forward and thereby assist the normal respiratory muscles. The respiratory action of the nasal alae consists of small inspiratory widening of the nasal opening. In some brachycephalic breeds the nasal alae cannot move; in these animals the nasal passage may even be so narrow that there is dyspnea with a sound (nasal stridor). In dogs with severe dyspnea the cheeks may puff out and some dyspneic cats breathe with the mouth open.

Type

Inspiration occurs partly because the respiratory muscles (chiefly the internal and external intercostal muscles) pull the ribs forward, laterally, and ventrally (costal respiration). The lateral and dorsoventral dimensions of the thorax thereby become greater, so that the volume increases. Inspiration is also the result of contraction of the diaphragm. The diaphragm becomes flattened and as a result the volume of the thorax also increases and the circumference of the abdomen becomes greater. This has been given the incorrect name of 'abdominal respiration'. In the dog and the cat both the respiratory muscles and the diaphragm play an important part in the respiratory movements and this combined action is called costoabdominal respiration (Fig. 8.1).

When the function of the diaphragm is lost (e.g., by rupture), inspiration is no longer accompanied by bulging of the abdomen. On the contrary, the abdominal circumference now usually decreases during inspiration, resulting in a so-called *pendulous respiration*.[2] Occasionally in severe dyspnea there is marked *costal respiration* and so little air is drawn in that the diaphragm does not stretch flat enough and thereby a pendulous respiration also occurs. Such forced inspirations can also be called pseudopendulous.

When there is loss of elasticity of the lungs, there may be slight abdominal pressure exerted on the diaphragm

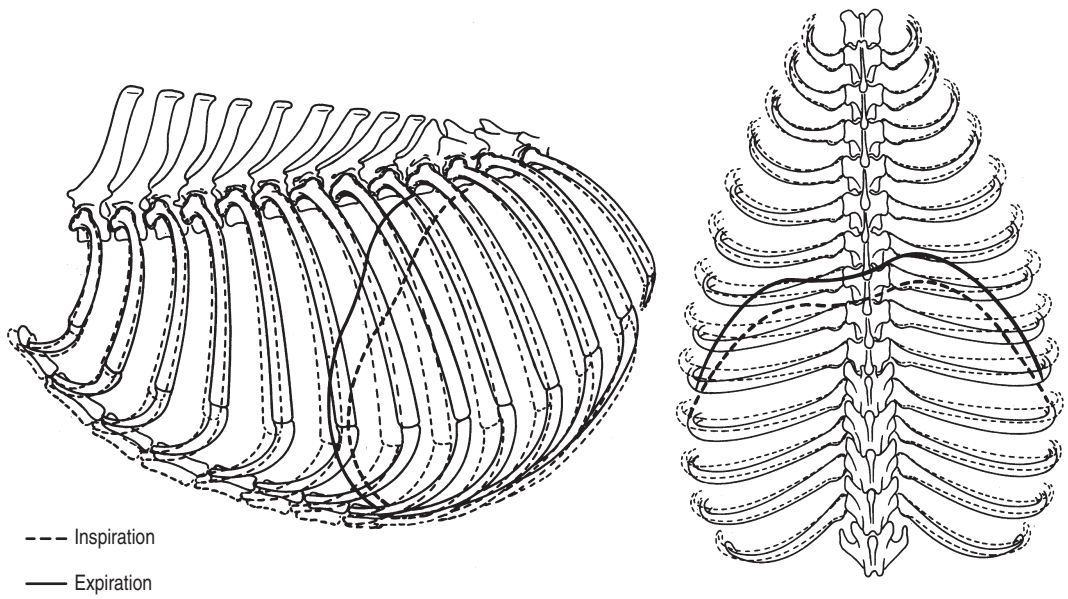


Fig. 8.1 The inspiratory and expiratory positions of the ribs and sternum in the dog, based on radiographs. The caudal limits of the lungs are also shown.

at the end of expiration. This is called an *abdominal type of respiration*. During forced expiration the intrathoracic pressure can increase so much that small bronchi are narrowed, which only adds to the respiratory distress.

Although inspiration is active, resulting from contraction of muscles, expiration is passive. The thoracic wall, diaphragm, and lungs return to a resting state at the end of inspiration. Loss of elasticity of the lungs and loss of flexibility of the thorax result in slow and incomplete expiration. This is sometimes assisted by the abdominal pressure mentioned above, by which the diaphragm is displaced forward. In such an *expiratory dyspnea* the relation between the duration of inspiration and expiration is also changed (normally 1:1.3).*

Narrowing in the respiratory passages cranial to the thoracic inlet is associated with *inspiratory dyspnea*. This is manifested by a marked costal type of respiration and often by auxiliary respiratory movements as well, sometimes including retraction of the lips (labial respiration). The air must be sucked in with increased force, which results in a greater difference in pressure between the inside and outside of the large respiratory passages. The walls can be drawn slightly inward during inspiration, which makes the narrowing worse. Also, parts of the thoracic wall that offer less resistance will be drawn inward, especially in the thoracic inlet. The caudal ribs can also lag slightly behind during the strong outward movement of the thorax and this can be quite noticeable in young animals with a soft thoracic wall.

Patients that have undergone severe trauma, such as being struck by a car, can exhibit a special type of breathing as a result of two adjacent ribs being fractured in at least two places. This results in a so-called flail chest (see § 23.2.3), in which the movement of the fractured segment is opposite to that of the rest of the thoracic wall, i.e., it moves inward with inspiration and outward with expiration.[3]

Rhythm

Sometimes the respiratory movements alternate for shorter or longer periods with apnea. This is called periodic respiration and it is only seen in patients with low arterial PCO_2 caused by hyperventilation.

The slight decrease in arterial PO_2 and the increase in PCO_2 during the apnea stimulate the respiratory center, so that respiration is resumed, which leads again to reduction in PCO_2, etc.

Hyperventilation can occur during sedation, depending on the drugs used. This leads to periodic respiration in which the periods of apnea alternate with periods of repeatedly identical respiratory movements (isovolemic periodic respiration).

Frequency

The following frequencies apply to healthy adult animals:

dog 10–30/min
cat 20–40/min

The variation is especially wide in the dog. In this species there is considerable variation in body size and therefore in the frequency of respiratory movements; the frequency is generally lower in the larger breeds than in the smaller ones.

An increase in the frequency (*tachypnea*) is a less efficient way of increasing ventilation than increasing the depth of respiration, because in the former the percent dead space remains unaltered. In general there is first a deepening of respiration and then only in severe disorders is the frequency also increased. In well-trained animals at rest there can be a very low respiratory frequency (*bradypnea*).

Technique

Small and medium-sized animals are given a little time to become familiar with the table surface on which they are placed and larger patients, which remain on the floor, will also have become familiar with their surroundings. This state of relative rest can be used for observation of the respiratory movements from a slight distance and without touching the patient.

By observing the animal from the side and from above it is possible to see quite well both the thoracic and the abdominal respiratory displacements. During inspiration notice is taken of the lateral movement of the thorax and the bulging of the abdomen. During expiration notice is taken of the falling in of the ribs and the decrease in abdominal circumference. When an animal is standing on the examination table, the ventral excursions can be observed by viewing from a lower position (e.g., by the examiner sitting at the desk).

In addition, attention is given to:

- the duration of inspiration and expiration
- the regularity of respiratory movements
- the depth of respiratory movements
- the type of respiration
- abdominal pressure at the end of expiration
- use of auxiliary respiratory muscles

Finally, the number of respirations per minute is determined by counting the inspirations during at least half a minute.

8.3.2 Pulse

Introduction

The term ‘pulse’ is taken from the Latin *pulsis*, meaning stroke.

In a healthy animal each heartbeat delivers a quantity of blood to the arterial system. This gives rise to the

* These are approximate values, in which respiratory pauses are not taken into consideration.

pulse wave. The speed with which the wave is transmitted is dependent on the elasticity of the arterial walls and is independent of the rate of flow of the blood. The rate of flow of the blood is about 0.5 m/s while the pulse wave advances at 4 or 5 m/s. The palpable pulsation is the front of a pressure wave and not the movement of the blood itself.

The form of the pulse wave is chiefly determined by the volume of blood pumped into the aorta per heartbeat, the speed of this ejection, and the compliance of the arteries. As the wave advances to the periphery, it changes in form (Fig. 8.2).

The purpose of palpating a peripheral artery is to obtain an impression of the arterial pressure wave and thereby the function of the arterial component of the systemic (in contrast to pulmonary) circulation. In dogs and cats the femoral artery is used for this purpose. Other arteries (coccygeal, abdominal aorta, anterior tibial) are sometimes accessible to palpation, but the various characteristics of the pulse are not as easily evaluated by use of these arteries.

The examination of the pulse wave consists of evaluating the following characteristics: uniformity, rhythm, amplitude, missing pulses, form, frequency, and symmetry.

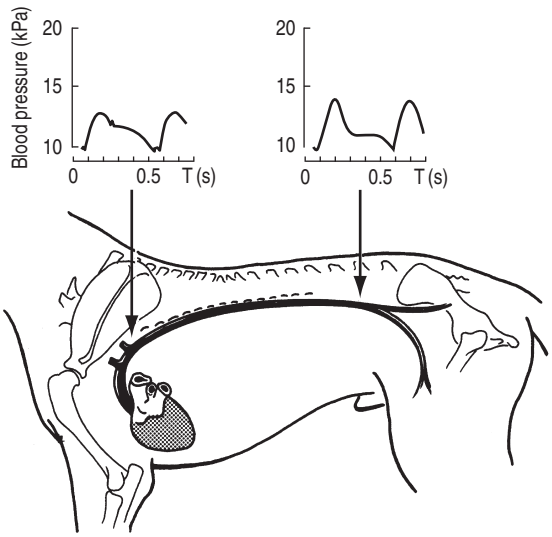


Fig. 8.2 The blood ejected during systole causes a sudden rise in pressure in the ascending aorta. The closure of the aortic valve results in an incisure in the pressure curve. The pressure is transported along the aorta to the periphery and is then reflected. The reflected pressure wave is superimposed on the wave moving toward the periphery. This causes an increase in systolic pressure, disappearance of the incisure, and a lower diastolic pressure in the femoral artery. The difference between the peak systolic pressure and the end-diastolic pressure is the pulse pressure.

Uniformity

If the amplitude of each pulsation is the same as the next, we speak of an *equal pulse*. In arrhythmias the volume per stroke can vary markedly and consequently an *unequal pulse* is found (Fig. 8.3). During arrhythmia the heart contracts at moments when there is little filling of the ventricles. Hence little blood is ejected and only a very weak pulse or no pulse is palpated peripherally.

A pulse of this type should not be confused with a sometimes also physiologically occurring variation in the amplitude of the pulse. This is the so-called *paradoxical pulse*, in which the amplitude decreases during inspiration and increases during expiration. This phenomenon is observed only with great variations in the intrathoracic pressure, such as occur during deep respirations. This variation in systolic blood pressure during breathing is caused by the negative intrathoracic pressure during inspiration. This allows more blood to collect in the lung vessels and thus less reaches the left heart, so the stroke volume decreases (Fig. 8.4). These small variations in pulse amplitude are rarely detected by the palpating fingers. The small amplitude of the fluctuations is also a consequence of the fact that

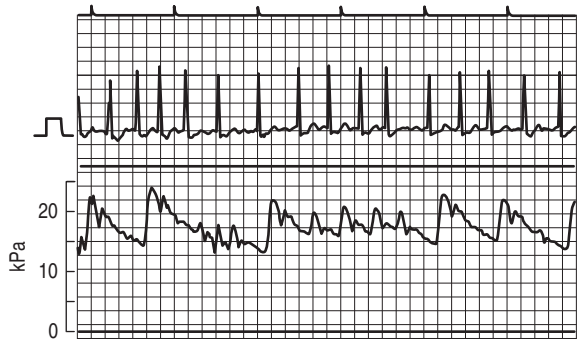


Fig. 8.3 (From top) the time in seconds, 1 mV reference pulse followed by ECG lead II, and pressure variation in the descending aorta, in a dog with atrial fibrillation. This is an example of an irregular and unequal pulse.

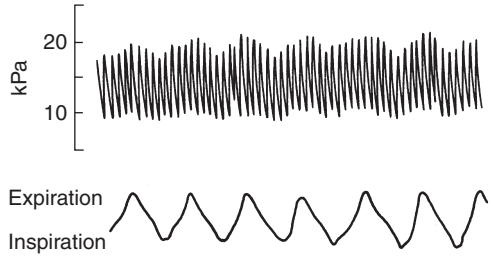


Fig. 8.4 Blood pressure recording, showing that the intra-arterial pressure is higher during expiration than during inspiration. The SI unit of pressure is the pascal (N/m^2 = Pa). (1 mm Hg = 133 Pa = 0.133 kPa).

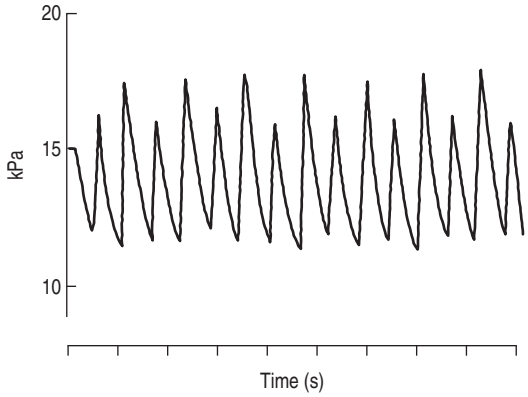


Fig. 8.5 Alternating pulse. Blood pressure recording showing an alternating decrease in the systolic pressure and to a lesser degree in the diastolic pressure.

the negative intrathoracic pressure during inspiration (= negative pressure in the central venous system) also increases the blood flow to the right heart. This partly compensates for the reduced filling of the left ventricle and limits the decrease in arterial blood pressure.

A different situation arises when filling of the heart is continuously low. A well-known example of this is pericardial effusion, which compromises cardiac filling.[4] The above-mentioned compensation mechanism is less effective and the decrease in systolic blood pressure during inspiration is much greater. The respiratory variation in pulse amplitude may become palpable. In humans the predictive value (see § 3.1.5) of a pulsus paradoxus for the presence of pericardial overfilling (cardiac tamponade) is 0.81–0.97.[5]

A special form of the unequal pulse is the *alternating pulse*, in which there are alternating clearly palpable and barely palpable pulse waves (Fig. 8.5). This is interpreted as an indication of insufficiency of the left ventricle and is seen, for example, in hypovolemia, but there is not a good explanation for it. What is known is that in these cases the end-diastolic pressure varies with the same regularity as the height of the pulse wave.

Amplitude

After the pulse is found to be regular, the size of the pulse wave (amplitude or pulse volume) is determined. It is difficult to say anything about amplitude when the pulse is unequal. The amplitude of the pulse wave can increase or decrease with changes in the stroke volume or peripheral resistance. A low peripheral resistance and therefore a strong pulsation of the palpated artery occurs with anxiety, fever, and lowered viscosity of the blood due to anemia. One must also remember that what is palpated with the fingers is also determined by the surrounding structures. The pulsations feel very weak in an obese animal. A strong pulse is called a *pulsus magnus* and a weak pulse is a *pulsus parvus* or even a *pulsus filiformus* (thready pulse).

Form

Small changes in the configuration of the pulse wave are not recognized by the palpating fingers. Only when there are marked changes in the outflow from the left ventricle (stenosis or insufficiency of the aortic valve) is the pulse wave so changed in form that the difference is noted in palpation. When the outflow is slowed by stenosis there is a wide pulse wave (*pulsus tardus*). Insufficiency leads to a narrow pulse (*pulsus celer*).

Rhythm

In the dog the heart action exhibits sinus arrhythmia under the influence of respiration (respiratory arrhythmia). During inspiration the vagal tonus is reduced, leading to increased frequency of discharge in the sinus node, while during expiration the opposite occurs. In animals with a low respiratory rate as well as a low heart frequency, the respiratory arrhythmia can be quite pronounced, even misleading the less experienced to think it is a pathologic rhythm. This misunderstanding occurs chiefly because in adult dogs during expiration, the slowing of the heart action in the respiratory pauses can be quite abrupt.[6] Careful observation of the respiratory movements during palpation of the pulse usually resolves the question. Respiratory arrhythmia cannot usually be detected with pulse frequencies higher than 120/min. It is also usually absent during panting.

Missing pulses

Very little blood is ejected during heart contractions which occur very soon after the previous contraction, for the time for diastolic filling is very short. This occurs in arrhythmias and may result in so-called frustrated contractions, in which no pulse wave is generated. This can be confirmed by simultaneously palpating a peripheral artery and the ictus in the left 5th intercostal space. At frequencies >100/min this method is not very reliable for determining whether each contraction leads to a pulse wave. In such cases the pulse frequency is first counted and then the heart frequency is counted by auscultation. If the latter is higher than the pulse, there are missing pulses (pulse deficit).

Frequency

The following values are for adult animals:

dog 60–120/min
cat 120–180/min

It is possible to count accurately up to a frequency of about 200/min. Hence counting errors can occur when there is a very rapid heart action (tachycardia)

and a rapid pulse (*pulsus frequens*). In the cat this is frequently the case under normal conditions. A frequency lower than the lower limit of the reference range is called *pulsus rarus*. The above reference values cover rather wide ranges. This is a consequence of stress rather than a variation due to breed differences. Two independent studies have shown that pulse frequency is not correlated with body weight.*

The stress of the visit to a veterinary clinic can increase the animal's pulse frequency considerably. In the above-mentioned studies, the pulse rates of healthy dogs were significantly higher when measured in the clinic by the veterinarian than when measured at home by the owner. In some dogs the pulse frequency at home was below 60/min. In tense dogs the pulse frequency in the clinic may be above 140/min. For cats it has been shown that the frequency at home under resting conditions varies from 80 to 160 beats/min, while in the clinic (during electrocardiography) frequencies between 142 and 222 beats/min are found.[7]

Symmetry

Under normal conditions the pulses in the left and right femoral arteries have the same characteristics. Asymmetry is only to be expected as a result of differences at or distal to the aortic bifurcation.

A thrill is an abnormality that can sometimes be detected by palpation of an artery. It is not a characteristic of the pulse wave and its origin lies in turbulence in the blood. Slight compression of the artery by the palpating fingers disturbs the normal laminar stream and causes turbulence. This can only be observed when the blood has a low viscosity, as occurs in anemia. The constant of Reynolds is exceeded (§ 4.1.4).

Technique

The examiner takes a position behind the animal and brings the hands from the side around the front of the thighs and uses the fingertips to locate the femoral artery high on the medial side of the thigh (Fig. 8.6). Then, one by one, attention is given to quality (equality, amplitude, and form), rhythm, missing pulses, frequency, and symmetry. Finally, the frequency is counted during at least 15 seconds.

By working in this sequence and not first counting the pulse frequency, we avoid concentrating our attention on the frequency and thereby giving too little attention to the other characteristics. Sometimes this important information about the arterial component of the circulation cannot be obtained because no pulses can be felt at all. This occurs sometimes with very obese animals and above all with heavier cats. In these it will only be possible to record the heart frequency by palpation of the ictus (also difficult in obese animals) or by auscultation.

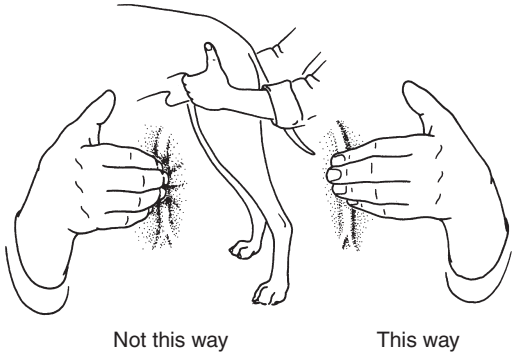


Fig. 8.6 The femoral arteries are palpated by softly pressing with the volar surface of the fingertips and not the ends of the fingers and nails. Not only is the latter unpleasant for the animal but the pulse wave can certainly not be evaluated in this manner.

The studies mentioned above concerning pulse frequency revealed that determining pulse characteristics is highly dependent upon experience. This is especially true for detecting inequality. Inexperienced examiners often miss an unequal pulse and thereby an arrhythmia. Their results improve greatly when they take the time to check all pulse characteristics carefully.

8.3.3 Body temperature

Introduction

In the healthy animal the body temperature is maintained within narrow limits by adjustment of heat production and heat loss. Heat is a continuous product of metabolism and it can also increase with muscle activity (including shivering and increased respiratory activity!), and as a result of increased metabolic activity, e.g., under the influence of thyroid hormones and catecholamines.

Heat loss occurs via radiation, conduction (via air and contact with objects), and evaporation. These processes can be promoted by vasodilatation in the skin, polypnea, changing body position to increase surface area, and seeking cool places. In the cat the care of the coat may also play a role via evaporation of saliva spread over the coat. Heat can be retained by vasoconstriction in the skin, by the raising of the hair by the piloerector muscles, by seeking warm places, and by reducing the body surface area via changes in position.

Regulation occurs via central and peripheral thermoreceptors that transmit information to the thermoregulation center in the hypothalamus.[8] This center is probably also responsible for the daily variation in temperature which has been shown in the dog and other species: at about six in the morning the

* Apprenticeship at Utrecht University Clinic for Companion Animals by Annelies Pernot and Annemiek van Dijk.

temperature is at its lowest (37.7–38.3°C) and at three in the afternoon it is at its highest (38.1–39.1°C).[9] Daily variations in body temperature are also strongly associated with physical activity.[10]

In many diseases there is a change in body temperature which is the result of pyrogens raising the set point of the thermoregulation center to a higher level. The measurement of body temperature, for which rectal temperature is used, can therefore provide an important signal for the first recognition of a disorder. In conditions associated with abnormal body temperature, repeated measurements are also informative about the course of the disease.

Technique

Body temperature is measured by placing a fever thermometer (§ 4.2) in the rectum. The tail (if not docked) is grasped quietly but firmly near the base and raised. Grasping the tail near the base restrains the animal to some extent. After the thermometer has been shaken well and lubricant has been applied to it, it is introduced with a soft, turning motion. In the cat there is almost always a definite resistance about one centimeter cranial to the anus. This is caused by a contraction which usually relaxes if the soft turning motion is continued for half a minute without pressure. Increasing the pressure causes a great deal of pain to the cat. For a good measurement of the central body temperature the thermometer must be introduced at least 2 cm. The mercury thermometer must remain in place for at least 1 minute, while a digital thermometer only requires 5–10 seconds (§ 4.2).

The introduction of the thermometer also provides a good opportunity (without using extra time) to observe the tonus of the tail, cleanliness of the perineum (feces, parasites), status of the anus (open, closed), anal reflex, rectal tonus, and possible resistance in the rectum. After removing the thermometer the adhering feces should be noted (color, consistency, presence of blood).

Reference values

dog 38.0–39.0°C
cat 38.5–39.0°C

The excitement and manipulations in a clinical examination can easily elevate the temperature by 0.5–1.0°C, which makes interpretation difficult. When a more reliable measurement is needed, the owner can be requested to measure the animal's rectal temperature at home, twice daily, for a few days.

8.3.4 Coat and skin

Introduction

The skin protects the organism against loss of water, electrolytes, and macromolecules, as well as against the entrance of chemical, physical, and microbiologic agents. In addition, the skin with its rich circulation plays an important role in thermoregulation, while the rich sensory innervation provides contact with the surroundings. In the dog and cat the hair contributes to these functions of the skin.

Coat

In the dog the hair is thick on the back and on both sides of the trunk. In contrast, the inner surfaces of the pinnae, the groin, and the ventral surface of the tail are mostly without hair. In the cat the entire trunk is thickly haired. The growth of hair in the dog and cat goes through cycles (Fig. 8.7), in which the anagen (growth period) and telogen (rest period) are the most important. During anagen the hair is formed by cell division in the matrix surrounding the papilla of the hair follicle deep in the dermis. In the transition phase (catagen) the hair pushes up and the follicle is shortened by up to one-third. The resting hair formed in this way is pushed out shortly thereafter by newly formed hair. In the dog and the cat the growth of hair is asynchronous and in a mosaic pattern, so that hairs lying close together can be in different phases. This process is slightly influenced by exposure to daylight (length of the photophase and scotophase). The increase in length of the photophase in the spring leads to much loose hair.[11] The fact that household dogs shed throughout the year is related to replacement of a seasonal variation by exposure to artificial light. During pregnancy and pseudopregnancy there is some synchronization in the hair growth and few hairs pass into the telogen phase. The change in the hormonal status at parturition then results in the shedding of much hair at one time.

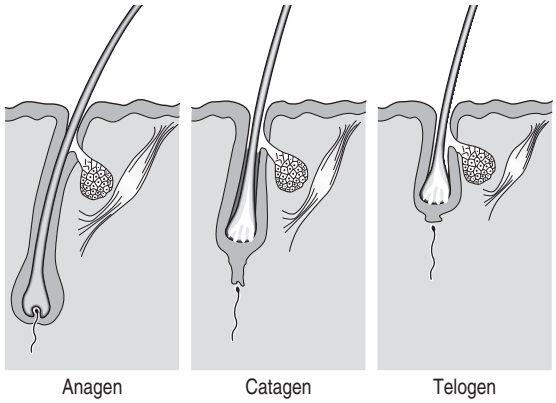


Fig. 8.7 Hair growth cycle. The part of the follicle that is a direct extension of the epidermis is called the outer root sheath. The inner root sheath (black) keratinizes and flakes off on the top of the hair canal at the height of the mouth of the sebaceous gland. In the underlying thicker part of the hair follicle, the bulb, is the space for the mesodermal papilla, rich in blood vessels.

Roughly speaking, three types of coat can be distinguished,[12] in which the coat of the German shepherd (and the wolf) is considered 'normal'. In this type of coat there are not only primary (guard) hairs but many secondary hairs (undercoat). The second type of coat, the short-hair type, consists primarily of short primary hairs with few secondary hairs (boxer and short-haired dachshund). The third type is the long-haired coat, which can be subdivided into a fine-haired long coat (English cocker spaniel) and a wooly coat (poodles). These coats consist primarily of secondary hairs. In cats by far the greatest part of the coat consists of secondary hairs.

Hair is almost completely protein (keratin). A deficiency in hair development occurs quickly in disease. The anagen is shorter and hence a greater percentage of hairs move into telogen. These telogen hairs are less strongly anchored in the skin, so that in disease the coat becomes thinner. Diseases can also lead to an abnormal hair structure, which can result in a dull appearance and sometimes some loss of pigment.

Examination of the coat

The examination of the coat includes a general inspection and a local inspection. In the general examination one forms a general impression of the coat and takes note of the color, the gloss, the closure or way the coat fits together, and any areas of alopecia (also see Chapter 7).

The local inspection of the coat is an evaluation of its density (guard and undercoat hairs) and of the occurrence of loose hair. For this purpose a forceps is used to lift up portions of the coat (Fig. 8.8). By doing this in the lumbosacral area an impression is also obtained of the presence of the most important parasite of the dog and cat, the flea.

The skin

The skin (cutis) consists of a thin, superficial avascular cell layer (epidermis) and a fibroelastic layer (dermis). In the latter there are also blood vessels, sweat glands, sebaceous glands, and hair follicles. In the dermis there is a rich adrenergic motor innervation of the blood vessels, the erector pili muscles, and the myoepithelium around the apocrine sweat glands. The sensory innervation is not restricted to the dermis; in the epidermis there are also sensory nerve endings via which cold, mechanical influences, pain, temperature differences, and pruritus are detected. The skin is thickest dorsally and thinner ventrally, especially in the axilla and groin.

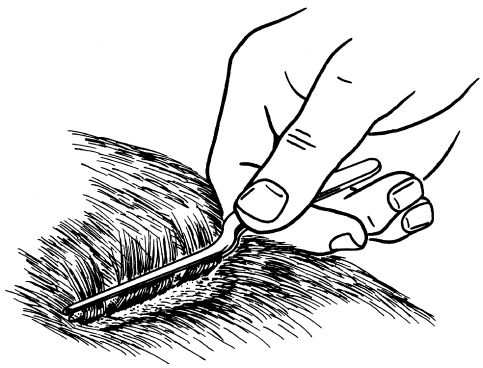


Fig. 8.8 Local inspection of the coat with the aid of a forceps.

Under the skin is the subcutis, a layer of loose connective tissue with fat. The amount of fat varies from dog to dog and from place to place on the body. The dog has no subcutaneous fat on the distal extremities but well-fed animals usually have subcutaneous fat on the trunk.

Skin changes can be the result of primary skin disease or part of a systemic disease. For purposes of the general examination, the examination of the skin is limited to detecting abnormalities that can help in formulating the problem and choosing further examinations. With or without skin lesions, the examination of the skin gives useful information about the general health of the patient.

Examination of the skin

In this examination the skin is evaluated on the basis of the following four aspects.

Color and presence of hemorrhages. For this purpose the thinly-haired parts of the skin are examined. In the dog and cat the inner surface of the pinna can be used but sometimes a tattoo is a hindrance. In the dog the groin is also suitable for this inspection. To examine this area well, the dog must usually be laid on its side or back. Occasionally the inspection is hindered by pigmentation of the skin.

In healthy animals the skin is light pink. Sometimes it is so thick that the pink color of the vasculature is scarcely visible and the skin is rather grayish-white. The skin can be pale as a result of reduced circulation or anemia. Locally increased circulation causes redness (erythema). An increased bilirubin concentration in the blood leads to a yellow color (icterus).

Hemorrhage in the skin can be in the form of petechiae (pinpoint bleeding) or larger areas of bleeding. A fresh hemorrhage in the skin is red. If it has been present for a short time, it becomes green and then yellow because the hemoglobin is changed locally into biliverdin and bilirubin. Bleeding into the subcutis or musculature produces an accumulation of blood called a hematoma.

Thickness, elasticity, and turgor. Since these characteristics are not the same in all areas, we always evaluate them at the same location, namely, halfway up the side of the thorax by the tenth rib. Here a fold

of skin is picked up between the thumb and forefinger to evaluate its thickness and the ease with which it can be raised. How quickly it returns to its place when released gives an impression of its elasticity (skin tension, turgor). The elasticity of the skin is clearly greater in young animals than in older animals and this must be taken into account if the turgor is used as a measure of dehydration. In young animals the skin returns to its place almost immediately (<0.5 s) when released, while in older animals this can take one second without being abnormal. To make this an evaluation that can be compared and reproduced, the animal should be standing without bending of the trunk to either side, which would make the fold snap back very quickly or very slowly. Poor nutritional condition also results in loss of elasticity of the skin without necessarily being an indication of dehydration.

Temperature. An impression of the temperature of the extremities such as the feet, lips, and pinnae can be obtained by holding them or by touching them with the back of the hand. In healthy animals which have not just come in from cold surroundings these extremities feel warm. If the peripheral circulation is poor (regionally or generally), these extremities feel cool. In the area of an inflammation the skin can feel extra warm. In making these evaluations the influence of the coat covering the area must be considered.

Presence of edema. This examination is limited to inspection and palpation of places in which edema most readily occurs because of gravitation and tissue pressure. In the dog and cat these are the ventral surface of the trunk (in the male dog especially above the prepuce) and the area just proximal to the tarsus between the achilles tendon and the tibia. Inspection of this area can reveal an increased circumference and even a slightly stretched skin. A depression made in the swelling with a finger remains for some time. Edema resulting from inflammation is accompanied by warmth and pain, but this is not the case with edema due to other causes.

8.3.5 Mucous membranes

Introduction

The structure of the mucous membranes is quite similar to that of the skin. The most superficial layer is also an avascular cell layer of squamous epithelium. Beneath it lies vascularized connective tissue (lamina propria) in which there are usually not many glands. The ducts from the glands in the submucosa pass through this layer.

The mucous membrane of the genital opening is generally less suitable for examination because its condition changes with the reproductive cycle (female dog) or inflammation (male dog).

Examination of the mucous membranes

This consists of evaluation of the color and moisture of the membrane, the capillary refill time, and inspection for hemorrhages or lesions.

Color

The color of the mucous membranes is easier to evaluate because the lamina propria is thinner than the comparable fibroelastic layer (dermis) of the skin. Where the lamina propria and submucosa are well vascularized the mucosa in healthy animals is pink. This is not so on the sclera, where the overlying conjunctival mucosa is completely transparent. Inadequate perfusion and anemia can cause the mucosa to be pale. The sclera is used to detect icterus. In a few breeds the mucosa is pigmented locally, which may interfere with its examination.

Capillary refill time

An impression of the peripheral circulation is obtained by measuring the capillary refill time. After slight pressure is applied to make an area of the mucosa 'bloodless', the pink color returns in no more than one second.[13] At first glance this seems attractive: in a quick and noninvasive manner, it appears to give an impression of the circulating volume. However, as with some other clinical practices, it has come into use without evaluation (see Chapter 1).

There have, however, been a few critical assessments of it in human medicine.[14] It has been shown that the results are highly dependent upon the observer (high inter-observer variability). In addition, it does not detect moderate hypovolemia. In blood donors from whom 450 ml blood was removed, the sensitivity of the method (see § 3.1.5) was 0.11. In the same study, the measurement of capillary refill time had a sensitivity of 0.77 in patients with unequivocally low arterial blood pressure (hypotension).[15]

Moisture

In healthy animals the conjunctival mucosa is kept moist by tears and the oral mucosa by saliva. Dehydration can make these dry and sticky.

Hemorrhages

Blood vessels can be recognized in mucous membranes, especially in the scleral conjunctiva (see also § 19.4.6 and 19.4.8). Under normal circumstances there should be no hemorrhages (petechiae and/or ecchymoses). Their presence indicates trauma, or vascular, thrombocyte, or coagulation abnormalities.

Lesions

Defects in the oral mucosa can be due to local injury or to a systemic disease with mucosal lesions. Local injuries usually correspond to inflammation of the supporting tissue of the teeth (periodontitis) or dental calculus.

Technique

For examination of the oral and conjunctival mucous membranes it is easiest to hold the animal's head with one hand on top of the skull and the other under the jaw. From this position the thumb of the lower hand can be used to turn down the lower lid for inspection of the conjunctiva (Fig. 8.9). The thumb of the upper hand can be used to raise the upper lid for inspection of the sclera. The third eyelid (nictitating membrane) is not good for evaluation of color, because of its bluish-gray cartilage.

Next, the upper hand is moved forward a little so that the thumb and forefinger can lift the upper lip. The lip should not be stretched because the capillaries will be compressed, making the mucosa misleadingly pale. In this manner a large area of mucosa can be examined without opening the dog's mouth (Fig. 8.9). In the cat it is necessary to open the mouth a little because the oral mucosa is normally rather pale, due to its having such a fibrous lamina propria. By opening the mouth you can examine the tongue, which has a nice pink color in the healthy cat (Fig. 8.10).

To examine the capillary refill time, press a finger briefly on an area of nonpigmented mucosa of the raised upper lip. After abruptly removing the finger, note the time required for disappearance of the whiteness. The gingival mucosa is not suited for this because sometimes even with very poor peripheral circulation the refill time here is still good.

Inspect the oral mucosa in the same manner on both sides, to determine whether any abnormalities observed on one side are only local changes, but also to increase the chance of detecting any hemorrhage, defects, or other abnormalities.

8.3.6 Lymph nodes

Introduction

The lymph nodes are structural and functional units of the lymphatic system. They are so located that they are well protected against exterior influences and yet do not interfere with locomotion or with flow in the vascular system. What we refer to here as a lymph node is in the *Nomina Anatomica Veterinaria* described as a lymphocenter.[16] It is defined as a lymph nodule or group of lymph nodules that always occurs in the same location and drains the same area. From this definition it is apparent that what we call a lymph node can consist of more than one lymph nodule and that the number can vary from individual to individual. The number of nodes in a given area can also increase pathologically, although it is not certain whether by hypertrophy of preexisting nonpalpable lymph follicles or by formation of new follicles.[17]

Each lymph node is surrounded by a thin capsule of collagenous connective tissue that extends into the node in the form of septa and trabeculae. In the outer layer (cortex) are the lymph follicles in which lymphocytes are formed and which are partly surrounded by a lymph sinus. The sinus is the area under the capsule and along the septa and trabeculae through which the lymph circulates (Fig. 8.11).

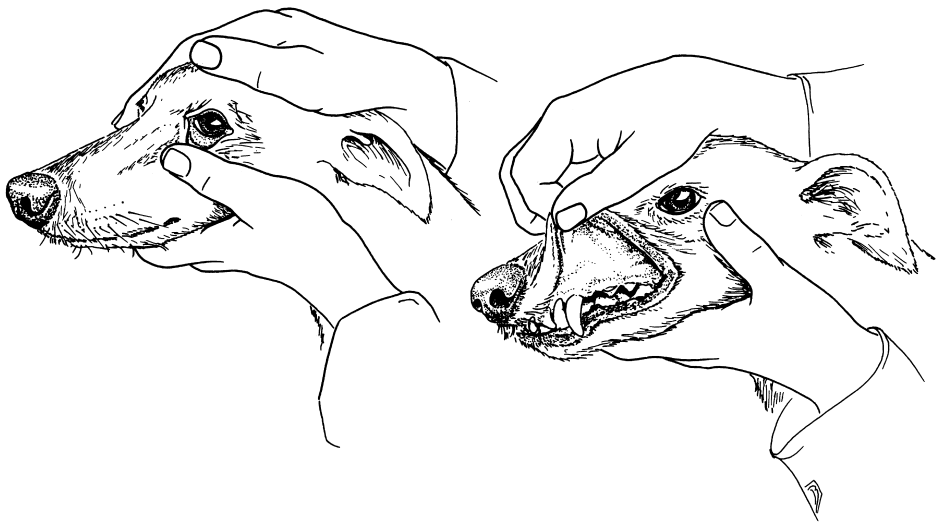


Fig. 8.9 Inspection of the conjunctival and oral mucous membranes in the dog.

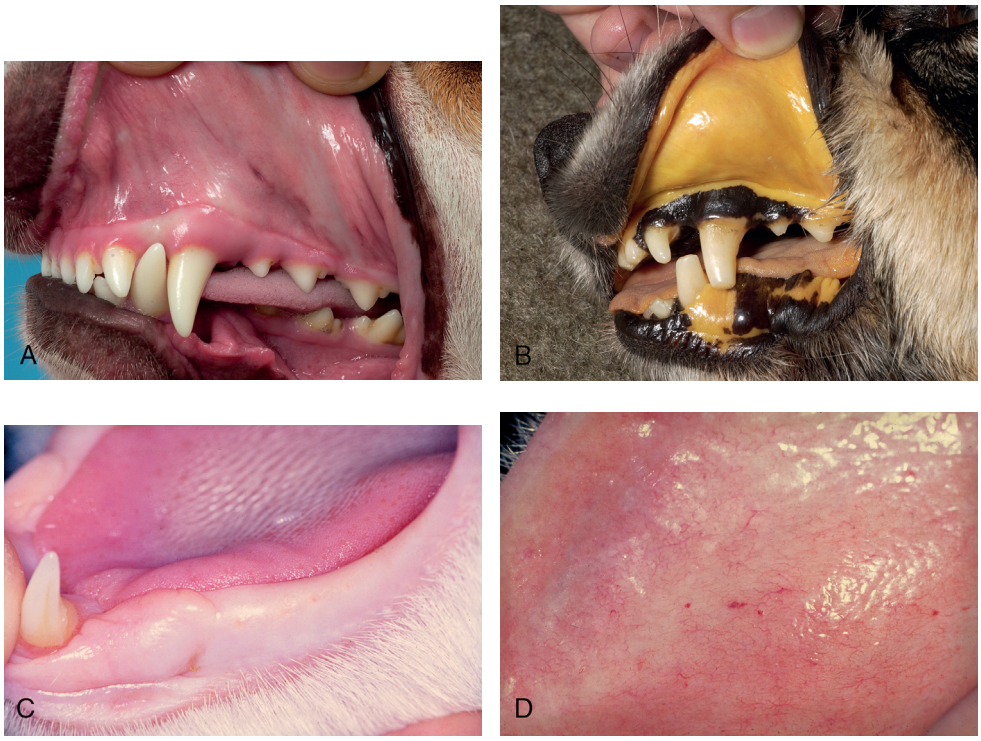


Fig. 8.10 A Mucosa of the lip and gingiva of a healthy dog. It is pink, moist, and without lesions or hemorrhages. B Severe icterus and anemia in a dog. C Opened mouth of a healthy cat. The gingiva is somewhat pale in comparison with that of dogs, because of the thick lamina propria, while the tongue is nicely pink. D Close-up view of pale pink mucosa with a few petechiae.

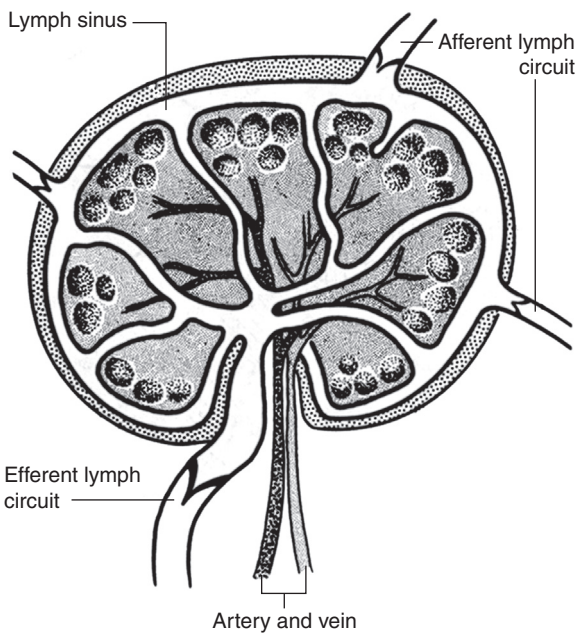


Fig. 8.11 Structure of a lymph node.

The lymph follicles serve as (1) filters for lymph and (2) germinal centers for lymphocytes. The phagocytes which surround the sinuses remove microorganisms and other particles out of the slowly streaming lymph. Such material is virtually completely removed during one passage of the lymph through a lymph node. The phagocytosis of antigens is potentiated by binding with specific antibodies, a process which is part of the immune response.

Just as in other lymphoid tissue, lymphocytes and plasma cells are produced following antigenic stimulation. These cells promote cell-mediated immunity, secrete antibodies, and form an immunologic memory.

Localization and drainage areas

In many places lymph nodes and groups of lymph nodes lie close to the surface and are accessible for palpation. In the dog[18] and the cat, they include the following.

Mandibular lymph node. This consists of a group of two or three nodules lying ventral to the angle of the mandible. This node is palpable in the healthy dog and cat just rostral to the mandibular salivary gland and it is often confused with the latter.

The mandibular node drains the skin and more superficial structures of the head together with the *parotid lymph node*, which lies under the cranial edge of the parotid salivary gland and is not normally palpable. The afferent lymphatics of these nodes have slightly overlapping drainage areas so that, for example, the eyelids and their glands and the skin of the skull drain to both nodes (Fig. 8.12).

Retropharyngeal lymph node. This is a large, elongated node that lies between the atlas and the larynx and is covered laterally by the brachycephalic muscle. It is not palpable in healthy animals. Its afferent lymphatics arise from deeper structures of the head, such as the tongue and walls of the nasal passages, mouth, and pharynx, as well as from the larynx and esophagus.

Prescapular lymph node. This usually consists of two nodules covered by the thin cleidocervical muscle and the omotransversarius muscle. The node is palpable about halfway up and just in front of the scapula. This node drains a large area: the skin of the caudal surface of the head, superficial parts of the neck, the lateral and distal part of the front leg, the shoulder, and the cranial part of the thorax.

Axillary lymph nodes. These consist of the axillary node and the accessory axillary node. The axillary node lies a few centimeters caudal to the shoulder joint, where the subscapular artery leaves the brachial artery. This node is bordered on the lateral side by the teres major muscle and ventrally by the deep pectoral muscles. Because of this location, high in the axilla, the node is not normally palpable and is only found when markedly enlarged.

The accessory axillary node lies rather caudal to the axillary node in the fascia between the latissimus dorsi muscle and the deep pectoral muscle, which lie in contact with each other. It is usually not palpable in healthy animals and if enlarged it is usually felt on the wall of the thorax slightly above the level of the elbow.

The axillary lymph nodes drain the thoracic wall and deep structures of the front leg. The afferent lymphatics on the thorax reach as far cranial as the neck and as far caudal as the wall of the abdomen, including the first three mammary glands. The afferents from the mammary glands overlap with the lymphatics draining to the inguinal lymph node.

Superficial inguinal lymph node. In the female dog this lies in the fat between the abdominal wall and the medial side of the thigh, dorsolateral to the last mammary gland. This node is usually not palpable in the healthy female dog. In the male dog the node lies

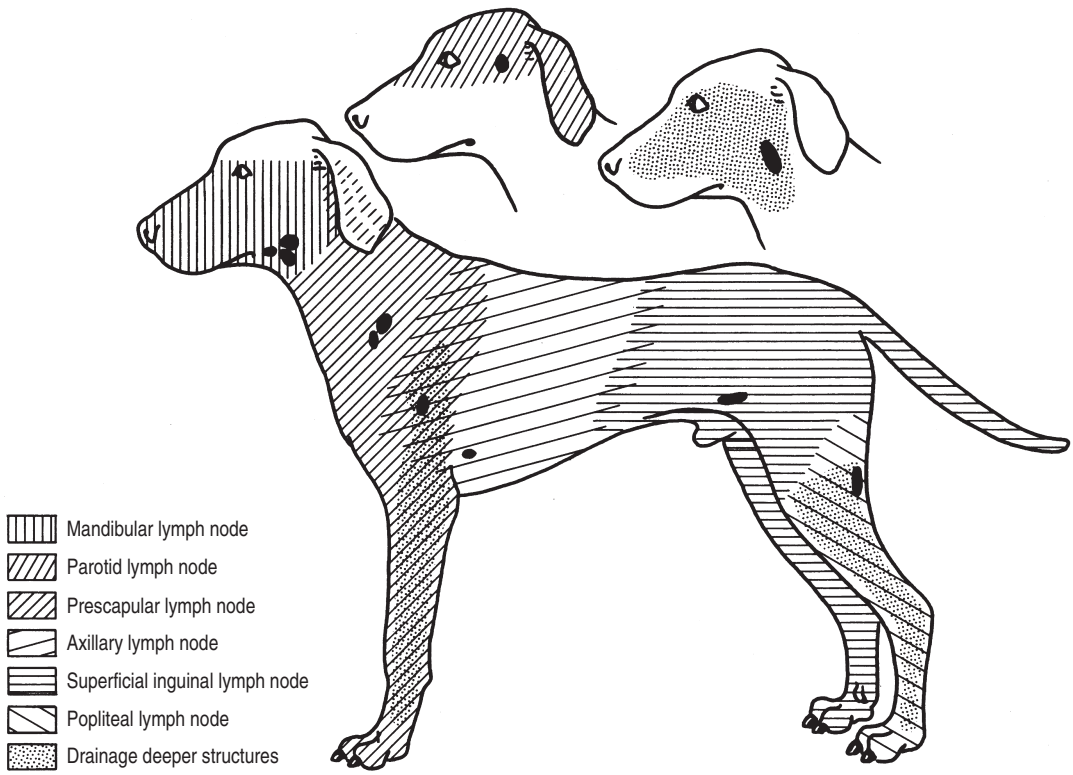


Fig. 8.12 Lymph nodes and their associated drainage areas.

dorsal to the most caudal part of the penis, just under the abdominal wall. It is palpable in the healthy male dog but palpation may be difficult because of a local accumulation of fat.

In the female dog the afferent lymphatics drain the abdominal wall and the most caudal mammary glands. At the level of the third mammary gland there is usually some overlapping with the afferent lymphatics of the axillary nodes (see also Fig. 16.2). In the male dog the superficial inguinal node drains the penis, prepuce, and scrotum. There are also afferents from the ventral part of the pelvis, the tail, and the medial side of the thigh and knee.

Popliteal lymph node. This lies in fat between the biceps femoris and semitendinosus muscles, caudal to the knee joint. The node drains all structures of the rear leg distal to the node.

Examination

The examination of the lymph nodes consists of evaluation of their size, form, consistency, and painfulness and the presence of adhesions.

Size

If a lymph node described above as not normally being palpable can be palpated, this should be considered to be a pathologic change. It is more difficult to decide what is abnormal for the nodes that can normally be palpated. Their sizes vary with the size of the animal, from a few millimeters in cats and toy breeds of dogs to 2.5 centimeters in large dogs. The normal size must always be evaluated in relation to the size of the animal. It is helpful to estimate the size of a possibly enlarged node in mm or cm after subtracting the contribution of overlying tissue, especially for reference in follow-up examinations. An increase to more than 1½ times the expected normal size should be considered suspicious and a greater increase than this should be considered pathological.

Shape

Many lymph nodes are ellipsoidal and retain this shape during enlargement by inflammation or malignant growth of the lymphoid tissue. This shape is usually lost during enlargement due to other causes such as metastases from malignancies in the drainage area.

Consistency

In healthy animals the nodes have the consistency of soft rubber. Depending upon the cause of the change in a lymph node, they can become harder or softer. This can be recorded on an ordinal scale (see § 4.1.2 and § 3.1.2)

Painfulness

The palpation of lymph nodes in a healthy animal causes no pain.

Adhesions

In healthy animals the nodules are not attached to each other (particularly the mandibular nodes) or to the surrounding tissues. Adhesions can develop chiefly as a result of inflammation and individual nodules may no longer be distinguishable. They may also become adhered to the surrounding tissues. It is then noted by palpation that the node is less moveable. Invasion by a tumor through the capsule of a node into the surrounding tissue can also reduce moveability.

Technique

The lymph nodes are examined by palpation and the corresponding nodes on opposite sides of the body are compared repeatedly. It is of great importance to palpate softly: the sensitivity of your fingers is always reduced by palpating with a hard grasp and this can also be very unpleasant for the animal.

Most of the superficial lymph nodes can be palpated between the thumb and one or more fingers. Palpation often must begin with finding the node and the chance of doing so is improved by letting the thumb slide softly over the tips of the fingers with the area of tissue you are examining lying between. Thus the mandibular lymph node is sought caudoventral to the angle of the mandible and it can be helpful to first seek the more dorsocaudally located (and larger) mandibular salivary gland and to proceed from there in a ventral and rostral direction (Fig. 8.13). For the (normally nonpalpable!) parotid lymph node the area under and around the external ear canal is palpated.

The retropharyngeal area can be palpated by placing one or more fingers, on both sides, between the atlas and the larynx, and then proceeding medially. In healthy animals in a normal nutritional condition, the tips of one or two fingers can almost be brought into contact with those on the other side.

To evaluate the prescapular lymph node, the omotransversarius muscle, lying just in front of the scapula, is grasped between the thumb and fingers. By then moving cranially (hence along the length of the muscle), the lymph node is usually felt beneath the muscle.

The presence of an enlarged axillary lymph node is examined by palpating high up in the axilla, during which the front leg can be held slightly laterally. The accessory axillary lymph node is sought by moving a flat hand over the wall of the thorax (Fig. 8.13.D1).

In the male dog the superficial inguinal lymph node is evaluated by palpating fairly caudally and high above

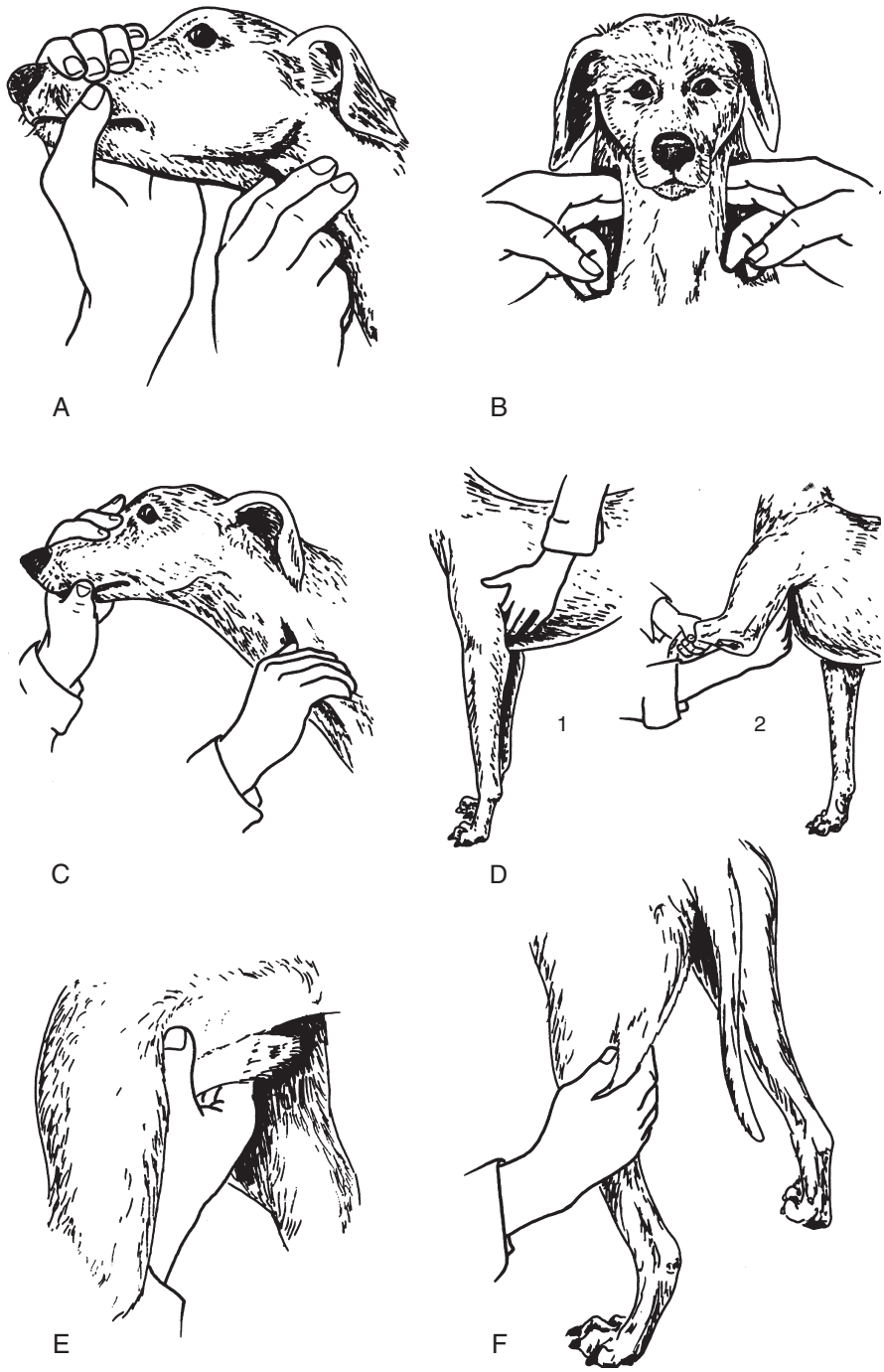


Fig. 8.13 Techniques for palpation of lymph nodes. A Mandibular lymph node, B retropharyngeal lymph node, C prescapular lymph node, D axillary lymph nodes, E inguinal lymph node, F popliteal lymph node.

the penis, just under the abdominal wall (Fig. 8.13). In the bitch palpation is carried out on both sides dorsolateral to the last mammary gland. For thorough inspection and palpation it is still sometimes necessary to position the animal on its side or back (see also § 16.2.2).

The popliteal lymph nodes are usually most easily found by pressing the semitendinosus and biceps femoris muscles slightly together behind the knee and then moving the palpating fingertips caudally. This brings the lymph node caudally out between the muscles so that it is only covered by the skin and can easily be evaluated.

8.3.7 Other notable findings

During the examinations described above, there may be other notable findings quite unrelated to the objectives of the general examination. This might be, for example, a tumor in a mammary gland or accumulation of gas under the skin (subcutaneous emphysema). Such findings are also recorded on the record used for the general examination.

8.4 Notation

The results of the general examination can be recorded on the form shown on the DVD, which combines 'General Impression' and 'General Examination'. If any structure is found to be enlarged, measurements should be given (after subtracting the contribution of skin and surrounding tissue), together with the findings by inspection and palpation (see § 4.1.1 and § 4.1.2).

If a certain characteristic (e.g., body temperature) is to be followed for some time, the results can also be shown graphically.

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09 Respiratory system

A.A. Stokhof and A.J. Venker-van Haagen

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If the screening examination has led to formulation of a problem and a diagnostic plan that includes examination of the respiratory system, the first step is to further focus the history on this system. The second step is to observe the respiratory movements, although this has usually already been done in the general examination. Then, to evaluate the respiratory sounds, we return to the description in the history, although abnormal respiratory sounds are sometimes clearly recognized during the examination. Then comes the external examination of the nose and sinuses, followed by examination of the larynx and trachea, and then finally the thorax.

9.1 History

In focusing the history on the respiratory system, we use the same approach as for the general history (Chapter 6). Further questions are asked about the symptoms reported by the owner. More detailed questions are then asked about other symptoms associated with the respiratory system, such as nasal discharge, sneezing, additional sounds, coughing, sputum, gagging or retching, and labored respiration. After this, additional specific questions are asked about the situation in which the patient is living and any previous illnesses in the patient or its relatives. We go into these aspects of the history as follows.

9.1.1 Symptoms

Nasal discharge is often associated with one or more of the other signs given above. The owner is asked whether the nasal discharge is from one or both nostrils and whether it is continuous or only occurs at certain times (e.g., mainly in the morning when the dog awakens, or mainly when the dog goes outside), or only occurs when the dog sneezes. Questions about the description of the exudate must be asked in layman's terms, such as watery, mucus, pus, or blood.

A *stridor* is a respiratory sound that can be heard at some distance from the animal and keeps recurring; it is of fairly constant amplitude and frequency. A narrowing (stenosis) in the upper airways can lead to such an acceleration of the air stream that the Reynolds value

(§ 4.1.4) is exceeded and strong turbulence develops. The stridor is named after the location of the obstruction, such as a nasal stridor, pharyngeal stridor, or laryngeal stridor. The location of the obstruction also determines the sound. For example, sniffing is characteristic of nasal stridor, snoring is characteristic of a pharyngeal stridor, and a soft 'sawing' sound typifies a laryngeal stridor. In a few breeds of dogs, selective breeding for brachycephalic characteristics has led to various types of stridor. The tooting sound of a collapsed trachea is expiratory, while the sounds mentioned above can be inspiratory or both inspiratory and expiratory, depending on the severity of the obstruction. A stridor of the nose or nasopharynx disappears as soon as the animal begins to breathe through the mouth. In very severe nasal obstruction the animal does this spontaneously, but often keeps alternating with attempts to breathe through the nose. In a mild stenosis the stridor is only heard during and shortly after exercise.

Sneezing is one of the two reflexes that protect the respiratory system against injury. Stimulation of subepithelial receptors in the nose triggers the sneezing reflex.[1] The stimuli include inflammation or products of inflammation, foreign bodies, and tumors. In addition to sneezing, which everyone recognizes, there is another sound that occurs in the dog and which is called 'reverse sneezing'. This occurs as a result of stimulation of the mucosa of the nasopharynx, leading to a spasm of the pharyngeal muscles, which hinders the passage of air to the larynx. The dog (it occurs chiefly in the dog) makes an inspiratory snoring sound and at the same time shows all the signs of severe dyspnea. The pharyngeal spasm can be interrupted by reflex swallowing, which can be brought about by massaging the throat or by obstructing the nostrils until the dog swallows. Reverse sneezing occurs without warning in otherwise healthy animals and episodes can last from seconds to minutes. If there is irritation or inflammation of the mucosa in the nose and nasopharynx, the frequency can increase to several times per day.

Coughing is the second important reflex by which the respiratory system protects itself against injury. The reflex can occur via stimulation of the airways anywhere from the larynx to the larger bronchi.[2] After a deep inspiration the intrathoracic pressure is increased (sometimes to 20 kPa!) by closure of the glottis and contraction of the thoracic and abdominal muscles. This is followed by an abrupt decompression, by opening the glottis and driving out the respiratory gas, together with any sputum that may be present.[3] The frequency, severity, and character of the stimulus is determined by (1) the nature of the causative lesion, (2) the presence of sputum, and (3) any complicating factors such as pain or reduced ventilation capacity. The following types of cough can be distinguished, according to the site of the stimulation:

1. A cough that is started by stimulation of the *larynx* usually occurs episodically, is often heavy, and is sometimes associated with gagging or retching, a tendency to vomit, and sometimes the coughing up of a little mucus or saliva.
2. A cough that is due to a process in the *trachea* is a loud, explosive cough that often has the characteristics of a bark.
3. Stimulation of the *bronchi* can result in various kinds of coughing. In the acute phase the pattern is not easy to differentiate from a cough due to tracheitis. When much mucus and pus are produced, the cough has a wet and rough character.

The tracheal cough—and even more so the bronchial cough—are above all dry and nonproductive in the acute phase and then associated with the coughing up of sputum in the chronic phase. In taking the history an attempt is made to describe the cough in terms of frequency, duration, strength, whether it is painful, the production of sputum, the probable localization of the cough stimuli, and the time of occurrence (excitement, time of day, change of environment).

Sputum is the substance in the airways that is transported by coughing. In the dog and the cat we are seldom well informed by the history about its character (serous = watery, mucous, purulent = pus, mucopurulent = mucus and pus) or the amount, because the coughed-up material is usually swallowed immediately. In by far the majority of cases it is only on the basis of the nature of the cough (productive or nonproductive) that one can form an impression about the presence or absence of sputum. Sputum is coughed out only when coughing itself so stimulates the pharynx that the animal begins gagging or retching so severely that swallowing does not occur. The owner can describe the nature of the sputum with the help of questions about its color, stringiness, and odor. Account must be taken of the frequent mixing with saliva and the possible addition of material from the digestive tract. In acute lung edema there may be not only coughing of serous sputum but also serous discharge via the nasal openings, with the formation of air bubbles at the nostrils. The discharge can have a pinkish-red color due to the presence of some blood. Damage to the blood vessels can lead to the production of sputum that is blood-red.

Dyspnea (labored or difficult breathing) is characterized by forced respiratory movements, whereby auxiliary respiratory muscles are activated. When the history is being taken it must first be determined whether the dyspnea is acute and recurring or chronic and continuous. In cases of acute dyspnea it is certainly necessary to also ask about the conditions under which this difficult breathing recurs and whether there are any accompanying signs (e.g., stridor). Owners do not always find it easy to distinguish

between panting (thermal or nervous polypnea) and dyspnea. Questions about the depth of the breathing can help here. A chronic dyspnea is sometimes clearly recognizable to the owner and the examiner when the animal is at rest. In other cases the signs occur only during exercise (dyspnea of exertion). In the latter case one must be aware that owners do not always recognize the difference between the rapid development of fatigue during exercise and the loss of interest in exercise. The latter is an apathy, for which there need be no cardiopulmonary problem. It is also possible that the animal does not want to continue exercising because of difficulties in locomotion. By asking questions about the character of breathing following apparent respiratory difficulty, about the development of auxiliary respiratory movements, and about the way the animal was walking, we usually succeed, on the basis of the history, in differentiating among these forms of what an owner sometimes calls reduced endurance.

9.1.2 Living conditions

Here we are concerned with questions about what is required of the animal (such as strenuous physical training), its contacts with other animals (possible transmission of infectious disorders), and whether it is allowed outdoors without observation (increased chance of trauma).

9.1.3 Past history

Information about all previous disorders can be of great importance in connection with interpretation of the findings. This ranges from illnesses, wounds, and injuries by automobiles to surgery that has been performed. The same applies to any known disorders of the respiratory system in the relatives of the patient or in the breed.

9.2 Physical examination

9.2.1 Respiratory movements and sounds

Evaluation of the respiratory movements has been described in the general examination (§ 8.3.1). The respiratory sounds have been described in the general impression (Chapter 7) and in the above discussion of the history.

9.2.2 Nose and frontal sinuses

Introduction

The shape of the nose is determined by a solid bony structure and a moveable cranial part having a cartilaginous skeleton. The flat front surface of the nose is the nasal plane. There is a small groove down the middle (the philtrum). The nasal openings (nostrils or nares) are bordered laterally by wings (nasal alae). In brachycephalic breeds the nose is very short and the nasal openings are often small (Fig. 9.1), which can cause respiratory difficulties.

The nose of dogs and cats is largely filled with richly vascularized conchae. A bullous extension of the ventral concha (plica alaris), which proceeds craniolaterally into the nasal ala, divides the incoming air over the dorsal, medial, and ventral nasal passages. Most of the air is turned ventromedially toward the largest passage, the ventral nasal passage (ventral nasal meatus). It is only via this passage that a tube can be passed (hence also ventromedially) into the esophagus for artificial feeding (Fig. 9.2).[4] Caudally the ventral nasal passages are fairly wide and they pass through the oval openings (the choanae) to the nasopharynx. This area is dorsal to the caudal part of the hard and the soft palate (Fig. 9.2).

Of the paranasal sinuses the maxillary sinus is actually a lateral extension or recess of the nasal cavity and only on the medial side of the caudal part is it bordered by bone (Fig. 9.3). Hence this sinus is not considered separately but rather as part of the nasal cavity. The frontal sinus lies in the frontal bone and varies markedly in form and size due to the great variety in skull shapes that occur in the dog.

These very briefly described structures form the first part of the passages to the site of gas exchange, the

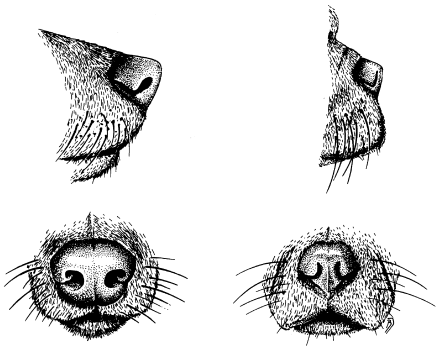


Fig. 9.1 Lateral and rostral views of the nose of a dolichocephalic dog (left) and a brachycephalic dog (right).

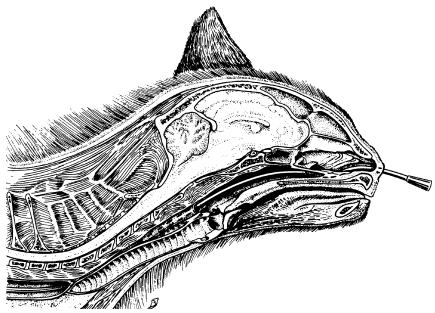


Fig. 9.2 Section of the head of a cat, in which a tube has been passed via the ventral nasal passage into the esophagus.

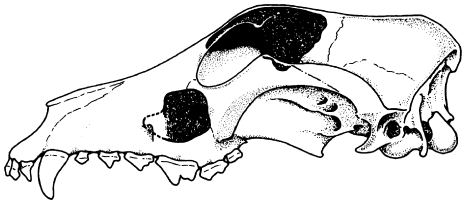


Fig. 9.3 Skull of a dog, in which the locations of the maxillary sinus and frontal sinus are shown. The cranial part of the maxillary sinus, which is not bordered by bone medially, is shown by a dotted line.

lungs. But in addition, these upper airways have a number of other functions:

- They warm and humidify the inspired air.
- They protect against inspired particles that are irritating or infectious. The nose contributes to this by the sneezing reflex and the turbulent air stream over a richly vascularized mucous membrane. This is covered by a sticky secretion having bactericidal properties, that is passed to the esophagus by ciliated epithelium.
- They enable detection of odors by the olfactory nerve ends, half of which lie in the ethmoidal conchae. The perception of diverse odors is facilitated by the interior structure of the nasal cavity. The convoluted conchae create a variety of turbulent air streams that result in an uneven distribution of odorant molecules and thereby selective exposure of olfactory receptors.[5]
- The upper airways facilitate emission of heat in the form of heat of vaporization. In the dog and cat the lateral nasal gland plays an important role in this at high environmental temperatures, by increasing the secretion of fluid at an exponential rate.[6] During thermal polypnea most of the air is inspired via the nose and expired via the mouth.[7] Hence the inspired air is rapidly saturated with moisture on the large mucosal surface in the nose and then expired via the mouth. This prevents the warmth and moisture in the expired gasses from being released again to the nasal mucosa. In addition, this form of panting has a constant frequency, which corresponds to the resonance frequency of the respiratory movements, thereby much reducing the energy expenditure for these activities.[8]

Nose

After evaluation of the shape of the nose as a whole, the following are examined in sequence:

- Nasal stridor. Under quiet conditions, listen very close to the animal's nose with its mouth closed. If there is a stridor resulting from a too-narrow nasal opening (brachycephalic breeds), the tone of the stridor can be changed by moving the nasal alae laterally.



Fig. 9.4 Testing the airflow through a nasal passage by use of a fluff of cotton. The cotton is held at a steady distance from the nasal opening by resting the hand against the bridge of the dog's nose.

- Expired air. The symmetry of the air stream is examined by watching the movement of a small fluff of cotton held before each nostril (Fig. 9.4). At the same time, the odor of the expired air should be noted (for nasal fetor).
- Nasal discharge. In healthy animals there is sometimes a drop of serous fluid. Abnormal discharges may be mucoid, purulent, mucopurulent, ichorous (rotting), or hemorrhagic. Episodic flow of pure blood is a nosebleed or epistaxis. Occasionally during vomiting or regurgitation some material from the digestive tract may be discharged through the nasal passages. If milk or other food comes directly out of the nostrils of a puppy while it is eating, the palate may not be fully closed. Any material that remains in the nasal passages or nasal openings may dry out and can hinder the passage of the air stream.
- Nasal plane. In most animals the nasal plane is slightly moist and, depending on the distribution of pigment over the body, it may or may not be pigmented (Fig. 9.5). In some completely healthy dogs the nasal plane is almost always dry. In other animals the nose appears to become dry when there is reduced secretion by the tear glands and the salivary glands.
- Nasal openings. Attention should first be given to the width of the nasal openings and the moveability of the nasal alae. The plica alaris described above prevents direct examination of the nasal passages with the naked eye. By slight lateral displacement of the nasal ala only the entrance of the ventral nasal passage can be inspected. Further inspection can be accomplished with the aid of an otoscope or rhinoscope, under anesthesia.
- Palate. By opening the animal's mouth one obtains a view of the ventral wall of the nasal passages and thus of any deformities that result from processes in the nose. At the same time, abnormalities may be



Fig. 9.5 The nasal plane in two dogs. Left: a moist nasal plane with its characteristic irregular surface. Right: a dry nasal plane, smeared with dried vomitus (also present in the hair around the mouth).

seen in the mouth (e.g., involving the canine teeth) which can be the cause of a disorder in the nose.

Frontal sinuses

The frontal sinus is inspected and palpated to detect possible swelling, pain, or crepitation. The frontal sinus is surrounded on all sides by bone and thus percussion produces a slightly hollow tone. When the sinus is filled with fluid or tissue the tone can be slightly damped. This is best detected if the change is unilateral and the percussion tones on the left and right are compared. Percussion is performed by tapping on the frontal bone bilaterally with the forefinger or middle finger (Fig. 9.6).

Nasopharynx

Examination of the nasopharynx must be performed completely under anesthesia. Only then is it possible to reach the caudal part via the mouth and to inspect the area with optical instruments and mirrors. As noted above, the nasopharynx can also be reached by a tube or an optical instrument introduced via the ventral nasal passage. The retropharyngeal lymph node is palpated as described in § 8.2.6.

Oropharynx

The respiratory and digestive tracts cross here and so this area is inspected during the examination of both systems.

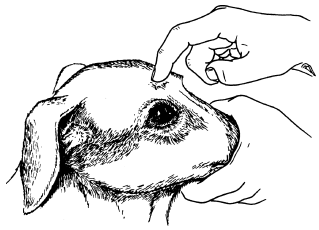


Fig. 9.6 Percussion of the right frontal sinus of a dog.

The mouth is opened and the base of the tongue is depressed (Fig. 9.7) so that the tonsils, hard palate, and soft palate can be inspected. Sometimes even the glottis can be seen. Usually this area can only be examined adequately when the animal is anesthetized.

9.2.3 Larynx and trachea

The larynx reaches to the base of the tongue and the soft palate and it lies ventral to the atlas. This mostly cartilaginous structure is about six centimeters long in a medium-sized dog. Caudally it joins the trachea, a cartilaginous tube with an interior diameter slightly smaller than that of the larynx. Cranial to the larynx lies the hyoid apparatus, which is attached dorsally to the skull and acts as a suspensory mechanism for the tongue and the larynx. Parts of the hyoid apparatus can be palpated cranial to the larynx between the mandibles.

The examination consists of inspection and palpation. Inspection is performed with attention to possible deformities in the throat and neck regions. Palpation serves to detect possible deformities and to determine sensitivity to pressure.

Under normal conditions the larynx is palpable in the throat area and the transition from larynx to trachea—marked by an abrupt change to a somewhat smaller diameter—can be felt easily. The trachea can be followed to the thoracic inlet. In dogs that are not especially brachycephalic, the base of the tongue can be retracted far enough forward during inspection of the pharynx (Chapter 11) to reveal the cranial part of the larynx. If further internal examination is necessary, it must be carried out under anesthesia with a laryngoscope and a bronchoscope.

Technique

The throat and neck are inspected with the neck stretched slightly forward and upward. In this position palpation can be performed by placing one hand around the larynx (without pressing!) and then moving it caudally.

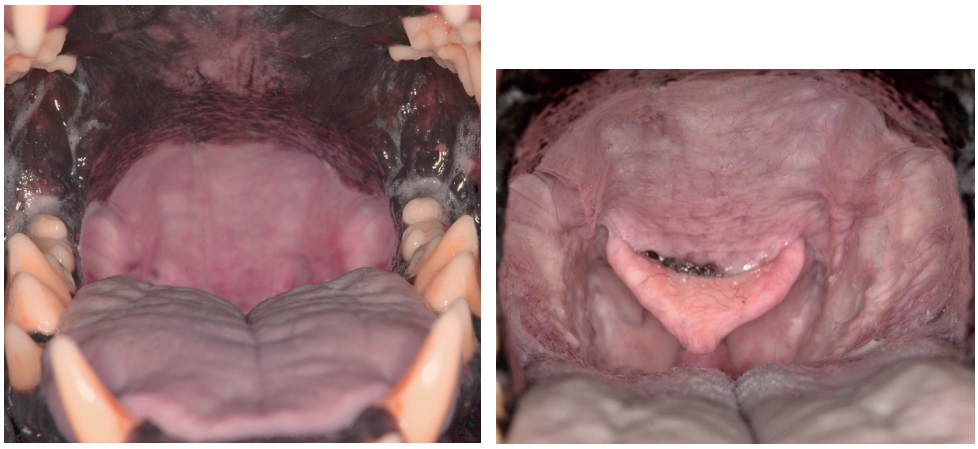


Fig. 9.7 Oropharynx of a healthy dog. Opening the mouth without pressing on the base of the tongue (left) provides a view at the transition from the hard palate to the soft palate. By pressing the base of the tongue downward and forward (right), the caudal part of the soft palate (somewhat long in this dog) can be inspected, together with the epiglottis and the tonsillar fold. The method for opening the mouth is described in detail in Chapter 11. Note: Few dogs tolerate this inspection without anesthesia and in cats anesthesia is always required.

The pressure sensitivity of the trachea is examined by applying slight pressure at three locations: just before the thoracic inlet, at the midpoint of the cervical trachea, and at the level of the first tracheal rings. The pressure should be just sufficient to cause a slight deformation of the trachea. After this kind of deep palpation, always pause slightly (at least until the next expiration) to see if a cough follows (not normal!). Finally the larynx is also palpated. This is left until last because usually the larynx in dogs and cats is more sensitive to pressure than the trachea and because even in healthy animals a cough may be stimulated by this palpation. If a laryngeal or tracheal stridor is suspected but there is some doubt about the localization, then brief and light pressure can be applied to the larynx and to various places along the trachea. A change in tone of the stridor usually gives more certainty about the location of the obstruction.

9.2.4 Thorax

The objectives of examination of the thorax are:

- observation of the respiratory movements by inspection
- detection of abnormalities in the thoracic wall by inspection and palpation
- detection of abnormalities in the structure and function of the bronchi, lung tissue, and pleura by auscultation and percussion

Good examination of the thorax requires some familiarity with the anatomy. The following remarks refer to the superficial anatomy of the thorax and cranial abdomen (Fig. 9.8) and to the branching of the bronchi and the divisions of the lung lobes (Fig. 9.9).

Examination of the first ribs and most cranial parts of the cranial lung lobes is partly or completely prevented

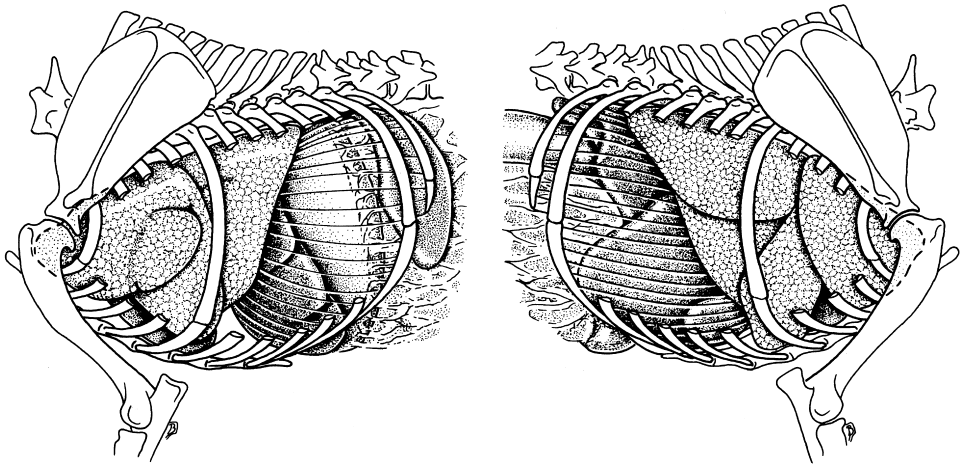


Fig. 9.8 Structures in the thorax and cranial part of the abdomen of the dog seen from the left and from the right.

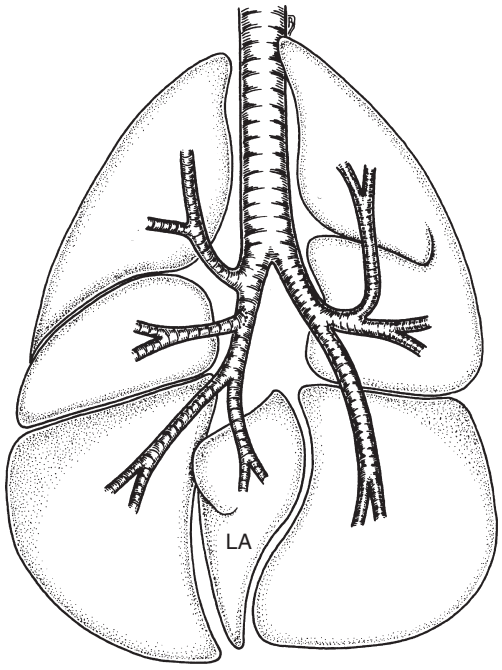


Fig. 9.9 Diagram of the lung lobes and bronchial tree in dogs and cats viewed in the ventrodorsal direction (LA = accessory lobe of the right lung).

by the musculature of the front legs. In order to count intercostal spaces as reference points, we begin in the most caudal (twelfth) intercostal space. Keep in mind that just behind the front leg the thorax is covered, especially dorsally, by the serratus, scalenus, and latissimus dorsi muscles.

On the right side the lung field is bordered caudally by the liver, which lies against the diaphragm, while on the left the stomach forms most of the caudal border. The ventral part of the thorax is largely filled by the heart. Nevertheless, the lungs on both sides reach nearly to the sternum as very thin extensions of the cranial lobes (Fig. 9.8). The left lung is divided into two lobes, the cranial one being further divided into a cranial and a caudal part. The right lung consists of four separate lobes. As a result, the left and right bronchial branching also differs markedly. In Figure 9.9 it can be seen that the right main bronchus gives off three branches, while on the left there is one large branch that further divides into branches for the cranial and caudal parts of the cranial lobe. The bronchus of the right middle lobe is directed quite ventrally.[9] This has the consequence that, especially in mucopurulent bronchitis, mucopus accumulates primarily in this lobe and can result in complete obstruction of the bronchus.

Thoracic wall

This examination consists of evaluating the shape of the thorax and looking for abnormalities.

The shape of the thorax varies markedly among different breeds. Especially among racing and hunting dogs there are breeds whose thorax is very deep dorsoventrally. When these dogs lie on the sternum they easily develop pressure sores. In other breeds the form of the thorax is much less laterally compressed and especially in the English bulldog the thorax is almost cylindrical or even dorsoventrally flattened. Pups generally have a much more cylindrical thorax than do adult dogs.

The examination for abnormalities of the thoracic wall is, in this examination of the respiratory system, only concerned with those related to respiration. Those only affecting the skin are dealt with in Chapter 15. Hence we are concerned here with subcutaneous or deeper lesions that can be the cause or result of abnormalities of the pleura or lungs.

Technique

Examination of the thoracic wall is carried out by looking at the shape and symmetry of the thorax from above and slightly to one side. Then the superficial layer of the wall is palpated from behind, with one hand on each side. Attention is given to the presence of any difference in temperature, pain, and/or crepitation. If a local abnormality is found, it is examined in more detail (§ 4.1.2). Next, the ribs and the strength of the intercostal muscles are examined. The ictus cordis is palpated on the right and the left, followed by deeper palpation to detect any areas of pain or of crepitation.

Respiratory movements

See § 8.3.1.

Bronchi, lungs, and pleura

These structures are examined by auscultation and percussion. Some fundamental aspects of these techniques have been explained in Chapter 4.

Auscultation

The sounds heard by auscultation may be extrathoracic, pleural, or bronchopulmonary in origin. Extrathoracic sounds can be caused by such things as movement of the stethoscope tube over the hair, or muscle trembling.

Pleural movements can also produce sounds. They occur in pleuritis when there is little fluid production (pleuritis sicca). This is called 'pleural rubbing' and resembles the sound of walking on hard snow ('snow crunching').[10] However, it is seldom if ever heard in dogs and cats, because in these species pleuritis is usually exudative rather than fibrinous.

Bronchopulmonary sounds may be inaudible (no sound), weaker than expected (weak respiratory sound), of normal loudness and only during inspiration (normal respiratory sound), or louder than expected and including the beginning of expiration (enhanced respiratory sound). Finally, the respiratory sounds may be similar to those

heard over the trachea, in which inspiration and expiration are alike (bronchial respiration).

The movement of respiratory gasses is only audible if there is some turbulence. The development of turbulence is very much dependent on the diameter of the airway and the speed of the air stream (see also § 4.1.4) and therefore above all the respiratory frequency. In large dogs with a normal respiratory frequency, turbulence is present down to about the bifurcation of the trachea. Peripheral to this the stream of the respiratory gasses is laminar and thus no respiratory sound is produced. The reason is that towards the periphery the total diameter of the air passages continuously increases; the velocity of the stream of the respiratory gasses is therefore very slight. There are no indications that the soft tissues of the peripheral airways or the alveoli are able to produce vibrations of an audible frequency if they are subject to gradual pressure changes.[11]

If the respiratory frequency increases then the limit of turbulence extends to the first branches of the main bronchi. In smaller animals the usually somewhat higher respiratory frequency and the small diameter of the airways leads to respiratory sounds that under normal conditions can be heard over a relatively large area. In contrast, in larger dogs with a relaxed respiration there are often almost no audible respiratory sounds at the level of the caudal lobes.

The transmission of sound from the larger air passages to the thoracic wall is determined by the acoustic impedance (density of the material × speed of the sound) of the intervening tissues. If the impedances are quite similar, as when an infiltrated lung lies against the thoracic wall, a large part of the sound is transmitted.[12] When there is a large amount of gas-containing lung tissue between the source of the sound and the thoracic wall, a large part of the sound is reflected back from the pleural surface. When the lungs and thoracic wall are separated by gas or fluid in the pleural space, sound transmitted through the lung is reflected back when it reaches the lung surface, with the result that no respiratory sound reaches the thoracic wall.

The respiratory sound is audible over the trachea throughout the respiratory cycle. It is also audible on the cranial part of the thoracic wall, certainly in smaller animals, but as one moves caudally along the thoracic wall, the expiratory sound in particular becomes softer and sometimes falls away completely. This situation, in which a fairly constant respiratory sound is heard during inspiration but dies away during expiration, is called the *normal respiratory sound*. Inspiration is an active process and expiration is passive. During expiration the speed of the respiratory gasses decreases such that peripherally there is no longer a sound that is still audible on the thoracic wall.

As noted above, infiltration of the lung can lead to better transmission, such that expiratory sounds can also be heard on the thoracic wall. One then hears respiratory sounds which are similar to the sounds that can be heard over the large air passages (trachea) and these are called *bronchial respiratory sounds*. We must remember that in smaller animals this type of respiratory sound is heard in the cranial part of the thorax even under normal conditions (Fig. 9.10).

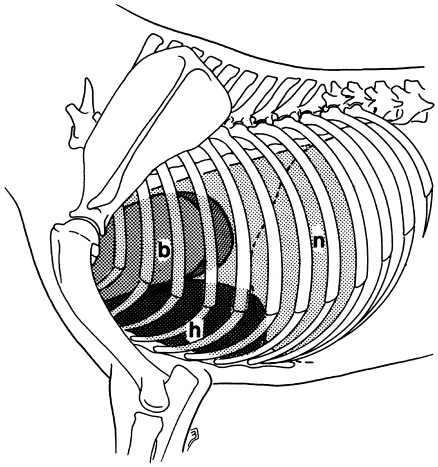


Fig. 9.10 These are the locations on a medium-sized dog (15–30 kg) where one can hear normal respiratory sounds (n), bronchial respiratory sounds (b), and heart sounds (h).

During rapid respiration (including thermal polypnea) the turbulence is so intensified and the borders of turbulence are extended so far peripherally that respiratory sounds with a bronchial character are heard far caudally. In lung disorders in which there is active expiration as the result of obstruction of the peripheral bronchi or bronchioles, a very clear expiratory sound is heard. In such an expiration the intrathoracic pressure rises so much that the central bronchi and the trachea are narrowed enough to cause turbulence.

Under pathologic conditions other sounds can be heard in addition to the respiratory sounds. After many years of dispute[10,13,14] about the terminology, two types of *rhonchi* (rhonchus is Greek for snoring sound) are now distinguished.[11,14]

Musical rhonchi. These are sounds with a peeping or wheezing character. They occur in patients with obstructive lung diseases that result in active expiration. They can sometimes be heard at a distance. Partly via the Venturi effect (§ 4.1.4), the larger airways sometimes become so narrowed that the opposing walls almost come into contact. They begin to vibrate between the open (inspiration) and almost closed (expiration) state and thus produce one musical tone. The tone is low if a large and soft mass is in vibration and high if the vibrating tissues are light and stiff. Such a 'peep' can sometimes occur during inspiration, if the bronchus is not adequately

open during inspiration because of a persisting stenosis, such as may be caused by a foreign body or tumor in the bronchus.

Nonmusical rhonchi. These are short crackling sounds (crepitation) at the end of inspiration, sometimes continuing to the beginning of expiration. They occur in areas that are not adequately filled with respiratory gasses but are infiltrated with fluid. It was for a long time supposed that these sounds were the result of an excess of fluid in the airways. Now, however, there are good grounds for assuming that they are caused by the abrupt opening of previously closed bronchioles.[15] Because of the very rapid change in the pressure, turbulence suddenly occurs in the bronchioli. In addition, the explosive equalization of the gas pressure brings the adjacent walls of the air passages into vibrations, which results in the sound.

The interstitial accumulation of fluid affects the elastic properties of the lung and causes the closure of bronchioles. This also explains why nonmusical rhonchi sometimes recur directly after an episode of heavy coughing, at exactly the same point in the respiratory cycle and with the same rhythm as before. A series of moist rhonchi can result from the opening of different bronchioles one after another and/or from the opening of the same bronchioles time after time.

It is possible that sputum in the larger bronchi can cause such sounds, but it seems likely that narrowing also contributes. Narrowing of a large bronchus can be the result of inadequate cartilaginous support[16,17] or the sagging inward of the membranous part of the bronchus. At the beginning of inspiration the walls of the bronchus remain slightly in contact (perhaps in part via a little sputum) and then open up as the lung expands and the intrathoracic pressure decreases.

In addition to muscle trembling, *vocal sound* can also interfere with auscultation. Vocal sounds are weakened and filtered through the lung and thoracic wall, just like the respiratory sounds and other sounds. Low frequency sounds are especially well transmitted. Auscultation can also be hindered by groaning of the patient. In cats, purring makes lung auscultation completely impossible. Purring occurs via frequent alternating activity of the diaphragm and the intrinsic laryngeal muscles.[18] A stridor in the upper airways can also often be heard over the entire lung field and can prevent auscultation of the lungs.

Borborygmi are not heard in the lung field under normal conditions.

Technique

It is very important to perform auscultation in a quiet room. The patient should be allowed to relax as much as possible, for muscle tension causes a quite disturbing humming sound. By pressing the stethoscope firmly but not hard, one can avoid the disturbing sound of hair scratching on its diaphragm.

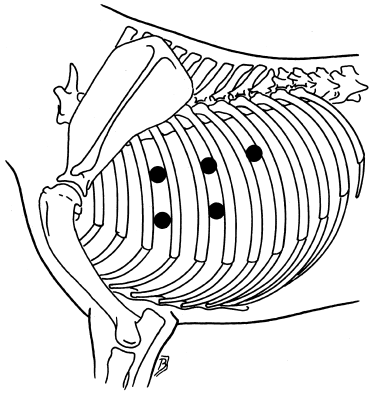


Fig. 9.11 Auscultation of the left side of the thorax. The auscultation sites are shown by the dots.

In order to detect even small localized lesions, the diaphragm or the cup of the stethoscope is placed on at least five locations on each side. At two-thirds of the height of the thorax the eighth, sixth, and fourth intercostal spaces are auscultated, and at one-third of the height the sixth and fourth intercostal spaces are used (Fig. 9.11).

For auscultation of the left side of the thorax it is best to stand at an angle on the left side behind the animal (Fig. 9.12) and hold the stethoscope with the left hand against the thoracic wall. The right hand can help to hold the animal in position. To auscultate on the right side it is best to be positioned on the right side, holding the animal with the left hand. At each auscultation site, the examiner should listen to at least two respiratory cycles, concentrating fully on the inspiration and the expiration in order to determine the type and intensity of the respiratory sound. In addition, a search is made for the occurrence of other sounds and if any are detected, the type, number and location are recorded.



Fig. 9.12 Lung auscultation in a dog. The researcher is positioned on the side of the auscultation sites and keeps contact with the animal with his other hand.

Percussion

In contrast with the percussion of an air-filled barrel, percussion of the thorax only produces a slight resonance. The vibrations are quickly deadened by the structures of the thorax. The pitch and above all the intensity of the sound are very much determined by the elasticity and thickness of the thoracic wall. This explains the fairly large variation in percussion tones obtained with different shapes of thorax and from animals in different states of nutritional condition. In animals with a thin thoracic wall the percussion tone sounds definitely more hollow than it does in animals with a thick thoracic wall. Nevertheless, in the individual animal sounds of such differing tone value can be produced that it is possible by percussion to:

- determine the borders of the lungs
- obtain an indication of whether the amount of gas in the underlying structures is increased or decreased

Technique

The examiner presses slightly against the standing animal and bends over in such a way as to be able to percuss on the other side (Fig. 9.13). Depending on the size of the patient and the height of the examination table, the animal may or may not be placed on the table. It is not very satisfactory to attempt percussion with the animal lying down, because the underlying table will also resonate. However, the condition or the type of animal (cat) may not allow a standing position to be maintained and so percussion may have to be performed with the animal lying on its sternum. The animal is positioned in such a way that the entire spinal column as seen from above forms a straight line, in order to avoid differences between left and right in the tension of the thoracic musculature.

Both sides of the thorax are percussed along three vertical and three horizontal lines (Fig. 9.14). First, the caudal border of the lung field is determined on the basis of three horizontal lines equally spaced over the thoracic wall. In many animals these lines are found to be at (1) the midpoint of the scapula, (2) the shoulder joint, and (3) the midpoint of the humerus. It is advisable to begin percussion on the right side, because there the caudal border is usually clearly determined by the damping of the sound by the liver. As noted earlier, the stomach is on the left side and it often contains some gas, which can make determination of the lung border difficult.

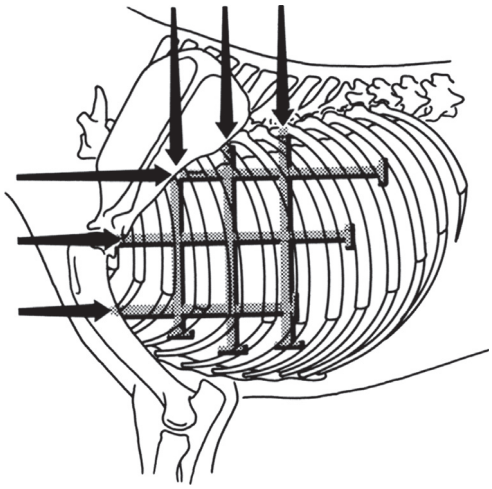


Fig. 9.14 The percussion lines are shown with the caudal and ventral limits of the lung field.

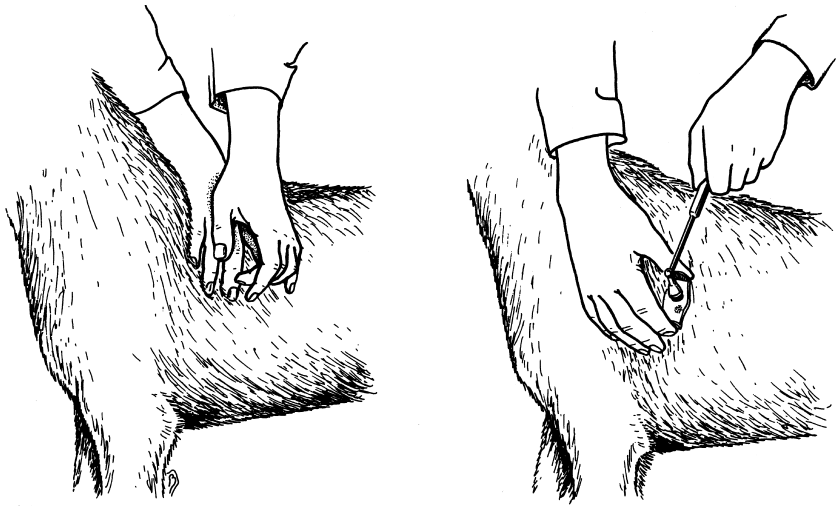


Fig. 9.13 Percussion of the wall of the thorax by a left-handed person using the finger-finger method and using the percussion hammer and plessimeter.

For the vertical percussion lines the front leg is moved forward so that the cranial part of the thorax is covered somewhat less by the triceps muscle. In spite of this, the percussion area in small animals is quite small. Hence in the area cranial to the sixth intercostal space, one to three lines are percussed, depending on the size of the animal, to determine the ventral border of the lung field (= absolute damping by the heart).

In a *healthy* animal a slightly dull (muscle) tone is heard along the top horizontal line. Caudally the tone becomes a hollow (lung) tone, which makes it possible to define the border (tenth intercostal space) of the abdomen, which produces a damped tone, especially on the right side. During percussion along the middle horizontal line a muscle tone is only heard directly behind the triceps muscle. Caudal to this a full lung tone is produced, which makes the caudal border (eighth intercostal space) easy to define. Especially on the left side, the relative damping of the sound by the heart affects percussion along the lowest horizontal line, where definition of the caudal border of the lungs (sixth intercostal space) is already difficult because the stomach does not give a clearly deadened tone.

Percussion along the vertical lines first produces a muscle tone dorsally and then a full lung tone, which gradually becomes damped in the lower half of the thorax because of the relative damping by the heart. Here the lungs are only a thin covering over the heart, especially on the left. Depending on the size of the patient, the lower border of the lung percussion field is found to be 1.5 to 4.5 cm above the sternum, in the form of the absolute damping by the heart. However, the absolute damping can lie a little higher in dogs with a deep thorax than in those with a more rounded thorax. During percussion one should pay attention to possible reactions of the patient, such as coughing, and/or pain reactions.

Some authors are of the opinion that percussion of the thorax has little or no diagnostic value in dogs and cats.[19,20] This is primarily based on the argument that most dogs and cats are too small for this purpose.[20] Along with many others, we have the experience that serious intrathoracic abnormalities (liquothorax, pneumothorax, and diaphragmatic hernia) can be characterized in dogs and cats by physical examination (Table 9.1). In large dogs some examiners find it better to use a percussion hammer and plessimeter (Fig. 9.13) to generate a sound that can be interpreted. In small dogs and in cats the thoracic wall is much thinner than in large dogs, and usually the finger-finger method produces an adequate percussion sound.

An overview of possible thoracic abnormalities that can be found is presented in Table 9.1. The table lists global characteristics that may be observed by physical examination in some of the conditions of the lungs and pleura.

9.3 Notation

The form on the DVD can be used to record findings in a way that provides an overview. Drawings are included on which to mark the results of auscultation and percussion. Both the location of various sounds and the borders of the lung percussion field can be shown on the drawings.

Table 9.1 Overview of findings by inspection/palpation, auscultation, and percussion in some abnormalities of the lungs and pleura (see also Chapters 4, 8, and 10). (This table is meant to stimulate thinking about the basis for the findings; it is not meant to be memorized)

condition	*inspection/palpation*	*auscultation*	*percussion*
Liquothorax in dogs bilateral; in cats sometimes unilateral	Usually no abnormalities except forced respiratory movements. Breathing is often pendulous.	Very few or no respiratory sounds ventrally in thorax. Heart sounds can also be dampened. Usually enhanced respiratory sounds dorsal to the (horizontal) fluid line.	The percussion sound is dampened ventral to the (horizontal) fluid surface. Above it the resonance is normal or increased.
Pneumothorax usually bilateral	Trauma may have caused local lesions (swelling, skin defect, subcutaneous emphysema). Breathing is usually pendulous.	Respiratory sounds weak or inaudible despite forced respiratory movements. Heart sounds are audible and unaffected.	Increased resonance, especially dorsally. Enlargement of the percussion field caudally but caudal limits are difficult to identify.
Diaphragmatic hernia often unilateral	Pendulous respiration. Change in location of the ictus cordis: weak on the side of the hernia and enhanced on the contralateral side; it may also be shifted cranially.	Heart and lung sounds decreased on the side where intestines are located and enhanced on the contralateral side.	Decreased resonance on the side of the hernia, but if a gas-filled stomach is herniated into the thorax, the resonance can be increased.
Lung infiltrate often unilateral	As in liquothorax.	Enhanced respiratory sounds (bronchial respiratory sounds) in the area where the infiltrate reaches the thoracic wall. If the bronchus is closed, the lung sounds are weak.	Decreased resonance in the affected area.

9.4 Further examination

If further examination of the respiratory system is necessary, there are several possibilities, at progressively higher levels of practice:

- white blood cell count and differential
- radiographic examination, aspiration from the thorax, bacteriologic examination, rhinoscopy with otoscope, laryngoscopy
- cytologic examination, rhinoscopy with appropriate optical instruments, bronchoscopy, bronchography
- lung function studies (including dynamic scintigraphy), lung biopsy

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10 Circulatory system

A.A. Stokhof and A. De Rick

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The circulatory system can only function optimally when both the flow of lymph and the circulation of blood are adequate. Examination of the lymphatic system, chiefly by examination of the lymph nodes, was described in Chapter 8. The examination of the remainder of the circulatory system can be divided into:

- arterial system
- capillary system
- venous system
- the heart

The examination of the circulatory system consists of taking the specific history and the examination of the above systems and the heart.

10.1 History

Among the disorders of the circulatory system which lead to signs observed by the owner, cardiac insufficiency is the most important and so questions are concentrated around this. The picture of the failing left ventricle is dominated by signs of lung congestion and lung edema. A failing right ventricle leads to signs of systemic venous congestion and peripheral edema. A combination of the two also occurs frequently. In these cases endurance can be markedly reduced and fainting can occur. Hence the following aspects are relevant to a history concerned with the circulatory apparatus.

10.1.1 Symptoms

Dyspnea and rapid fatigue (dyspnea of exertion)

These signs were discussed in Chapters 8 and 9. Cardiac dyspnea is not readily differentiated from dyspnea of

other causes, but sometimes a remark by the owner leads to questions about differences between rest and exercise; difficulty in breathing that is of cardiac origin can decrease markedly during rest.

Coughing

Coughing has been described in Chapter 9. Sometimes the owner has heard episodes of loud coughing at night.[1] During sleep the animal remains in the same position for a long time and this can lead to redistribution of blood from the large (systemic) to the small (pulmonary) circulation, resulting in stimulation of cough receptors in the trachea and bronchi.[2] The coughing often stops after a small amount of thick, foamy material has been coughed up. The material is then usually swallowed, leading to gagging. Sometimes white, foamy fluid flows from the nasal opening; this fluid may also be slightly red because of the presence of blood.

Edema

The owner may notice edema in the locations described in Chapter 8, but the edema is often so slight that it is only detected by physical examination. The increased venous pressure can also lead to accumulation of fluid in the peritoneal cavity, such that the owner observes an increase in the size of the abdomen. Portal congestion in cardiac insufficiency can also result in diarrhea. Pleural fluid due to heart failure is primarily seen in cats and—understandably—causes dyspnea.

Fainting

Inadequate perfusion of the brain with blood can lead to inability to continue walking or even to falling down and brief loss of consciousness. The owner's description will reveal that fainting occurs during periods of inadequate reserve cardiac capacity, thus in particular after exercise or exertion. When it has been shown that the fainting spells have a cardiac etiology, they are called Adams-Stokes seizures.

Other signs

There is a wide range of other signs. Growth can be retarded in young animals with cardiac insufficiency, probably as a result of suboptimal perfusion of various organs. Anxiety and restlessness may occur during episodes of tachycardia. Some cardiac disorders affect the concentrating ability of the kidney (the mechanism is not fully understood), with the result that polyuria may occur.

10.1.2 Living conditions

The use of the animal can be important if it is required for work involving physical effort which it can no longer fulfil. There might not be a problem under other conditions.

10.1.3 Past medical history

The interpretation of findings may take into account previous illnesses and treatments, including viral infections, septic processes, and the occurrence of heart disorders in relatives of the patient.

10.2 Physical examination

10.2.1 Arterial system

The quality of the peripheral pulse (uniformity, amplitude, and form) is dependent on the forward stroke volume of the left ventricle, the ejection speed, the elasticity of the arterial vascular bed, the peripheral resistance, the pulse frequency, the systolic and diastolic blood pressure, the size and pressure-volume characteristics of the specific vessel, and the distance between the heart and the place where the pulse is palpated.[3] Other aspects of this part of the examination were discussed in Chapter 8.

No reliable impression of blood pressure can be obtained by counting the peripheral pulse. Blood pressure can be measured by direct (invasive) and indirect (noninvasive) methods. Direct measurements are very accurate but because they are invasive they are not suited for routine clinical use. As described in § 4.2, two indirect methods are being used in dogs and cats and they employ two different physical principles: oscillometry and the Doppler principle.

In both of these indirect methods a cuff is placed around a leg or the tail. The cuff is inflated until there is complete closure of the underlying artery (Fig. 10.1).



Fig. 10.1 Measurement of systolic blood pressure in a cat by use of the Doppler system. The position of the cuff enables measurement of blood pressure in the brachial artery. Both slightly flexing the cat's elbow and placing a finger on the cuff help to prevent the cuff from sliding down. The transducer is placed over the artery distal to the cuff.

Then the cuff pressure is lowered gradually by releasing the air. The pressure at the reopening of the artery is the systolic blood pressure. Further lowering of the cuff pressure leads to complete opening of the artery, and the corresponding pressure is the diastolic blood pressure. The changes in sound frequency associated with the latter are not accurately detected by the Doppler system but oscillometric measurements often allow measurement of both diastolic and systolic blood pressure.[4]

Noninvasive blood pressure measurements are in increasing use in dogs and cats. While the currently available instruments appear to provide useful results, they do not accurately reflect blood pressure. For example, in comparison with the results of invasive measurements of arterial blood pressure in dogs (the upper limit of normal systolic pressure being 160 mm Hg), the sensitivity and specificity of indirect measurements were 0.65 and 0.85 by oscillometry (see also § 3.1.5) and 0.71 and 0.86 by the Doppler system.[5]

Particularly in cats, blood pressure measurements are being made because of the not infrequent occurrence of signs suggesting hypertension. In these patients results appear to be reliable only with the Doppler system,[6] oscillometric measurements giving erroneously low values. For measurements with the Doppler system, the upper limit of systolic blood pressure in healthy cats is usually considered to be 170 mm Hg. Accuracy (see also § 3.1.3) is influenced by several factors. In addition to technical aspects such as the width and placement of the cuff, the resting condition of the patient is important. Measurements are most easily made with the cat sitting on the owner's lap. If this is not possible, the cat should be put at ease as much as possible and should be supported ventrally. Stress may cause a rise in arterial blood pressure of >20 mm Hg.[7,8]

10.2.2 Capillary system

At the point where blood flows from the arteriole into the capillary, the pressure is about 4 kPa (30 mm Hg). In the systemic circulation the capillary blood can be considered to be arterial blood as far as blood gasses are concerned. The flow rate in the capillaries is 1/1000 of that in the aorta (the cross-section of the aorta being 2.5 cm^2 and that of the capillaries being 2500 cm^2) and it has a value of about 0.3 mm/s.[9] Since capillaries have a length of 0.3 to 1 mm, a unit of blood remains in the capillaries for 1 to 3 s.

The condition of the capillaries is examined by evaluating the mucous membranes. Their color indicates the degree of oxygenation of the blood. Reduced hemoglobin is slightly more blue than oxygenated hemoglobin. When the blood is poorly oxygenated, a blue coloring of the mucous membranes (cyanosis) is observed. However, cyanosis can only be detected if at least one-third of the normal amount of hemoglobin is present in the circulation.[10] Hence in a more severe anemia the poor oxygenation of the blood is not seen as cyanosis.

The capillary refill time and the temperature of the skin of the extremities reveal information about the peripheral perfusion (§ 8.3.4 and § 8.3.5).

10.2.3 Venous system

Under normal conditions 59% of the circulating blood volume is in the venous system (Fig. 10.2).[9] Blood flows from all of the systemic veins to the right atrium. The pressure in the right atrium is called the central venous pressure (CVP) and it depends on both the venous flow to the heart and the ability of the heart to pump out the blood that is delivered. A marked underfilling of the vascular system will result in a low central venous pressure, but this can also result from a very strong heart action. An abnormally high central venous pressure can be caused by cardiac insufficiency as well as by overfilling of the vascular system.

In cardiac insufficiency the renin-angiotensin-aldosterone system (RAAS) is stimulated. This leads to enlargement of the circulating volume and thereby to further elevation of the CVP. The observed abnormalities depend on the severity of the increase in pressure. A slight increase in pressure can only be observed by examining the jugular and saphenous veins. With greater increases in pressure, hepatic enlargement and ascites develop. Peripheral edema is seen in only the most severe cases.

Since a high venous pressure causes the walls of veins to be under tension, pulsations in the large veins are visible more peripherally than under normal conditions. The pressure wave is transmitted better by the increased tension of the wall of the vein. During each heart cycle, three venous pressure waves can be recorded (Fig. 10.3): the A wave, the C wave, and the V wave. The A wave or presystolic wave follows

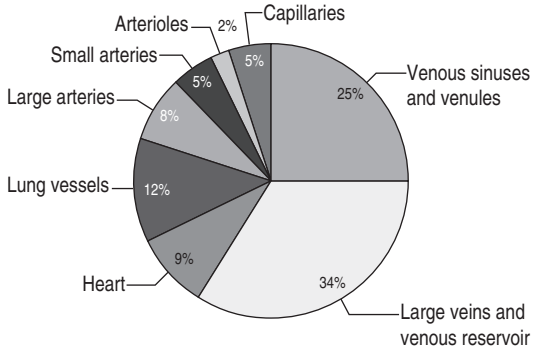


Fig. 10.2 Distribution of the blood volume among various types of blood vessel.

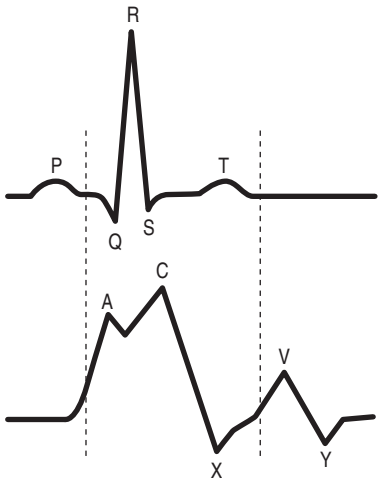


Fig. 10.3 Schematic illustration of an electrocardiogram (above) and a pressure recording in the jugular vein. The A wave or presystolic wave is the result of the atrial contraction. The C wave results from a presystolic wave caused by bulging of the tricuspid valve during isovolumetric contraction and from the propagation of the movement of the adjacent carotid artery. The V wave is caused by accumulation of the venous blood. The decrease which follows is the result of the opening of the tricuspid valve. The fall at X is the result of relaxation of the atrium and the decrease in bulging of the tricuspid into the atrium at the end of the contraction of the right ventricle. The fall at Y marks the rapid filling phase of the right ventricle after opening of the tricuspid valve.

immediately behind the P wave in the ECG and is the result of atrial contraction. The C wave is a presystolic wave and is synchronous with the plateau phase of the carotid pulse. It is a movement of the jugular vein caused by pulsations of the carotid artery. The V wave is a somewhat flatter wave and marks the end of ventricular systole; it is caused by the gradual filling of the right atrium with blood from the venous system. The associated movements are called the 'venous pulse'.

Measurements made by a catheter introduced via a peripheral vein into the right atrium (Fig. 10.4) reveal that the central venous pressure in healthy dogs is between −1 and +4 cm H_2O. During the physical examination, it is possible to obtain an impression of the central venous pressure and the associated venous tension by a number of external signs.

The venous system is a system of communicating vessels. It does not behave entirely as such, however, because it is a closed system. Yet due to the fact that the veins are collapsible, it is possible by examination of peripheral veins to obtain an impression of the central venous pressure. Such a peripheral vein is thus used as a manometer tube. It must be remembered that any venous obstruction between the point of measurement and the right heart can cause an increase in venous tension, without being an indication of cardiac

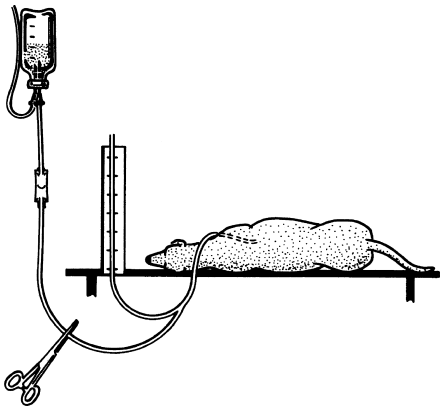


Fig. 10.4 Measurement of the central venous pressure with the aid of a column of fluid.

insufficiency. A number of peripheral veins are suitable for estimating the CVP.

In the physical examination, attention is first given to the jugular vein, after which the ventral surface of the thorax and abdomen, the prepuce, and the tarsus are examined for signs of edema. The abdomen is palpated to determine whether the liver is enlarged and an undulation test is performed. Finally, the saphenous vein is examined.

Jugular vein

When an animal is in a standing position and holding its head in the normal way, the jugular vein is not visible or palpable. At the thoracic inlet soft pulsations may be recognizable. When the venous return is obstructed, the jugular is often easily seen and/or palpated. If the animal's coat is not too long, the A, C, and V waves are also visible more peripheral to the heart than under normal conditions. The variation in venous tension caused by intrathoracic pressure changes during respiration is also more easily seen when the central venous pressure is increased. A recording is necessary for precise examination of the venous pulsations.

Edema

If a hindrance to venous drainage leads to peripheral edema, the edema will be seen in dependent areas having a relatively low tissue pressure. These areas are the ventral thoracic and abdominal walls, the prepuce, and the area around and above the tarsal joint (Fig. 10.5). A slight depression made in the edematous area remains for some time.

Size of the liver

The liver is capable of taking up a large amount of blood as a result of the compliance of the intrahepatic venous system and the elasticity of this organ. Thus an increase in central venous pressure quickly leads to enlargement of the liver. This can be used to evaluate





Fig. 10.5 Left, a 12-year-old dog with cardiac insufficiency, photographed from behind. There is edematous thickening around both tarsi and metatarsi. At the time the photograph was taken, this was most pronounced on the left. This type of asymmetry may occur when the patients lies for a long time on one side. Right, a skinny boxer (note ribs and spinous processes of vertebrae) with severe ascites.

the venous circulation. The liver then becomes palpable on the right behind the costal arch. The examiner stands behind the dog and moves the right hand caudally over the right ventral surface of the rib cage. Normally the liver is not palpable but when the liver is enlarged a resistance is felt in the abdomen just behind the costal arch. An estimate is made of how far (in cm) behind the costal arch the liver is palpable (Fig. 10.6).

Ascites

Persistent elevation of the central venous pressure leads to free fluid in the abdominal cavity, especially in the dog (Fig. 10.5). If the volume is sufficient this fluid can be detected by testing for undulation. For this purpose the examiner stands behind the dog (Fig. 10.7). With one hand placed flat on one side of the abdomen as a detector, a short tap is made with the fingers on the abdominal wall on the other side. The undulation test is positive when the resulting vibration is very clearly felt with the flat hand (see also § 11.2.3). In the cat an increased central venous pressure leads after a short while to accumulation of free fluid in the pleural cavity rather than the abdominal cavity.



Fig. 10.6 Detecting hepatic congestion by palpation. In the ventral epigastrium the right hand carefully palpates with a back-and-forth movement to determine whether resistance is felt in the abdomen directly behind the costal arch.

Saphenous vein

Although examination of the jugular vein can sometimes reveal hindrance to the central venous return, local venous obstructions either proximal or distal to the place of observation can cause an erroneous impression. There is also a great variation in the shape of the thorax and neck, so that another vein would be preferable. The saphenous vein is quite suitable, with the understanding that it is a relatively small peripheral vein and the resulting 'manometer system' responds rather slowly. The venous pulsations referred to above as the A, C, and V waves, cannot be observed here, but variations in venous tension induced by respiration are surprisingly easy to observe here in large dogs.

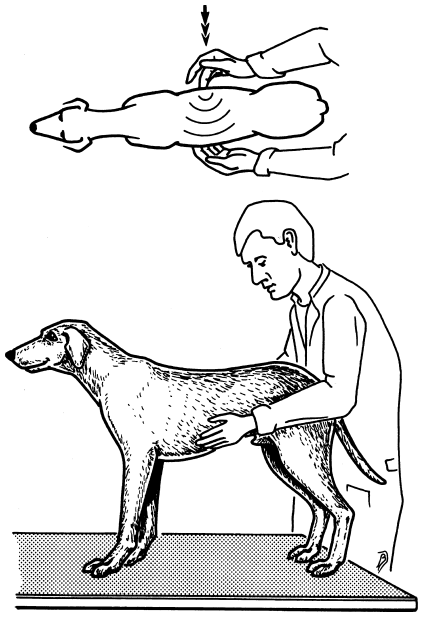


Fig. 10.7 Undulation test to determine whether there is free fluid in the abdominal cavity (ascites).

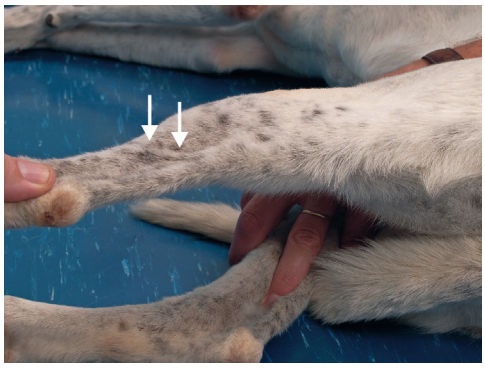


Fig. 10.8 Assessment of the venous tension at the saphenous vein. In this healthy dog in lateral recumbency the leg has been moved to a height a few centimeters above that of the central venous system. In this position the saphenous vein has not yet collapsed completely. The vein is still visible (arrows), but tension is no longer palpable.

For examination of the saphenous vein the patient is placed lying on its side and, because of the almost median position of the central venous system and the modest sensitivity of the measuring system, it does not matter whether on the right or the left side. The distance is then measured from (a) the sternum to the table surface and (b) the dorsal process of the seventh thoracic vertebra to the table surface. The sum of these two values, in centimeters, is divided by 2 to obtain the distance of the central venous system from the table surface. This distance is the 0 value for the measurement of central venous pressure in this dog. If the saphenous vein is raised to this height by lifting up the leg, under normal circumstances the vein will lose its tension and partially collapse (Fig. 10.8). Only when the vein is about 5 cm above the reference point does it collapse completely. The tension of the vein is evaluated by inspection and especially by palpation, which is possible even in long-haired dogs without clipping the hair. If the vein does not collapse, the leg is raised further and the height at which the vein finally does collapse gives an indication of the degree of venous hypertension.

10.2.4 The heart

The heart action produces a range of vibrations whose frequencies are between 1 and 1000 Hz (cycles/s). These vibrations can be perceived on the outer side of the body and have diagnostic meaning. The lower frequencies, up to about 30 Hz, can only be seen or felt but not heard. The frequencies above 30 Hz can only be heard. The examination of the heart must therefore include inspection, palpation, and auscultation. Percussion can also be used. Both inspection and palpation are used to observe the apex beat or ictus cordis. This local movement of the thoracic wall is primarily a reflection of the contraction of the left ventricle, in which it moves forward and touches the thoracic wall.[11] The location and strength of the ictus are normally determined by the size of the heart, the stroke volume, the ejection time, the ballistic rebound, and the turning of the heart during systole. The ictus is influenced by the thickness of the thoracic wall and the amount of lung tissue between the heart and thoracic wall. The position of the patient is also very important.[12] In the healthy dog and cat the ictus cordis is found in the ventral part of the thorax, closer to the sternum on the right side than on the left.

Inspection

Inspection is especially useful in animals with a deep thorax and a short coat. Note should be taken of the place where the heart action is visible and also the intensity with which the thoracic wall moves in this location. Normally the movement is visible at locations where the ictus is palpable. In healthy animals the ictus is stronger on the left than the right. The ictus is inspected from a position to the side and slightly behind the animal.

Palpation

The examiner stands behind the animal and performs palpation with both hands (Fig. 10.9). The movements in the healthy animal are always more intense on the left than on the right. To determine the intercostal spaces in which the ictus cordis is palpable, counting is



Fig. 10.9 Palpation of the ictus cordis in a medium-sized dog.

begun in the 12th space and proceeds forward ventral to the level of the latissimus dorsi muscle. Two characteristics of the ictus are determined: (1) the areas over which it is palpable, and (2) whether there is a fremitus (palpable vibration or thrill) and, if so, where it is located.

The strength of the ictus cordis is difficult to describe exactly. The surface over which the ictus is felt provides information about its strength. For example, excitement leads to a greater stroke volume and consequently the ictus is clearly stronger than at rest, and it can also be palpated over a larger number of intercostal spaces. In the healthy animal at rest the ictus cordis is palpable on the left side in the 4th, 5th, and 6th intercostal spaces, and on the right in the 3rd, 4th, and 5th spaces. Normally there is no fremitus (vibration which can be felt on the thoracic wall). If a fremitus is felt with the animal in a standing position, the intercostal space in which it is located and its height on the thoracic wall are both recorded.

In small dogs and in cats the ictus cordis can also be palpated by holding the thorax with one hand from below, using the other hand to count the intercostal spaces as described above (Fig. 10.10).



Fig. 10.10 Palpation of the ictus cordis in a cat, whereby the intercostal spaces are being counted.

Auscultation: heart sounds

The heart sounds detected by auscultation are described as the first, second, third, and fourth sounds. In the healthy dog and cat the first and second sounds are particularly well heard. The origin of the sounds is as follows:[13]

First heart sound. The first heart sound is mainly caused by the contraction of both ventricles. Four components can be differentiated, indicated as A, B, C, and D (Fig. 10.11).

The atrial contraction brings the atrioventricular valve into a state of preparation for closure. This forms the beginning of the first heart sound (A). This is followed by the isovolumetric pressure increase in the ventricle, via which the intraventricular column of blood is brought under pressure and begins to vibrate (B). The pressure now becomes higher in the ventricle than in the aorta and pulmonary artery, causing the semilunar valves to open (C). Part of the blood in the ventricle is now ejected (D).

Second heart sound. During the remainder of systole there are normally no audible sounds. After ejection of the blood, the pressure in the ventricle falls below that in the aorta and the pulmonary artery, so that the blood column in these vessels begins to flow back and the semilunar valves close. The resulting vibration causes the second heart sound. The first component of

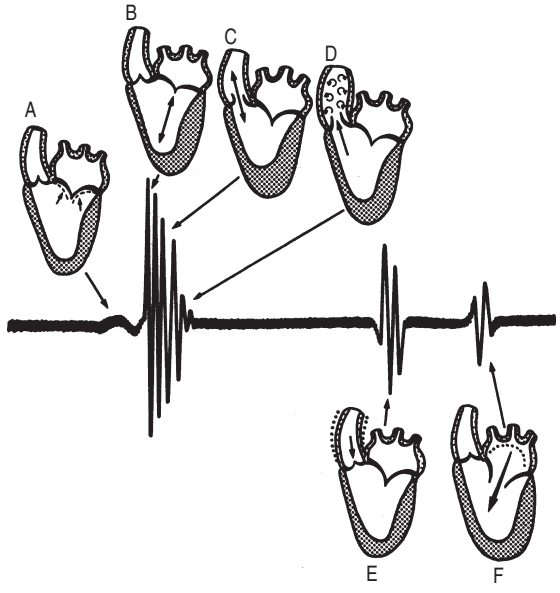


Fig. 10.11 Schematic explanation of the development of the heart sounds. The first heart sound is built up from the following components: A atrial contraction prepares the atrioventricular valve for closure, B isovolumetric contraction, C opening of the semilunar valves, and D rapid ejection phase. The second heart sound is mainly produced by the closure of the semilunar valves. E The third heart sound marks the beginning of diastolic relaxation, F.

this sound consists chiefly of the vibration caused by the aortic valve and the second component is from the pulmonary valve. The aortic valve closes just slightly earlier than the pulmonary valve.

Third heart sound. Since the first heart sound the ventricle has still been in the contraction phase. At this moment it comes to an end. The blood which has accumulated behind the closed atrioventricular valve flows rapidly into the relaxed ventricle. This causes the third heart sound.

Fourth heart sound. During the remainder of diastole there is no audible heart sound except during the contraction of the atria, which can be heard as the fourth heart sound. This can be heard in the dog and cat when the propagation of the impulse from the atrium to the ventricle is completely disturbed.

In healthy dogs and cats only the first and second heart sounds are audible. The third and fourth heart sounds have too low an intensity to be heard normally, but become audible in certain pathologic conditions (gallop rhythm).

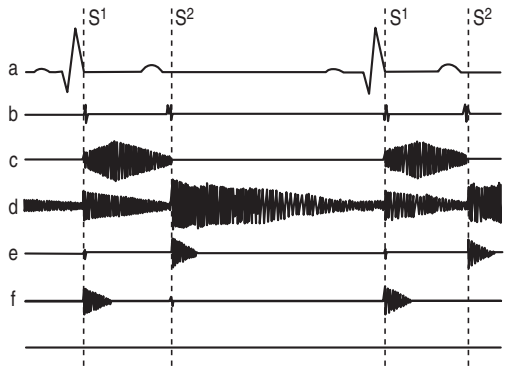


Fig. 10.12 ECG and location of the heart sounds during two heart cycles, illustrating the relative sound intensity. S1 and S2: first and second heart sounds. a: ECG. b: heart sounds without murmurs (pure heart sounds). c: systolic crescendo-decrescendo murmur. d: continuous murmur, both systolic and diastolic crescendo-decrescendo. e: prediastolic crescendo-decrescendo murmur. f: presystolic crescendo-decrescendo murmur.

Auscultation: murmurs

If additional sounds are heard, it is important to determine whether they are cardiac or extracardiac in origin (see Technique). If the origin is cardiac, the intensity of the murmur is recorded on an ordinal scale (§ 3.1.2) having six classes or grades for each valve area.[14] The valve area with the highest murmur intensity is called the maximal point. This may indicate an abnormality in that valve.

When, for example, we speak of a murmur with an intensity of 4/6, we indicate that the intensity is grade 4 on a scale of 6. The grades can be described as follows:

grade 1: a murmur of very low intensity, only heard when one has been auscultating for a few seconds

grade 2: a very soft murmur that is heard directly upon auscultation

grade 3: louder than grade 2 but without fremitus

grade 4: a loud murmur, with fremitus

grade 5: louder than grade 4 but no longer heard when the stethoscope is removed from the thoracic wall

grade 6: the sound of the murmur is even audible when the stethoscope is held slightly away from the thoracic wall.

The variation in intensity in relation to the heart action is described as, for example, a systolic crescendo-decrescendo murmur, a crescendo noise, a continuous noise, a diastolic noise, etc. (Fig. 10.12). These characteristics can often only be recognized by an experienced examiner. For a more objective and detailed evaluation of the murmur, a phonocardiogram is made.

In addition to the intensity and the maximal point, the type of sound is described (pitch, quality, intensity), as well as the variation in the sound related to times in the cardiac cycle. The quality or character of the sound is described in terms such as blowing, creaking, rough, musical, etc.

The transmission of the murmur can sometimes be important for its localization. Transmission of murmurs is good when very little of their energy is absorbed. Acoustic impedance (resistance) also plays a role (§ 4.1.4). With certain abnormalities the transmission of the murmur is such that it is heard at locations other than the maximal point. For example, in aortic stenosis the crescendo-decrescendo noise during systole is easily heard over the carotid arteries. The stethoscope is therefore placed over the thoracic inlet, where the pulsations of the carotid arteries can be felt.

Auscultation: technique

The examination must be carried out in as quiet a room as possible, and the patient must be as relaxed as possible. Conversation should be stopped during auscultation. The examiner stands behind and to the left of the animal to auscultate on the left thoracic wall and to the right in order to auscultate on the right side. The diaphragm side of the stethoscope end piece is used (§ 4.2). The cup side is used only when low-tone diastolic murmurs are suspected. When listening to the heart one must differentiate between cardiac and extracardiac sounds, the epicardium forming the border. It is helpful to temporarily stop the animal's respiration by closing its nostrils (Fig. 10.13).

In the systematic approach attention is given to:

Heart rate. In dogs a heart rate above 120/min is termed tachycardia and a rate below 60/min is termed bradycardia. In cats the corresponding limits are 180/min and 120/min.

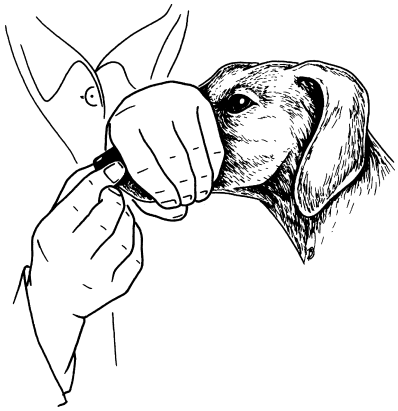


Fig. 10.13 Closing the animal's nostrils to exclude the respiratory sounds during auscultation of the heart.

Pulse deficit. As discussed in § 8.3.2, the heart rate and the pulse rate should be identical. A pulse deficit indicates arrhythmia.

Heart rhythm. In dogs with heart rates below 120/min there is usually respiratory sinus arrhythmia (see § 8.3.2). This physiological arrhythmia becomes more pronounced as the heart rate decreases and it disappears as the heart rate increases. A very regular rhythm at a low frequency indicates the presence of a conduction disturbance. Arrhythmia at a high frequency indicates a pathological condition such as extrasystoles or atrial fibrillation.

Heart sounds. Under physiological conditions, two heart sounds can be distinguished. At very high frequencies, such as in cats, often only one heart sound is heard. The presence of more than two heart sounds is abnormal.

Murmurs. Murmurs are characterized by their intensity, quality (see above), and location (valve area). Clinical experience has shown that abnormalities of each valve can best be distinguished in a specific area of the thoracic wall. In dogs four valve areas are recognized. On the left side: the mitral area is in the 5th intercostal space (corresponding to the bicuspid or left atrioventricular valve), the pulmonic area is in the 3rd intercostal space (corresponding to the valve of the pulmonic trunk), and the aortic area is in the 4th intercostal space (corresponding to the aortic valve) (Fig. 10.14). On the right side the tricuspid area (right atrioventricular valve) is in the 4th intercostal space just below the level corresponding to the aortic valve on the other side.

First, one concentrates on the first heart sound and compares it with the succeeding first heart sound. Then one concentrates on the second heart sound and compares it with the succeeding second heart sound. Then attention is given to the relation between the first and second heart sounds together in relation to the valve region in which one is listening. In the regions of the mitral and tricuspid valves the first heart sound is louder than the second. In the regions of the pulmonic and aortic valves, the opposite is true. Using BR to represent the first sound and TP to represent the second, and by using large and small letters to indicate the intensity, we can create Table 10.1 (PCG = phonocardiography).

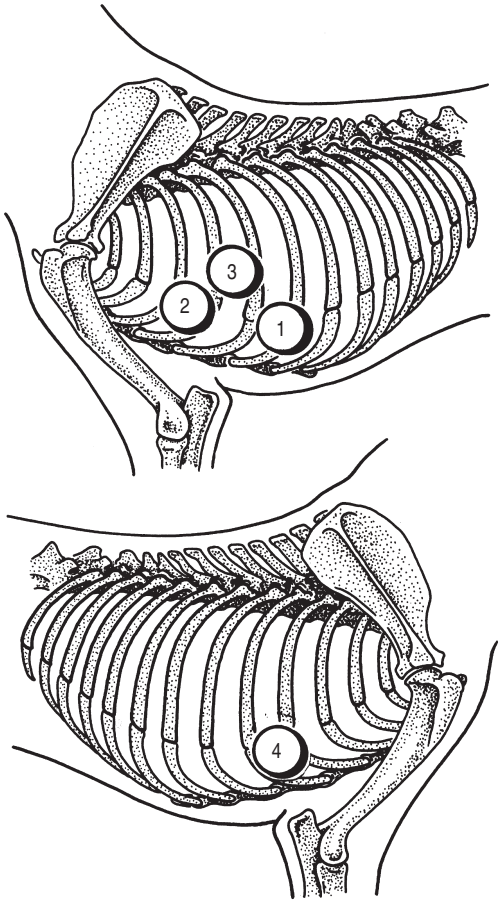


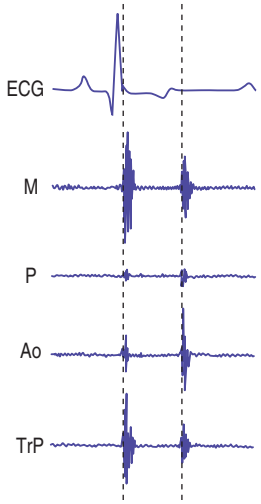
Fig. 10.14 Valve areas in the dog: 1 mitral, 2 pulmonic, 3 aortic, 4 tricuspid.

Then one concentrates on the third or fourth heart sound to determine whether either is audible. When the third or fourth sound is audible, the effect is usually referred to as a gallop rhythm (S_3 and S_4 gallop). In dogs and cats the fourth heart sound is mainly audible in third degree atrioventricular block.

In the cat, which often has a relatively small thorax, the valve regions are more difficult to describe. We usually limit auscultation to three regions (Fig. 10.15):

- mitral: left 5th and 6th intercostal spaces
- aortic and pulmonic: left 2nd and 3rd intercostal spaces

Table 10.1

valve region	*symbol*	*PCG*
		
mitral	BR tp	
pulmonic	br TP	
aortic	br TP	
tricuspid	BR tp	

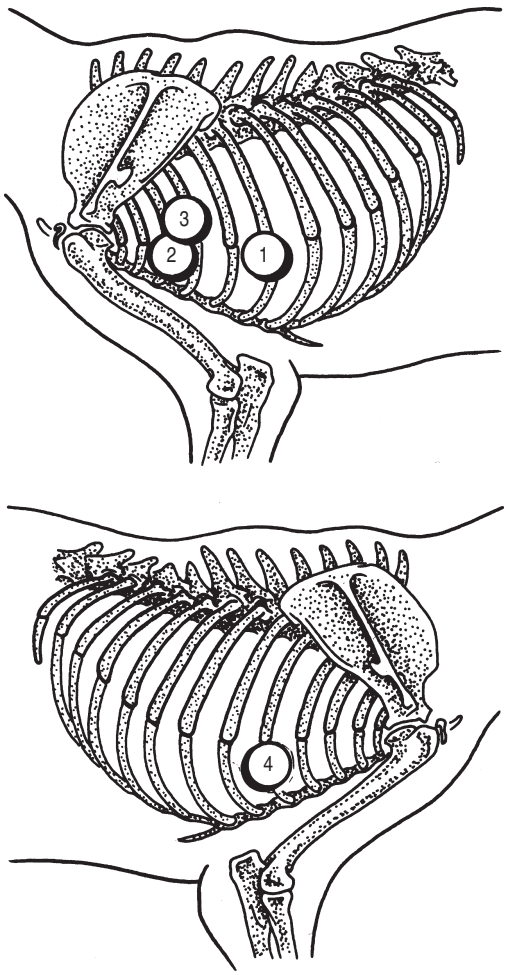


Fig. 10.15 Valvular regions in the cat: 1 mitral, 2 and 3 pulmonic and aorta (not easily differentiated), 4 tricuspid.

– tricuspid: right 4th and 5th intercostal spaces above the costochondral junction.

The difference in accent on the first and second heart sounds is the same as described above for the dog. Purring can be very disturbing. One can try to stop purring by stretching the cat's head backward and pressing slightly on the trachea just under the larynx, or asking the owner to let the cat loose. Also, it can often be stopped by holding an alcohol-soaked ball of cotton in front of the cat's nose.

Percussion

When it is not possible to make radiographs of the thorax directly, percussion still has a useful place in the examination. Indirect finger-finger percussion or hammer-plessimeter percussion makes it possible to define the percussion damping caused by the heart. Vertical percussion lines are chosen cranial to the sixth intercostal space, beginning on the left side. The technique is described in (§ 9.2.4). One can obtain an impression of the relative and absolute damping by the heart. Normally the relative heart damping begins just under the shoulder line as a gradually increasing damping. The absolute damping due to the heart is easily defined. In healthy, medium-sized dogs it is approximately 3 cm above the sternum on the right side and approximately 4 cm above the sternum on the left. These values must be adjusted according to the size of the dog and the shape of the thorax. In a dog with a deep thorax the line of damping lies a little higher than in a dog with a round thorax. Percussion is particularly useful when there is liquothorax, marked cardiac dilatation, or pericardial effusion.

10.3 Notation

The form on the DVD provides a convenient overview of the findings.

10.4 Further examination

If the above examinations do not lead to a diagnosis, further examinations can be carried out. In order of increasing requirements of equipment and experience, these include:

- plain radiography
- electrocardiography (ECG)
- phonocardiography
- ultrasonography
- scintigraphy
- cardiac catheterization
- magnetic resonance imaging (MRI)

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11 Digestive tract

J. Rothuizen, E. Schrauwen, L.F.H. Theyse and L. Verhaert

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In addition to the symptoms described by the owner in the general history (Chapter 6), such as dysphagia (difficult swallowing or complete inability to swallow), vomiting, abnormal feces, and abnormal defecation, several other symptoms may originate from the digestive tract. These will be discussed below in the specific history. When there is suspicion of aspiration pneumonia, as can occur with swallowing disorders, the history and physical examination must be extended to include the respiratory tract (Chapter 9).

The examination of the digestive tract is usually limited to that part relevant to the problem which has now been formulated (Chapter 3). Rectal examination

is not needed when the problem is dysphagia, nor is examination of the upper digestive tract necessary when the problem is tenesmus alvi (painful, repeated urgency to defecate). If a complete examination of the digestive tract is indicated, then the examination proceeds in sequence: mouth, pharynx, esophagus, abdomen, anus and perineum, and rectum.

11.1 History

The best known manifestations of abnormal functioning of the digestive tract are vomiting and diarrhea. These symptoms will be discussed in detail below and a series of specific questions will be presented together with examples. These questions also illustrate the importance of a careful history for further specifying the problem definition.

In 'vomiting' animals, questions must be asked to differentiate between regurgitation and active vomiting. Regurgitation is the passive, retrograde expulsion of contents from the throat, esophagus, or stomach. The act of regurgitation is 'passive' in the sense that it is not a recognizable, reflex-determined phenomenon. Expulsion occurs under the influence of the position of the head and neck, gravity, the intrathoracic pressure, the pressure relation between the thorax and abdomen, and the pressure in the abdomen. The manifestation of regurgitation can vary greatly with regard to the nature of the regurgitated material, the amount, and the time after eating. Regurgitation of food during eating can indicate an inability to relax the proximal esophageal sphincter (cricopharyngeal achalasia) or the presence of pharyngeal paralysis. Regurgitation of large amounts of mucus or food, independent of food intake (thus both before and after), is usually related to esophageal paralysis. Regurgitation of large amounts of food may occur with pyloric stenosis. Occasionally, regurgitation is characterized by belching of fluid, which can be due to dysfunction of the cardia or it can be due to pyloric stenosis.

We speak of active vomiting when there are active contractions of the abdominal muscles before the retrograde expulsion of vomitus. This is often preceded by swallowing, salivation, and restlessness (symptoms of nausea). Active vomiting is a reflex phenomenon. Neurogenic stimuli which lead to vomiting stimulate the vomiting center in the brainstem. Humoral stimuli that lead to vomiting stimulate the chemoreceptor center, from which the vomiting center is then stimulated. Stimulation of the vomiting center leads to coordinated muscle activity, of which the contractions of the muscles of the abdominal wall are the most striking.

The term diarrhea is used when the characteristics of the feces are changed by an increase in the volume and/or percentage of water. Diarrhea is also often used to describe an increased defecation frequency, with or without an increase in volume or water content. Similar to the important distinction between vomiting and regurgitation, it is essential to distinguish between small bowel diarrhea and large bowel diarrhea.

A small bowel diarrhea occurs when the effluent from the small bowel to the large bowel is so changed in volume and composition that in spite of the reserve capacity of the colonic mucosa to absorb water, the final contents and hence the feces are too voluminous and/or too watery. This form of diarrhea can be caused by an increased osmotic value of the intestinal contents, or by increased secretion and/or exudation of the intestinal mucosa, and/or by abnormal motility.

Large bowel diarrhea occurs as the result of abnormal colon motility, reduction of the absorptive surface of the colonic mucosa, or increased secretion and/or exudation in the colon. The most characteristic features are summarized in Table 11.1. The table once more illustrates that the distinction between small bowel diarrhea and large bowel diarrhea relies on findings in the history.

Questions that can be asked about problems that may involve the digestive tract are given below, with a few examples to illustrate their relevance.

Development. After determining the age at which the animal was acquired by the present owner, the next step

Table 11.1 Most characteristic differences between small bowel diarrhea and large bowel diarrhea. This distinction is only important in chronic diarrhea. Not all of the criteria have to be present for either type and there can be some overlapping

	small bowel diarrhea	*large bowel diarrhea*
Defecation frequency	Low	High
Tenesmus	Rare	Often (persisting)
Volume of feces	Large	Small
Mucus in feces	Rare	Often
Blood in feces	Rare	Often
Polydipsia	Often	Rare
Polyphagia	Often	Rare
Borborygmi and flatulence	Often	Rare
Weight loss	Often	Rare

is to ask when gastrointestinal problems were first noticed. Food intolerance generally appears at a young age, whereas enteritis is most often seen in young adult to middle-aged animals. Neoplasia is more likely to be involved in gastrointestinal problems in older animals.

Course. Knowing whether the problem is continuous or episodic is often helpful. Enteritis is often episodic, while exocrine pancreatic insufficiency (EPI) results in continuous problems without spontaneous remission.

Further characterization of the problem. The iatrotropic problem (§ 3.1.1) is documented and further described. Apart from vomiting and/or diarrhea (see above) there may be associated problems such as anorexia, dysphagia (swallowing problems), or bloody feces.

Additional symptoms may include:

- Decreased appetite, which is considered to be very serious if associated with weight loss. Malignancy (gastric carcinoma, malignant lymphoma) should be considered.
- Weight loss may not only be caused by decreased food intake, but may also be the result of maldigestion/malabsorption.
- Pica is the tendency to eat things that are inedible for dogs and cats, such as potato peelings or cloth. It may be the result of extreme hunger, as can occur in EPI. Eating grass or other plants may be a prodrome (forerunner) of vomiting and may be one of the manifestations of nausea.
- General signs of illness. Lethargy associated with a gastrointestinal problem usually indicates a serious disorder. It can also be secondary to one of the consequences of gastrointestinal disease, such as dehydration. Conversely, a problem outside the gastrointestinal tract may lead to general illness with vomiting, as occurs in renal disease when accumulating waste products trigger the vomiting center.
- Manifestations of abdominal pain. Conditions such as acute pancreatitis and intestinal foreign body with peritonitis may give rise to striking manifestations of pain. Dogs often assume a 'praying' position in which the front legs are extended forward so that the ventral thoracic wall touches the floor, while the hind legs remain vertical. During attacks of pain the animal may suddenly leap up, trembling, and then restlessly walk around.

11.2 Physical examination

11.2.1 Head

Introduction

Maintenance of the organism requires that food be taken in, reduced to smaller pieces, and transported through the pharynx and esophagus to the stomach. Dogs and cats hold large pieces of food with the front feet and then tear off pieces mainly with the incisor and canine teeth. Larger pieces can be cut off with the carnassials (fourth premolars in upper jaw and first molars in lower jaw). The incisor teeth are used to pick up smaller pieces of food or to tear them loose.

Dogs and cats only marginally chew their food. The premolars are mainly suited for holding the food (prey). The teeth of cats are characteristic of a real carnivore, whereas those of dogs have some characteristics of an omnivore. In dogs the upper and lower molars have a grinding occlusal surface.

By means of the short 'catching' movements of the head, which are very noticeable in the dog, the food, which is held and guided by the hard palate, cheeks and tongue, is moved caudally. Saliva is added while the food is broken or ground into slightly smaller pieces by the molars. The bolus of food formed in this way is pressed against the hard palate by the tongue and then by contraction of the muscles of the pharynx it is brought into the esophagus.

The soft palate closes off the nasopharynx in this process. The larynx is pulled more or less under the root of the tongue and together with tension on the vocal folds, the airway is closed off.

Chewing musculature

Of these muscles the masseter and temporal muscles are accessible for physical examination. The masseter muscle is on the lateral surface of the ramus of the mandible, ventral to the zygomatic arch. The temporal muscle is the largest and strongest muscle of the head and lies in the temporal fossa. Both muscles are important in opening and closing the mouth.

Oral cavity

The mouth or oral cavity lies between the mouth opening and the entrance to the throat. The hard palate forms the dorsal border; the lips form the rostral, the cheeks form the lateral, and the tongue and sublingual space form the ventral border of the oral cavity.

The teeth separate the mouth into the oral cavity proper (inside the teeth) and the labial vestibule and buccal vestibule (outside the teeth), bordered by the lips and cheeks, respectively.

The mouth opening is closed by the lips. There is a sharp border between skin and oral mucosa. The upper (maxillary) lip makes a transition to the nasal plane. The lower (mandibular) lip is much shorter than the upper, so that the upper lip hangs over the lower, especially at the angle of the mouth. The buccal mucosa changes to gingiva at the mucogingival junction. The cheeks are between the angle of the mouth opening and the mucosal fold that runs behind the last molar

between the palate and the lower jaw. The openings of the ducts of the parotid and zygomatic salivary glands are in the caudodorsal mucosa of the cheek. The opening of the parotid duct is situated dorsal to the fourth premolar and the opening of the zygomatic duct is dorsal to the first molar. The mucosa of the cheeks also changes to gingiva at the mucogingival junction.

The most common head shape in dogs is described as mesocephalic or mesaticephalic. Dogs with short skulls, such as boxers, are called brachycephalic, and those with long skulls (greyhound type) are called dolichocepahlic. Brachygnathia refers to an abnormally short lower jar or mandible and prognathism refers to relative elongation or protrusion of the mandible. In brachycephalic breeds there is shortening of the upper jaw, termed maxillary brachygnathia, so that the lower incisors protrude beyond the upper ('undershot'). When the lower jaw is shorter than normal we speak of an overbite ('overshot') or mandibular brachygnathia. The terms overshot and undershot do not describe jaw length per se but rather the relative proportions of the jaws. Especially with an overbite, mucosal damage can be expected due to the pressing of the lower canines into the hard palate.

The set of teeth is described by dental formulas (Table 11.2). The incisors (I), canines (C), premolars (P), and molars (M) are grouped according to the quadrants of the mouth (upper right = 1, upper left = 2, lower left = 3, and lower right = 4) and the tooth number is counted from the central incisor (based on a complete set of teeth). Thus, the fourth premolar of the upper right jaw is indicated as 108 and the second molar of the lower left jaw as 310.

The hard palate has 6–10 slightly angled ridges (palatine rugae), which help in moving the food backward in the mouth. Behind the first incisor teeth lies the incisive papilla, separated from the palate by two grooves. On both sides the nasopalatine duct opens here, the duct being a connection between the mouth and the nasal cavity.

The bottom of the mouth (apical sublingual cavity) is under the tongue. The frenulum divides the space into two elongated lateral sublingual recesses. The ducts of the

Table 11.2 Dental formulas per quadrant in the upper and lower jaws in the dog and the cat

	dog	*cat*
Deciduous	3i, 1c, 3p	3i, 1c,3p
	3i, 1c, 3p	3i, 1c, 2p
Permanent	3I, 1C, 4P, 2M	3I, 1C, 3P, 1M
	3I, 1C, 4P, 3M	3I, 1C, 2P, 1M

I = Incisor, C = Canine, P = Premolar, M = Molar (deciduous teeth in lower-case letters).

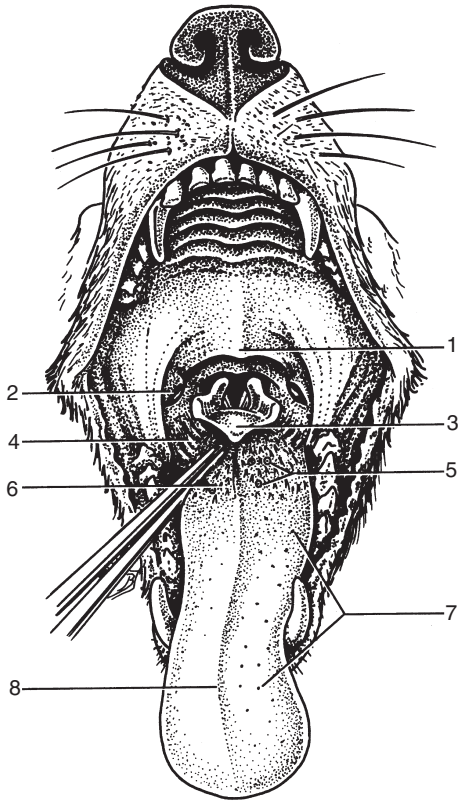


Fig. 11.1 The opened mouth of a dog with the base of the tongue depressed: 1 soft palate, 2 tonsillar sinus, 3 epiglottis, 4 palatoglossal fold, 5 vallate papillae, 6 conical papillae, 7 filiform and fungiform papillae, 8 median sulcus of the tongue.

mandibular and sublingual salivary glands open into the mouth in the sublingual caruncles, lateral to the frenulum. The ducts from these two glands lie in a small mucosal fold (sublingual plica) that runs caudally from the caruncles.

In addition to its role in taking up and transporting food, the tongue also has the function of sorting and testing food. In the cat the tongue also fills an important role in cleaning the body. The tongue is also used in heat regulation, communication, and caring for the young.

The tongue (Fig. 11.1) is a strongly muscled organ that fills a large part of the bottom of the mouth and the oral part of the pharynx. The tip of the tongue lies completely free while the body of the tongue is attached on its ventral side to the bottom of the mouth by the frenulum. The root of the tongue, of which only the upper surface is free, is attached near the epiglottis. The palatoglossal folds or plicae are mucosal folds which run from the side of the root of the tongue to the soft palate. On the flat upper surface of the tongue there is a longitudinal groove, the median sulcus of the tongue.

On the mucosa of the tongue various types of papillae can be recognized: filiform, fungiform, vallate, foliate, and conical (Fig. 11.1). The filiform papillae have a

primarily mechanical function, while the others play a role in the sensation of taste. A very rough mucosal surface is characteristic in the cat. On the ventral side of the tongue of the dog, beginning at the tip and running caudally in the lingual septum, is the lyssa. It was once thought that there was a relation between this 'string' and rabies (= lyssa in Greek). Possibly it fills a role as a stretch receptor.

Pharynx, tonsils, and soft palate (Fig. 11.1)

The pharynx is a space that connects the mouth with the esophagus, and the nasal cavity with the larynx. The soft palate divides the pharynx into the nasopharynx dorsally and the oropharynx ventrally. The oropharynx is divided into the isthmus of fauces (throat opening) and a laryngeal part. The isthmus of fauces is bordered by the root of the tongue, the palatoglossal folds, and the soft palate. The laryngeal part of the oral pharynx extends from the base of the epiglottis to the entrance to the esophagus. In the side walls of the isthmus of fauces lie the tonsils (palatine tonsils). They lie in the tonsillar sinuses and are covered on the medial side by a thin wall, the semilunar fold.

Salivary glands (Fig. 11.2)

The dog has four pairs of major salivary glands: the parotid, mandibular, sublingual, and zygomatic glands. The parotid gland partly encloses the base of the ear and is covered on the outer surface by muscles of the ear. On the ventromedial side the gland overlaps the dorsal edge of the mandibular salivary gland. The mandibular gland is more or less rounded and lies in the angle formed by the internal and external maxillary veins; it is always easily palpated. This salivary gland is sometimes mistaken for the mandibular lymph nodes (see § 8.2.6). The sublingual gland is connected to the mandibular gland by a connective tissue sheath. The zygomatic gland lies within the orbit.

Hyoid bones

Together the hyoid bones form the supporting and connecting structure which joins the tongue and larynx to the skull. The structure consists of a single basihyoid bone, paired thyrohyoid, keratohyoid, epihyoid, and stylohyoid bones, and paired tympanohyoid cartilages. The thyrohyoid is attached to the thyroid cartilage of the larynx. The tympanohyoid is attached to the mastoid process of the skull.

Examination of the head is necessary in animals that are troubled by problems in eating or by dysphagia. The examination includes the muscles of mastication, oral cavity, pharynx, salivary glands, and hyoid bones.

Technique

The examination begins with inspection of the head, taking special notice of the masseter and temporal muscles for atrophy, swelling, or asymmetry. Note the closure of the lips and any deformities of them. Salivation and the absence of closure of the mouth can be important findings.

The muscles of mastication are then palpated, with attention to painfulness, consistency, warmth, and size.

The oral mucosa (labial and gingival) was examined in the general examination by lifting of the upper lip (Chapter 8). This can also be done now to examine the buccal side of the teeth.

For further examination of the oral cavity the mouth must be opened. Standing in front of the dog, a right-handed person places the left hand over the top of the nose with the thumb and forefinger curving down each side of the upper lip just behind the canine teeth. The forefinger of the right hand is used to open the mouth by pressing on the lower incisor teeth. If this is done slowly and quietly, most dogs will allow the mouth to be opened in this manner. In order to examine the caudal part of the oral cavity and the isthmus of fauces, the right hand is moved so that the forefinger and middle finger press the base of the tongue forward and downward. The left hand can now be shifted to encircle the nose, with the thumb resting against the hard palate (Fig. 11.3). This stimulates a reflex which causes the dog to keep the mouth open.

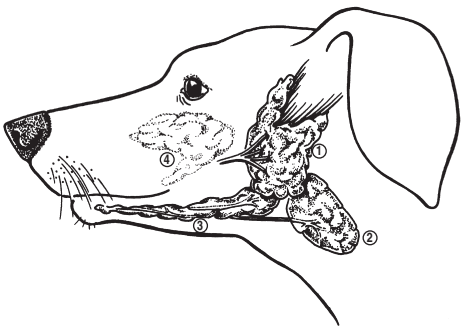


Fig. 11.2 Salivary glands in the dog: 1 parotid, 2 mandibular, 3 sublingual, 4 zygomatic.

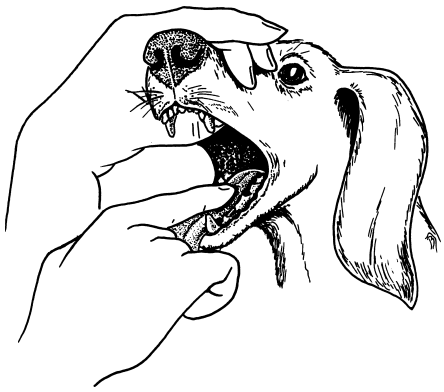


Fig. 11.3 Inspection of the oral cavity. The mouth is held open by holding the thumb of one hand against the hard palate and using a finger of the other hand to press down on the base of the tongue.

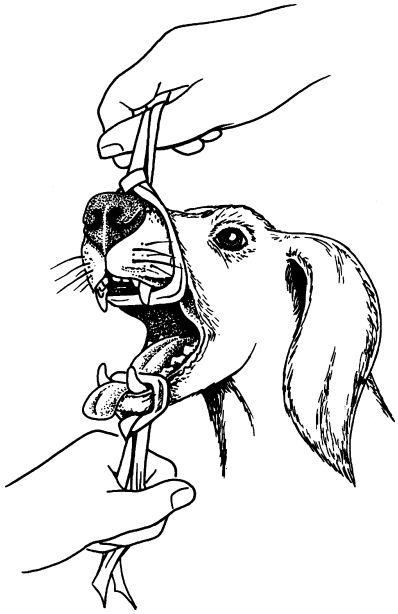


Fig. 11.4 Cloth straps can be used to hold open the mouth of a dog that resists the usual method. It is very important to remain aware of the forces involved and for this reason both cloth bands should be in the hands of one person.

It is clear that oral inspection as just described can only be carried out in cooperative dogs. If a dog resists having its mouth opened, an attempt can be made to bring strips of strong cloth between the teeth in order to spread the jaws. This usually succeeds if the dog is held quite securely, even if it is necessary to use tissue forceps between the canine tooth and first premolar to open the mouth just enough to place the cloth strips. The mouth can then be slowly opened with the cloth strips, but this should always be done by just one person (Fig. 11.4).

In cats the oral cavity can be inspected in a similar way. The mouth is opened by pressing downward on the lower incisor teeth (Fig. 11.5). It is usually necessary to restrain the front legs, as most cats resist the opening of the mouth.

While the mouth is being opened, attention is given to the ease or difficulty of passive movement of the temporomandibular joints. The animal's breath should be noted; a fetid odor may indicate necrotic tissue. Inspection of the mucosa of the buccal cavity is aided by stretching the cheek laterally with a finger. The teeth, hard palate, ventral part of the central area of the oral cavity, and the tongue are then examined.

To close this description of the technique of oral inspection we emphasize once more that this method can only provide global information about oral pathology. For thorough inspection and palpation, general anesthesia is required.

Teeth

Depending on the age of the animal, oral inspection will reveal deciduous or permanent teeth, or a mixture of the two. Deciduous teeth are much smaller than permanent teeth (Fig. 11.6). In both dogs and cats, the eruption of permanent teeth is complete by the age of 5 to 7 months, a variation that is somewhat breed dependent. The molars are the last to appear. In most dogs, molar 3 only erupts at the age of 7 months. The dentition is examined for completeness. If teeth are found to be missing during oral inspection, radiographic examination is needed to differentiate between absence and lack of eruption. Deciduous teeth found to be present after eruption of the permanent teeth are called retained or persistent deciduous teeth (Fig. 11.7). Their presence can lead to malocclusion, mucosal damage, trapping of food particles, early deposition of dental calculus, and periodontitis.

The occlusion or closure of the teeth is considered next. With correct (scissors) occlusion, the incisive border of the lower incisors touches the palatal side of the upper



Fig. 11.5 Left: Opening the mouth of a cat. Right: Close-up view of the tongue, showing the large and markedly keratinized conical papillae, characteristic of this species.

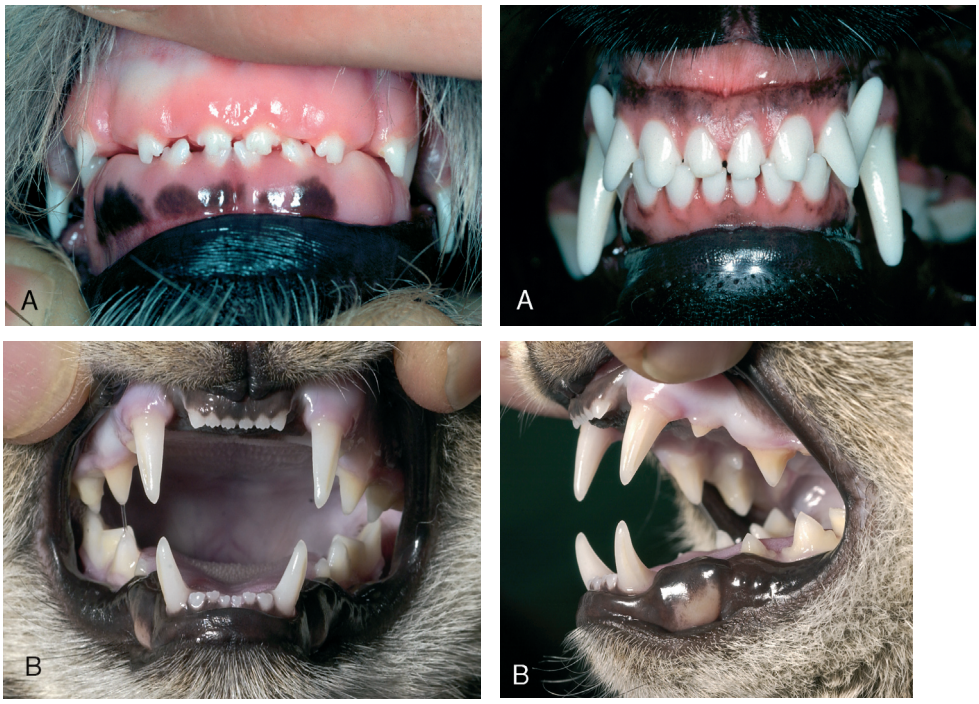


Fig. 11.6 A The deciduous teeth of a pup (left) and the permanent teeth of a 1-year-old dog (right).
B Frontal and side views of the teeth of an adult cat. The incisors are smaller than in the dog and the canine teeth are longer and sharper. These pictures also illustrate the sharp cutting premolars.

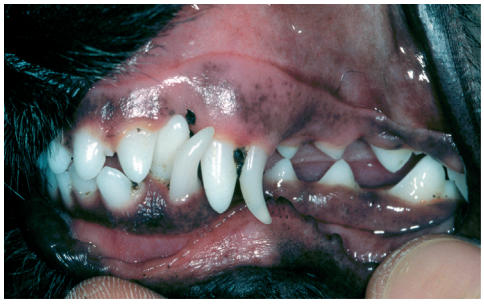


Fig. 11.7 A 7-month-old dog with persistent deciduous teeth (upper and lower canines).



Fig. 11.8 A 9-year-old dog with plaque (cremor dentium) on the canine teeth. There is also wearing of the central cusp of 101 and 201, while the cusps of 301 and 401 are still intact.

incisors. The lower canines occlude halfway between the third incisors and the canine teeth of the upper jaw. With correct occlusion, the premolars and molars interdigitate with one another ('pinking shears effect'). If the occlusion is abnormal, there may be mucosal damage. For example, a lower canine tooth that is more lingual in position can damage the hard palate, leading to pain and difficulty in eating.

The teeth are examined for the presence of plaque (cremor dentium) (Fig. 11.8), dental calculus (calculus dentium), and foreign material between them, such as hair or food residues (Fig. 11.9). The examination also includes a check for possible damage, such as fractures (e.g., canine, incisive, or maxillary P_4) (Fig. 11.10), enamel defects, and other tooth abnormalities.

Finally, the gingiva is examined for the presence of redness, swelling, and hemorrhages (gingivitis, periodontitis). This inventory provides a first impression of the condition of the dentition. An extensive inspection of the complete set of teeth is only possible with anesthesia and the use of a sharp probe and a periodontal probe. Radiographic examination is usually necessary, since only the crown, which is just one-third of the tooth, is visible.

In principle, the changes in dentition during growth and adult life (deciduous teeth, permanent teeth, wear of



Fig. 11.9 Side view of the mouth of a 10-year-old greyhound with large amounts of dental calculus, before (left) and immediately after (right) treatment. There is loss of gingival attachment to the mesial root of 108 (periodontitis).



Fig. 11.10 Complicated (open pulp) fracture of crown and root of the first molar in the right lower jaw (409).

lobules on the incisors, and the development of plaque and dental calculus) aid in estimation of the age of the animal. However, in adult dogs no reliable estimate can be made. The wear of the incisors can vary greatly, depending on use and occlusion of the teeth. Some dogs only eat soft food, while others gnaw bones and/or play with hard materials (Fig. 11.11). The first appearance and the progress of plaque and dental calculus may also vary greatly between individual animals.

In the adult dog, the combined impression of the posture, behavior, body proportions, haircoat (gray hair), eyes (cataract), and teeth may suggest a certain age, but it is still only a rough estimate and may actually be off by several years. The same holds true for cats. In fact, estimating age from the wearing away of the teeth is even less accurate in cats than in dogs.

Hard palate

The hard palate is inspected for mucosal lesions and deformities, as described for the general examination (§ 8.3.5), and to confirm that it is closed (no cleft palate).

Tongue

Examination of the tongue concerns its color, surface appearance, the presence of papillae, localized thickening, and foreign bodies. It is important to be conscious of the possibility of foreign bodies. Foreign bodies around the tongue cause swelling due to congestion of the entire tongue and such a tongue can become necrotic and then slough. In cats, needles can become embedded in the root of the tongue. The frenulum should be given special attention to be certain that no string or thread is caught there. Foreign bodies may also cause lesions under the tongue.

The lateral sublingual recesses and the apical sublingual cavity can be examined by using one finger to move the tongue to one side and lift it slightly.



Fig. 11.11 Pronounced wearing down of the teeth of a 5-year-old male bull terrier that enjoys playing with tennis balls and stones (left). In viewing this dog's maxilla from below (right), we can see that this has resulted in exposure of the pulp of the canine teeth (104 and 204) and teeth 103 and 203. Tooth 105 is missing, which could be a congenital abnormality.

The mucosa of the ventral surface of the tongue and of the bottom of the oral cavity can thus be examined and the frenulum can be inspected adequately. Inspection of the frenulum and the ventral surface of the tongue can be improved by pressing upward slightly between the mandibles while the mouth is open. The location of the sublingual salivary glands (Fig. 11.2) can be examined. A salivary cyst (ranula) may be found under the tongue. Under normal conditions, only the mandibular and part of the sublingual salivary gland is palpable.

Pharynx

Unless the dog or cat is anesthetized, the pharynx can be only partially inspected for a few moments while the tongue is depressed with the fingers. The isthmus of fauces, soft palate, and tonsils can be examined. The soft palate can usually be seen if the base of the tongue is depressed.

If the tonsils are hidden by the semilunar folds in an adult dog, it can be assumed that there is no abnormality; if they are visible, they are enlarged. If they are enlarged, the shape, color, presence of hyperemia, and appearance of the surface should be noted. In young animals the somewhat more active lymphoid tissue in the tonsils usually causes them to be visible.

A thorough examination of the oropharynx requires general anesthesia. Additional information about the pharynx can be obtained by palpating the area between the caudal edge of the mandible and the larynx. One hand is used to hold the dog's nose slightly elevated so that the area can be more easily palpated with the other hand. The hyoid bones can also be examined in this manner to detect deformities or pain.

11.2.2 Esophagus

Introduction

The oral esophageal sphincter lies dorsal to the larynx. In the neck the esophagus passes on the left of the trachea and in the thorax it is more dorsal. Under normal conditions it is empty, completely collapsed, and thus does not contain air. When a bolus of food is swallowed it is transported to the stomach by primary and sometimes secondary peristalsis. If peristalsis is reduced, the esophagus loses its tonus and becomes dilated, leading to the accumulation of fluid, food, and air. In the neck the esophagus is covered by musculature and is not palpable in healthy animals.

Technique and interpretation

During inspection, attention is given to the position of the neck, for pain caused by an abnormality in the esophagus can be manifested by keeping the neck stretched and the head low. Loss of saliva from the mouth can result from ineffective or inadequate swallowing.

Inspection and palpation of the neck can sometimes be helped by standing before the dog and raising its head with one hand. Special attention is then given to the thoracic inlet, to look for signs of a dilated esophagus. This is indicated by a slight bulging of the inlet, synchronous with expiration. If the esophagus is dilated, the left side of the thoracic inlet will probably feel full when palpated. By causing some movement in this area with the hand (rapidly opening and closing the hand or grasping and sliding the hand cranially and caudally), sloshing sounds may be heard (fluid and air). Although the thoracic portion of the esophagus is not directly accessible for examination, it can be examined radiographically if necessary.

The most frequent cause of obstructed passage through the esophagus is a foreign body. If it has been present for more than a few hours, there can be serious damage to the wall of the esophagus due to pressure necrosis. Because of the risk of perforation, the blind use of a probe or tube has no place in the examination of the esophagus.

11.2.3 Abdomen

Introduction

For purposes of physical examination of the liver, pancreas, stomach, and intestines, the entire abdomen is examined. For this examination a good knowledge of the anatomic relationships is an important requirement.

To describe and communicate our findings, we can divide the abdomen into 18 compartments (Fig. 11.12): the epigastrium, mesogastrium, and hypogastrium; dorsal, medial, and ventral; left and right.

The border between epigastrium and mesogastrium is a transverse plane just caudal to the 13th rib. The border between mesogastrium and hypogastrium is a transverse plane just cranial to the thigh musculature. Two horizontal planes equally divide the space between the lumbar muscles and the ventral abdominal wall into dorsal, medial, and ventral parts. A median plane divides the abdomen into left and right halves.

Inspection

We begin by inspecting the abdomen, giving attention to its size and form. The observations are interpreted in connection with other information, such as anorexia or pregnancy. An increase in abdominal size can lead to a specific form or shape. Hence a marked increase in the size of the liver or overfilling of the stomach will increase the size of the epigastrium and mesogastrium. Sometimes great overfilling of the intestinal tract can result in segments of intestine being noticeable by inspection. A large amount of free fluid usually results in bulging of the ventral part of the abdomen and falling inward of the upper part. Thus in the transverse plane the abdomen becomes pear shaped (see also § 10.2.3).

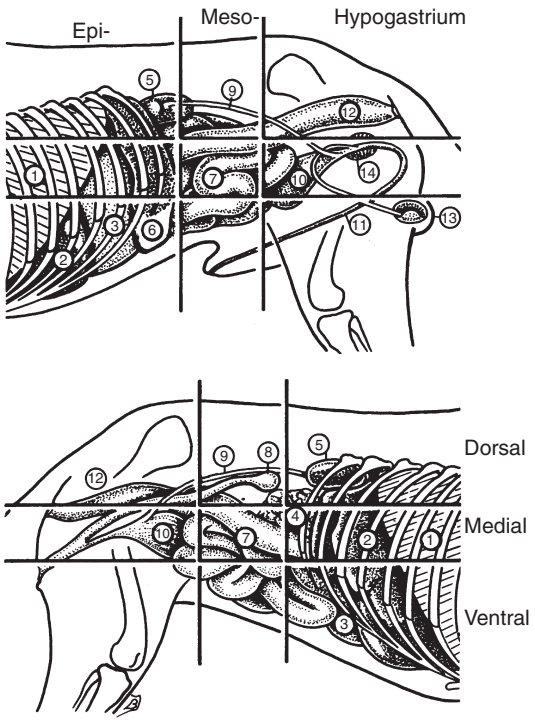


Fig. 11.12 Lateral view of the abdomen, divided into compartments: 1 diaphragm, 2 liver, 3 stomach, 4 pancreas, 5 kidneys, 6 spleen, 7 intestine, 8 ovary, 9 ureter, 10 bladder, 11 urethra, 12 rectum, 13 scrotum, 14 prostate.

Palpation

This is the most important part of the abdominal examination. It should if possible be performed while the animal is standing. The examiner takes a position at the end of the table and the person who is holding the animal stands at the side. All compartments are examined systematically and an effort is made to form an opinion about all organs in the abdomen. These findings must be directly translated into words and recorded.

In general, the palpation is done with both hands, using the fingertips of more or less flat hands. The abdomen is thereby approached from its two sides for examination of the epigastrium and mesogastrium. Certainly in large dogs the hypogastrium can also be palpated from below by standing behind the dog and bringing the hands forward between the rear legs. In small dogs and in cats, it may be easier to hold one hand on the animal's back and use the other hand to palpate from underneath.

Palpation begins in the dorsal epigastrium and proceeds to the hypogastrium. Palpation can be performed from dorsal to ventral and/or from ventral to dorsal. Full examination of the mesogastrium requires many repetitions of palpation movements. It may be very difficult to perform abdominal palpation in obese animals. Diagnostic imaging may provide a solution.

Superficial palpation

Experience teaches that a little discipline is required not to forget superficial palpation of the abdomen. It can provide valuable information. Superficial palpation means that the abdominal wall is pressed in as little as possible. The entire abdomen is explored in this manner. It allows the abdominal organs to be examined in place, that is, without affecting their position by palpating.

Abnormal muscular tension may indicate resistance by the animal due to unwillingness or pain. A tense and painful abdomen may be observed in association with acute and severe abdominal lesions. It can also be due to abnormalities in the spinal column that cause pressure on the spinal cord and/or spinal nerves.

During superficial palpation, overfilled intestinal loops and abnormal masses are not so displaced or changed in form that they are no longer recognized. Yet to be detected by superficial palpation, the abnormal structures must be more or less in contact with the abdominal wall.

Deep palpation

Deep palpation can be performed in different ways. It should always be approached slowly and performed carefully. The examiner must remain aware of and responsive to the reactions of the patient.

One method is to palpate by repeated movements with the fingers of both hands from a superficial level to as deep as possible. At many places in the abdomen the fingers from the two sides can come in contact.

Another method of deep palpation is to bring the fingers of the two hands as close to each other as possible and then to slowly move them simultaneously dorsally or ventrally so that the abdominal contents pass between them.

The objective of palpation is to discover abnormal structures, enlarged organs, pain, a thickened intestinal wall, abnormal intestinal contents, etc.

Palpation of the kidneys and urinary tract

This is described in Chapter 12.

Palpation of the liver

The liver lies in the epigastrium, completely within the costal arch and slightly to the right. In most dogs it cannot be palpated, though it may be in those with a broad thorax. In a dog with a deep thorax, such as greyhounds, the liver lies completely within the costal arch and cannot be reached. In healthy cats the caudal borders of the liver can usually just be touched.

As can be appreciated from Figure 11.12, diffuse enlargement of the liver is first detectable in the ventral epigastrium by superficial palpation. With further enlargement it can also be found by deep palpation in

the medial epigastrium, certainly if one palpates with the fingers inside the costal arch. This can usually be carried out quite well in cats. The enlarged liver will be found sooner on the right side than on the left. One can attempt by palpation to determine the texture of the surface and the presence of pain, although these features are rarely found to be abnormal.

Palpation of the spleen

The spleen is normally located in the epigastrium against the major curvature of the stomach. Since it is entirely within the costal arch, it cannot be palpated. The spleen and the stomach are loosely connected by the gastrosplenic ligament, so that when the spleen enlarges, and thus becomes heavier, it easily shifts ventrally and caudally. Enlargement of the spleen (splenomegaly) can usually be detected by superficial palpation in the ventral and medial mesogastrium and with slightly deeper palpation it can usually be recognized as the spleen because of a more or less oval cross-sectional profile. In contrast to the liver, the spleen can be displaced caudally by palpation.

If the spleen is palpable, an attempt is made to determine whether its shape is still normal.

Palpation of the pancreas

In general the pancreas is not palpable, even if abnormal. It lies in the right ventromedial mesogastrium.

Palpation of the ovary, uterus, and prostate

See Chapters 13 and 14.

Palpation of the stomach

If the liver is of normal size, the stomach, if empty, is completely within the costal arch and is not palpable. After a large meal, the epigastrium gives an impression of fullness because of a poorly defined mass that can be compressed.

In exceptional situations a markedly thickened gastric wall or a foreign body in the ventral part of the stomach can be palpated. An attempt to palpate the stomach can be made by lifting up the cranial end of the dog, in the expectation that the stomach will move somewhat caudally. The results are almost always disappointing.

Palpation of the intestinal tract

Severe overfilling of the small intestine can sometimes be detected by superficial palpation. By deep palpation the small intestine can be evaluated by letting the abdominal structures pass between the fingers of the two hands. This allows evaluation of the thickness of the intestinal wall, the contents of the lumen, the diameter, local thickening, and the presence of pain. In most healthy animals the small intestine is felt as 'supple loops', which indicates no abnormality of the wall and little luminal contents. During palpation of the intestine, the contents may give a crepitating or crackling sensation. The small intestine of the cat feels more firm and solid. Local thickening and/or irregularities can be an indication of foreign bodies, adhesions, granulomas, or tumors. Signs of obstructed passage through the intestine can also be found: too much material in the lumen, distended loops, splashing sounds. Pain associated with this may indicate peritonitis.

In most animals the colon is felt in the dorsomedial mesogastrium and hypogastrium as a somewhat stiff tube of variable diameter. By careful palpation this structure can be followed almost from the epigastrium to the hypogastrium. Its diameter is determined by the amount of feces it contains. It is usually filled, unless the animal has not been eating for several days. The colon contents are usually more segmented in cats than in dogs. Constipation and megacolon can result in extreme enlargement of the colon and extreme hardness of the fecal material. The wall of an empty colon feels more stiff than the wall of the small intestine. The diameter of the empty colon is also larger than that of the small intestine. When the contents are not too hard, careful pressure may cause an indentation. This indicates feces rather than a solid foreign body or a soft-tissue structure such as a lymph node. Solid feces also indicate there is no diarrhea.

A diffuse and generalized pathologic change in the colon can lead to palpable thickening and stiffness of its wall and the palpation can be painful for the animal.

Abdominal lymph nodes

The mesenteric and colonic lymph nodes can only be identified if enlarged. The mesenteric nodes and the right and middle colonic lymph nodes are in the medial mesogastrium. The left colonic node is nearer the junction of the mesogastrium and the hypogastrium.

Percussion

Percussion is only attempted if the abdomen is enlarged. The results may provide some information about the cause. Finger-on-finger percussion is used. It is performed along three vertical lines over the abdominal wall of the mesogastrium. Attention is given to the tone and possible local damping or a horizontal damping line. The presence of a horizontal damping line can be confirmed by repeating the percussion but with the dog in another position, such as sitting. If there is ascites, a horizontal line will also be found in this position. The percussion tone is determined by the abdominal contents: excessive gas in the intestine gives a tympanic tone, fluid gives a dull tone. Localized space-occupying processes cause a local damping.

Auscultation

The objective of auscultation is the detection of sounds occurring in the gastrointestinal tract, called borborygmi. They require the presence of fluid and gas as well as peristalsis. Their frequency says something indirectly about the character of the peristalsis, if it is known whether the animal is fasting or is in a digestive phase. A completely empty intestine can be completely silent. When the intestine is in a digestive phase of activity, the sounds are intermittent, infrequent, low-toned, and not very loud.

Auscultation is performed by placing the stethoscope on the ventral abdominal wall and listening for a few minutes. Frequent, loud borborygmi with an extremely variable high tone indicate a very strong peristalsis.

The absence of borborygmi, even though fluid and other material can be detected in the intestine by palpation or the presence of splashing sounds, indicates lack of peristalsis. This may be observed in intestinal obstruction, which is called ileus.

Generation of splashing sounds

Splashing sounds can be induced if there is a closed space containing gas and a large amount of fluid. Fluid accumulation without gas, such as ascites, an overfilled bladder, or pyometra, does not result in splashing sounds. Splashing sounds can be generated when there are large amounts of gas and fluid in the stomach and/or intestines.

Using the hands placed lower down on the abdomen on both sides, the abdomen is quickly moved up and down, while the ear is placed as close as possible or the stethoscope is placed against the abdominal wall. If splashing sounds are heard, an effort is made to determine the area from which they are coming and hence the part of the gastrointestinal tract that is involved. Splashing sounds from the epigastrium usually arise in the stomach, suggesting poor gastric emptying. Splashing sounds from the entire abdomen indicate an accumulation of gas and fluid in the small intestine. This suggests poor passage in the intestine, which could be due to a local obstruction or a generalized loss of peristalsis. Splashing sounds in the mediodorsal mesogastrium can arise from the colon and can therefore suggest the presence of watery contents, i.e., diarrhea. Interpretation of splashing sounds must be related to findings in the history and the rest of the physical examination.

Undulation test

The cause of abdominal enlargement may be found by palpation if it is a tumor or an abnormal organ, or by percussion if it is accumulation of gas. If the percussion tone is dull, the undulation test is performed to determine whether the damping is due to accumulation of free fluid in the abdomen (ascites) or enlargement of abdominal organs or accumulation of fat.

The examiner stands behind the animal with a flat hand against one side of the abdomen, while using the fingers of the other hand to give a short, sharp tap against the abdomen below the line of damping. The pressure wave which this causes is transmitted through the fluid and is felt by the flat hand at almost the same moment. If the dog does not have a very heavy coat, the pressure wave can also be seen to cause slight movement of the abdomen (see Chapter 10).

In a dog with a large amount of abdominal fat, the fat can give a slight pressure wave, but it is not so clear as that in ascites. Either a full bladder or a large fluid-filled cyst that is in contact with both sides of the abdomen can give a quite clear undulation, but it should be possible to differentiate either of these from ascites by abdominal palpation.

11.2.4 Anus and circumanal area

Introduction

The coccygeal muscle and levator ani muscle are important to the structure and function of the anus and rectum. The rectum is so enclosed by these muscles that they can be thought of as its supporting structures.

The anus is the terminal opening of the alimentary canal, but we also use this term for the combination of the internal and external anal sphincters. The anal sacs are located between the two sphincters and their excretory ducts pass along the caudal edge of the internal sphincter and exit ventrolaterally in the internal part of the cutaneous zone of the anal canal. The anal sacs form a reservoir for the secretion of the anal glands, which is thin or pasty, gray, and for humans has a very objectionable odor. The anal sacs are emptied in defecation and during sudden contraction of muscles in the anal area, as in fright and resistance.

The anal canal is about 1 cm long and lies between the termination of the rectum and the anal orifice. The mucosa of the anal canal is divided into three zones: cutaneous, intermediate, and columnar (Figs 11.13 and 11.14). The cutaneous zone has an external and an internal part. The external part does not actually belong to the anal canal. The border between the two parts, i.e., the anus, is not sharp but varies with the position of the tail. If the tail is hanging, the anus is visible as a transverse groove. The external part of the cutaneous zone does not have hair. The circumanal glands lie in the wall. The extent of this zone is largely determined by the degree of development of the circumanal glands. In older male dogs the external zone can be very broad, so that the external, dorsal (longer) part hangs ventrally. The shorter ventrolateral part runs ventrally in a slightly V-form. The internal part of the cutaneous zone is about 4 mm wide and has a slightly moist surface.

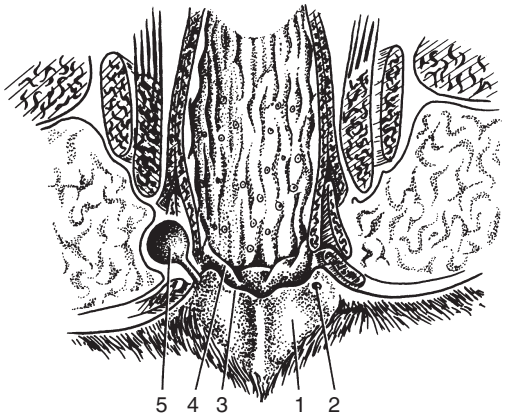


Fig. 11.13 Almost horizontal section of the anus of a dog: 1 cutaneous zone, 2 opening from the anal sac, 3 anocutaneous line, 4 columnar zone, 5 anal sac.

The intermediate zone has a width of no more than 1 mm and forms an irregular, fairly sharp edge, the anocutaneous line. This follows a more or less sinus wave form. The anal glands empty out into this zone. Their secretion is slightly fatty.

The wall of the columnar zone consists of longitudinal or slightly transverse ridges separated by the anal sinuses. The size of the latter is related to the course of the wave-shaped anocutaneous line. Most anal sinuses end cranially in a line which forms the cranial border of the anal canal, called the anorectal line. The rectum is the caudal part of the colon that is located within the pelvic canal, up to the anorectal line.

Dorsal to the rectum is the ventral part of the sacrococcygeal muscle and laterally the rectum is mainly bordered by the levator ani muscle. Ventrally it is bordered by the vagina in the female and by the urethra in the male.

Inspection

When the rectal temperature is being measured, several observations can be made, as described in Chapter 8. In dogs with defecation problems or other problems in this area, the inspection is more extensive. The following questions are a guide.

- Is the area beside the tail thickened? A loss of support by the coccygeus and/or levator ani muscle can lead to bulging out in this area, or perineal hernia. It can be on one or both sides.
- Are there perineal fistulas? Fistulas indicate extensive inflammation of the anus and sometimes also of the rectum. The inflammation and its consequences can cause problems in defecation. The openings of fistulas can be very small and therefore not readily seen.
- Are there circumanal tumors? If so, they are described in the usual manner (§ 4.1.2).
- Are there proglottids of tapeworms, in the anus or among the hairs of the adjacent skin?
- Are the anal sacs overfilled?

Palpation

Palpation of the perineal area is done with one hand while the other hand holds the tail up slightly. First,

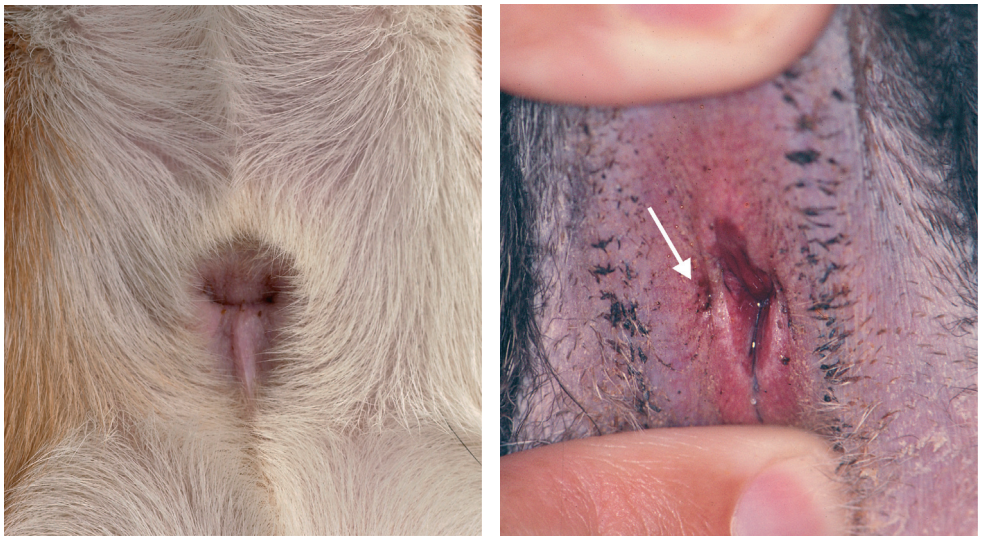


Fig. 11.14 Anus and circumanal area. Left: Raising the tail provides a view of the external part of the cutaneous zone. Right: dilation of the anus reveals the internal part of the cutaneous zone and the columnar zone. The internal sphincter is closed. The opening of the left anal sac is indicated by the arrow, while the opening of the right anal sac is hidden behind a small fold.

the condition of the coccygeal and levator ani muscles is noted. The area under the skin just to the left and right of the anus should be firm if these muscles are present and of normal size. Atrophy of these muscles can contribute to development of perineal hernia. When a perineal hernia is present, the skin can be pushed with the fingers of the palpating hand inward along the rectum, unless this is prevented by the accumulation of feces in the rectum.

Next, the circumanal area is palpated. Note is taken of the fullness of the anal sacs, thickening that could be due to tumor, or the presence of pain.

11.2.5 Rectum and adjacent structures

Introduction

Rectal examination is included in examination of the digestive tract only when there are specific indications for it. Important indications related to the digestive system are: constipation (obstruction or stricture), blood in the feces (tumor, inflammation), diarrhea (differentiation of small bowel and large bowel diarrhea), fecal incontinence, and tenesmus. Because cats tend to resist this examination, it is sometimes neglected even though there are indications for it, but this neglect is a mistake.

Technique and interpretation

The examiner stands at the end of the table and the assistant stands at the side to hold the animal. The examiner uses one hand to hold the animal's tail slightly elevated. An excess of lubricating cream is applied to the gloved forefinger of the other hand. A small amount of lubricating cream is applied to the anus, which gives the animal some warning and allows a little time for it to be calmed, if necessary. The palpating finger is then placed against the anus with light pressure and this should allow it to pass through the sphincters. No force may be used, and no turning or boring motion, since this can cause extreme pain. Rectal examination may provide much useful information. In order not to miss abnormalities, the examiner should take the time needed for careful attention to the following structures.

Anus

A normally functioning anus can be distended easily. The diameter of the anal canal should easily accommodate the palpating finger (assuming that this has been considered in advance and that the size of the finger is not too great for the size of the animal). Circumanal abnormalities can result in narrowing of the anal canal, sometimes to the extent that the finger cannot pass the anus. This should have been anticipated from a history of tenesmus together with the production of feces of very small diameter.

In general, animals do not strongly resist rectal palpation and the examiner should therefore recognize that resistance can be due to pain. Circumanal and rectal disorders can lead to pain that is so great that rectal palpation cannot be continued unless the animal is anesthetized. This may especially be required in animals with perianal fistulas.

The tonus of the anus must also be assessed. In general the tonus is such that the sphincters close firmly upon the finger. Either a reduced or an increased tonus is of importance. A reduced tonus can indicate a disturbance of innervation of the anus. If the tonus is reduced, both the anal reflex and the bulbocavernosus reflex should be checked. In the bulbocavernosus reflex, pressure on the bulb of the penis results in contraction of the anal sphincters. An increased anal tonus can indicate an increased sensitivity of the defecation reflex, which could be the reason for abnormal defecation behavior, such as defecation in the house.

The structures of the anus are then examined: the mucosa of the anal canal, the sphincters, the anal sacs, and the circumanal region. The examination can be carried out by palpating the entire area between the thumb and the finger in the anus. This main purpose of this palpation is to detect irregularities and thickening. The anal sac can be felt as a circumscribed thickening ventrolateral to the anal sphincter on each side.

Rectum

Now attention is given to the rectum and its contents. When the finger is inserted further and meets feces, the amount and consistency are assessed. The presence of a large amount of hard feces can be important (Why wasn't there a defecation reflex, or why did it not lead to emptying of the rectum and colon?).

Examination of the rectal mucosa is of great importance in animals with signs of large bowel diarrhea. In healthy animals the mucosa is supple, slightly folded and uniform. Inflammation can make the mucosa less supple and the surface finally becomes irregular. In addition, the palpation can be very painful.

Palpation should also reveal whether there is any thickening of the rectal wall or narrowing of the lumen by compression outside the wall of the rectum, or a rectal stricture. During palpation there may be a rectal contraction and this ring should not be misinterpreted as a stricture. Soft pressure will usually cause it to relax.

Coccygeal and levator ani muscles

After examination of the rectal wall, attention is given to the muscles bordering the rectum on the left and right sides, namely, the coccygeal and levator ani muscles. As mentioned above, a defect in these muscles leads to

a perineal hernia. If these muscles are intact, palpation will reveal a firm wall beside the rectum on both sides. If the muscles have atrophied, the palpating finger can reach directly to the subcutis. Because the lateral support for the rectum has been lost, there is usually a dilatation of the rectum and as a result the rectum is incompletely emptied by defecation. Since the feces remain longer in the dilated rectum, more fluid is removed and they may become hard.

Internal iliac lymph nodes

The internal iliac lymph nodes are only palpable if enlarged. Enlargement is usually due to tumor. The caudal border of the enlarged nodes can be felt dorsally through the wall of the rectum, below the lumbosacral junction. Enlargement of the nodes can also displace the colon and rectum ventrally.

Pelvic bones

The bones of the pelvic canal can be palpated. Abnormalities of the pelvis can lead to narrowing of the canal, via which the passage of feces can be severely obstructed and constipation can develop.

Prostate

Examination of the prostate is described in § 12.2.3. The prostate should be palpated in any male dog with a large bowel problem in which there is tenesmus or with any signs suggesting obstruction of fecal passage.

11.3 Notation

The results of the examination can be recorded on a form such as that shown on the DVD. The observations might result in a diagnosis, in which case a therapeutic plan will be made. More often they do not lead to a diagnosis but allow formulation of the problem to be sharpened so that a plan for further diagnostic studies can be made. Sometimes it is necessary to start symptomatic therapy in the meantime.

11.4 Further examination

There are many possibilities for further examination. Their applicability depends very much on the cost of apparatus, the anticipated number of patients to be examined in a given period, and the opportunity for the veterinarian to develop and maintain knowledge and experience.

- blood examination (routine clinical chemistry, trypsin-like immunoreactivity)
- urine examination
- fecal examination (parasites)
- plain radiography
- ultrasonography
- contrast radiography
- thin-needle aspiration biopsy and cytologic examination
- diagnostic laparotomy, also for full thickness biopsies of the gastrointestinal tract
- endoscopy (esophagus, stomach, duodenum, colon) with biopsies
- laparoscopy
- tolerance tests
- pH measurements in the esophagus
- pressure measurements in the esophagus
- measurement of gastric juice secretion, with stimulation
- liver biopsy

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12 Kidneys and urinary tract

A.M. van Dongen and H.F. L'Eplattenier

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The functions of the kidneys and the urinary tract are closely related and yet differ greatly from each other. The kidneys fill an important role in maintaining homeostasis. The production of urine eliminates the end products of metabolism and maintains the composition of the extracellular fluid within narrow limits. The urinary tract provides for the removal of urine, by means of a gradually filling reservoir which can be emptied at an appropriate time. Disorders of the urinary tract often lead to abnormal urine and/or an abnormal pattern of micturition. Kidney diseases may progress for quite some time before symptoms appear, and these may be aspecific.

If the formulation of the problem points in this direction, it must still be decided whether attention should be focused on the kidneys or on the urinary tract, bearing in mind that disorders of the urinary tract can affect the kidneys and, to a lesser degree, vice versa. While problems of the kidneys and urinary tract may overlap, it is simpler to discuss them separately, as will be done throughout this chapter, above all with regard to the history.

12.1 History

12.1.1 Kidneys

Via glomerular filtration and tubular reabsorption and secretion the kidneys are important in the maintenance of isovolemia, isosmosis, and isotonicity. In addition, the kidneys play an important role in the endocrine system, producing the hormones renin, erythropoietin, and dihydroxycholecalciferol. They are also the target organs for other hormones, such as aldosterone, parathyroid hormone, and vasopressin. Consequently, disturbed kidney function can affect many of the mechanisms of homeostasis.

Symptoms

Acute kidney disease is not usually recognized by the owner. Even with considerable loss of function in the acute phase, the only symptom may be oligouria or anuria, which can escape the owner's attention. Hence, under conditions which may give rise to acute kidney failure, such as persistent poor perfusion due to shock, it is important to ask questions about urine production and/or to measure it.

Kidney disease of longer duration can lead to symptoms recognized by the owner via three types of

functional disturbance: (1) decreased concentrating ability, (2) loss of plasma proteins, and (3) progressive loss of functional nephrons. Depending on the type of functional disturbance and its duration, the symptoms can vary considerably.

Tubular dysfunction may lead to decreased renal concentrating ability. This results in increased urinary volume (polyuria), which is compensated by increased water intake (polydipsia). If the opportunity to urinate out of doors is restricted, the increased urine production may cause the animal to urinate in the house. Since the night is usually the longest period of restriction, nocturia is usually noticed first.

Decreased selectivity of the glomerular membrane leads to increased permeability for plasma proteins of lower molecular weight. The principal result is a decrease in the concentration of albumin, but antithrombin III may also be lowered. Eventually the colloidal osmotic pressure can decrease to the extent that fluid from the vessels shifts to the interstitium, causing edema, and/or the peritoneal cavity, causing ascites (see also § 8.3.4 and § 10.2.3). A reduction in antithrombin levels can lead to the formation of thrombi, which, if they occur in the lungs, can cause dyspnea.[1]

An ascending infection of the lower urinary tract may cause pyelonephritis. Symptoms of lower urinary tract inflammation (dysuria) are usually prominent, but if there is general malaise (fever and anorexia), the cause cannot be a lower urinary tract infection alone. Further examination is indicated and may reveal pyelonephritis.

Independent of the cause and the location of the primary lesion (glomerular, tubular, or vascular/interstitial), progressive loss of nephrons eventually leads to symptoms of chronic renal failure.[2] When more than 50% of renal function is lost, the eliminating and homeostatic functions become inadequate. There is retention of compounds that are normally cleared by the kidneys, including metabolic end products such as urea and creatinine, organic acids, and hormones such as gastrin and parathyroid hormone. In addition, the excretion of administered drugs is delayed.

This leads to the combination of symptoms usually described as the uremic syndrome. In most cases the symptoms first noticed by the owner are those related to the gastrointestinal tract (decreased appetite and vomiting). At an earlier stage there may be very subtle symptoms of uremic encephalopathy, such as decreased consciousness and tremors.[3] The owner will observe that the animal is increasingly lethargic, for anemia also develops.[4] This is because with progressive loss of renal epithelium, the production of erythropoietin decreases. In advanced cases there may also be loss of blood via the gastrointestinal tract, not only from gastric ulcers associated with uremic gastritis but also as a result of hemorrhagic diathesis. The latter is due to an acquired 'uremic' thrombocytopathy and a related disturbance of the interaction of thrombocytes and vascular wall.[5,6]

In chronic renal failure the conversion of vitamin D to the metabolically-active 1,25-dihydroxycholecalciferol (calcitriol) may decrease, which in turn decreases the absorption of calcium from the intestine. The resulting tendency to hypocalcemia stimulates the release of parathyroid hormone (PTH) from the parathyroid glands. The decrease in negative feedback of calcitriol on PTH production contributes to increased PTH release. In young animals this secondary hyperparathyroidism may give rise to hyperostotic reactions on the skull, which may be observed by the owner. In older animals hyperparathyroidism leads primarily to osteodystrophy. This consequence of renal insufficiency rarely causes bone loss to the extent that a so-called rubber jaw develops.[5]

Living conditions and past history

It is important to consider two diseases which may not be indigenous to the area, leishmaniasis and dirofilariasis, which are often associated with severe glomerulonephritis. This possibility underscores the importance of questions about the patient's living conditions and past history, whether it has originated from or been taken to foreign countries.

12.1.2 Urinary tract

The bladder has two functions. In its reservoir function it is gradually filled with urine and in its micturition function it is rapidly emptied. The detrusor muscle of the bladder facilitates the reservoir function and also contributes to emptying. The neck of the bladder and the cranial part of the urethra facilitate opening and closing.

When there is a relatively low degree of filling the pressure in the bladder remains low and the neck of the bladder remains closed. As the filling increases, stretch receptors in the bladder wall activate a spinal reflex. If higher centers do not suppress the urge to urinate, this reflex leads to a detrusor contraction, which is accompanied by relaxation of the neck of the bladder and of the urethra. When contraction and relaxation are coordinated (detrusor-urethral synergism) the bladder empties itself with very little back pressure from the neck of the bladder and the urethra.

The detrusor contracts after cholinergic parasympathetic stimulation by the pelvic nerve. The decreased sympathetic stimulation of the neck of the bladder and urethra (predominantly via α-adrenergic receptors) results in lowering of the resistance of the bladder outflow tract. The simultaneous reduction in

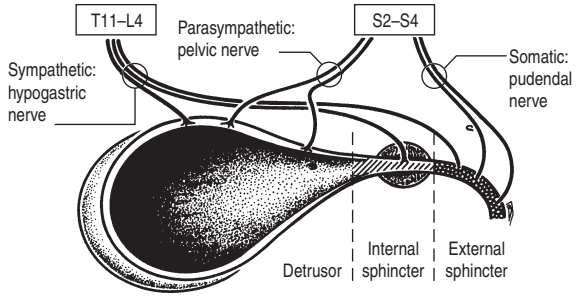


Fig. 12.1 Neurologic influence on the bladder and urethra.

sympathetic stimulation of the fundus of the bladder (passing via the hypogastric nerve and β-adrenergic receptors) makes an unimpeded contraction of the detrusor muscle possible. Thus the *micturition phase* is dominated by parasympathetic stimulation via the pelvic nerve; the sympathetic influence in this phase is minimal (Fig. 12.1.). The *reservoir phase* is dominated by the hypogastric nerve. Sympathetic control of α-adrenergic receptors in the neck of the bladder and urethra leads to adequately high closure pressure. Simultaneous stimulation of β-adrenergic receptors in the neck of the bladder causes a reduction in the parasympathetic reflexes. During the reservoir phase the sympathetic influence thus dominates and the parasympathetic influence is minimal (Fig. 12.1).

An uninterrupted detrusor contraction is only possible in the absence of blocking influence from higher centers. The possibility of voluntary interruption of micturition must always be considered in the evaluation. It is important, for example, in the micturition behavior of male dogs.

The micturition of female dogs and cats and intact and castrated male cats can be considered to be normal if a large volume of urine is produced by the first attempt at urination. The owners of healthy female dogs and cats should be able to report that the urine is released in an adequately forceful stream. The male dog's micturition is repeatedly interrupted when he is urinating for the purpose of marking his trail. The conclusion 'undisturbed micturition' in male dogs can only be made after an extensive history interview and/or the veterinarian's own observation. Sometimes it is necessary to measure the amount of residual urine in the bladder. If the animal has had adequate opportunity to urinate, this volume should be small (0.2–0.4 ml/kg).[7]

Symptoms

Symptoms of a urinary tract abnormality that the owner can observe concern the urine (odor and color) and micturition (dysuria and urinary incontinence), and they will be discussed in this order. Finally, consideration will be given to tenesmus alvi, a sign sometimes seen in abnormalities of one of the adnexa of the urinary tract, the prostate. Just as in preceding chapters, the various signs will be discussed independently but it should be understood that they often occur in combination.

The urine of intact male cats in particular has a very penetrating odor. In dogs and female cats this is not so often the case. If there is a pronounced bacteriuria the owner may note a 'sharp' odor because a large amount of urea is converted to ammonia.

Whenever bloody urine is reported, it must be determined whether this means *hematuria* (mixing of blood in the urine) or *blood loss independent of micturition*. This is a question which many owners cannot immediately answer with certainty. Questions concerning the animal's house training, fluid loss in the house, and the pattern of micturition almost always provides a definite answer. Blood loss independent of micturition indicates hemorrhage distal to what is sometimes referred to as the internal sphincter (neck of the bladder and proximal urethra). Sources of such blood loss in male dogs include the prostate, penis, prepuce, and urethra. Bright red blood suggests a very distal bleeding, while darker blood corresponds to a more proximal bleeding. In female animals the source of the bleeding can be in the genital tract (see Chapter 13).

The occurrence of hematuria means that the source of the blood is proximal to the internal sphincter (Fig. 12.2). Concentrations of 2.5×10^9 erythrocytes/l can be observed with the naked eye; in other words, this is the border between microhematuria and macrohematuria. It is very exceptional for urine streaming through the urethra to become mixed with blood originating locally in the urethra, without blood loss also occurring independent of micturition. Hematuria can originate in the bladder, ureter, or kidney.

Hemorrhage originating in the bladder can be differentiated from that originating in the kidney or ureter by asking whether there is simultaneous dysuria

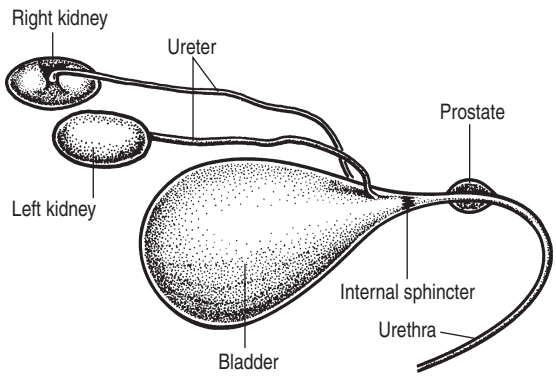


Fig. 12.2 Schematic drawing of the urinary tract in a male dog.

(painful and/or difficult micturition). If there is dysuria it is very likely that the blood enters the urine in the bladder. Blood loss from the kidneys or ureters is not associated with dysuria.

The color of the blood, the presence of blood clots, and the mixing of blood with the urine can also aid in differentiating between hemorrhage in the bladder and hemorrhage in the kidney or ureter. If blood in the urine occurs primarily at the end of micturition and the color is bright red, it is highly probable that the bleeding is occurring in the bladder. The presence of blood in the urine throughout urination, resulting in a dark red fluid and usually without blood clots, indicates bleeding in the kidney or ureter.

Dysuria is the result of stimulation of pain-sensitive and stretch-sensitive receptors in the bladder wall. These stimuli follow an afferent pathway via the pelvic nerve and the resulting efferent stimuli via parasympathetic fibers can lead to detrusor contractions. Owners then report symptoms such as painful discharge of urine (stranguria) and/or frequent passage of small amounts of urine (pollakiuria) In the absence of a urethral obstruction this is associated with a moderately filled or empty bladder. Disorders such as cystitis, a tumor of the bladder, or cystic calculi can generate persisting afferent stimuli, leading to repeated nonproductive straining. The owner usually reports that the animal remains straining after micturition.

Urinary incontinence is involuntary urine loss in which the bladder pressure exceeds the resistance of the urethra (Fig. 12.3). There are two principal types to differentiate:

1 a relatively too low urethral resistance (sphincter incontinence)
2 a relatively too high bladder pressure (detrusor incontinence).

In the discussion with the owner it is usually possible to differentiate between these two forms. Detrusor incontinence is usually seen in connection with signs of dysuria. The owner usually reports that the dog loses urine while lying and/or sleeping. When sphincter incontinence is being considered, it is important to check whether there is polyuria. Rapid overfilling of the bladder can lead to involuntary urine loss in the presence of an otherwise appropriately functioning sphincter.

In some bitches, castration leads to loss of sphincter function and thus urinary incontinence. Disorders of the nerves controlling bladder function may also cause incontinence. A neurogenic cause could be suggested by the presence of other neurogenic deficits: ataxia or paresis, decreased tone of the tail muscles, and fecal incontinence. The simultaneous occurrence of dysuria or stranguria with a full bladder and urinary incontinence is usually caused by a functional urethral obstruction with an overflow bladder.

The occurrence of urinary incontinence in a young animal should lead to consideration of a congenital disorder. One or both ureters may be ectopic, inserting in the urethra caudal to the sphincter. This typically results in a history of persistent urine loss, drop by drop. Owners sometimes mistake the loss of another fluid for urinary incontinence, such as the loss of fluid associated with vaginitis or balanoposthitis.

Tenesmus alvi is painful and/or difficult defecation (see also Chapter 11). Enlargement of the prostate can lead to hindrance of the passage of feces through the rectum. In pronounced cases the feces are even flattened. An enlarged prostate sometimes slides forward toward the abdomen, which increases the space for passage of feces, but abdominal pressure during defecation displaces it caudally again, with the result that the defecation reflex which has arisen is increased even further, leading to tenesmus.

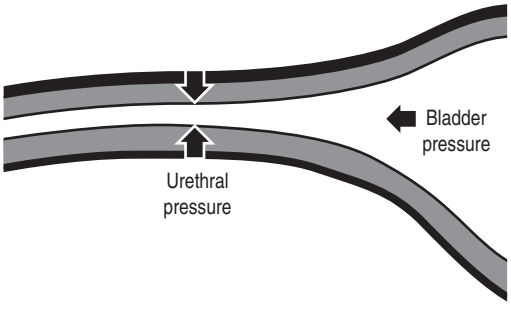


Fig. 12.3 Urodynamic relation between the bladder neck and the bladder lumen.

12.2 Physical examination

The physical examination includes examination of the head and the abdomen, with special attention to the kidneys, bladder, and prostate. The urethra and prostate are examined per rectum and then the penis and prepuce or the vulva and vagina are examined.

12.2.1 Head

The examination of the head begins with examination of the bony structures, which are palpated to detect possible hyperostotic changes. Then the jaws are examined for possible softening or flexibility ('rubber jaw'). The color of the mucous membranes may indicate the presence of anemia. In severe uremia there may be a strikingly sharp fetor ex ore due to ammonia and eventually there may be mucosal ulcers.

12.2.2 Abdomen

Examination of the abdomen proceeds as described in § 11.2.3 and includes inspection and palpation of the abdomen and, if indicated, percussion and testing for

undulation. The abdomen is inspected to determine whether it is drawn up in a normal manner or hangs too low, and whether it is distended, symmetrically or asymmetrically. The abdomen is first examined by superficial palpation and then by deep palpation. Percussion and testing for undulation are performed if the abdomen is enlarged. Ascites can be the result of severe proteinuria (see § 12.1.1) but it can also occur following traumatic rupture of the urinary tract. Examination for the presence of ascites is discussed in Chapters 10 and 11. Sometimes a full abdomen is seen in combination with dysuria; this can be the result of urine retention of such severity that the increased circumference of the bladder is outwardly visible.

Kidneys

In dogs both kidneys are retroperitoneal and are held in position by subperitoneal connective tissue. The fixation is fairly loose and the kidneys are slightly displaced by respiratory movements. The right kidney lies slightly more cranial than the left (Fig. 12.4). In most dogs the right kidney does not lie entirely within the costal arch. The cranial pole lies in the caudal fossa of the liver. The medial limit of the right kidney is immediately adjacent to the caudal vena cava and the ventral border makes contact with the pancreas and the ascending colon. The left kidney also contacts the pancreas cranially and the craniolateral surface lies against the medial side of the spleen and the major curvature of the stomach. The caudal vena cava also lies on the medial border of this kidney and the descending colon is ventral to it.

In the dog usually only the caudal pole of the left kidney can be palpated. A distinct increase in size as a result of tumor, cyst, or hydronephrosis can usually be confirmed by palpation. In contrast, a reduction in size is very difficult to confirm and attempts to do so still lead to mistakes.

In the cat it is usually possible to palpate both kidneys. The retroperitoneal fixation is much less firm than in the dog. The kidneys can also be moved by the palpating fingers, which sometimes results in a kidney being mistaken for an abnormal mass.

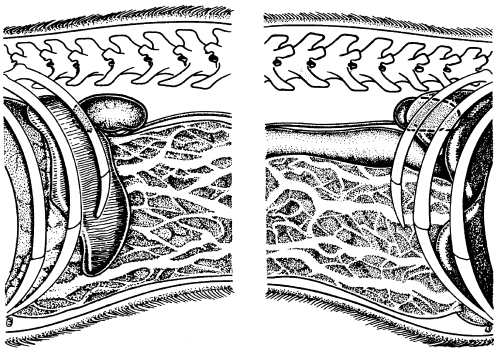


Fig. 12.4 The location of the left and the right kidney.

Because of the more supple abdominal wall of the cat it is usually easier to say something about the size and consistency of the kidneys than it is in the dog. Sometimes even the surface can be described. Thus it may be possible to detect the effects of fibrous tissue contraction in the kidney (in chronic renal insufficiency), as well as perirenal cysts and neoplasia. In obese cats the kidneys may be surrounded by so much fat as to create the false impression that they are enlarged. In very thin cats the kidneys can usually be palpated in detail, including the hilus.

Ureters

The ureters are retroperitoneal and even when markedly dilated they are not palpable. Both ureters lie chiefly in the immediate vicinity of the aorta and caudal vena cava. They proceed caudally and then curve ventrally to open out in the trigone of the bladder.

Bladder

The bladder is bordered ventrally by the abdominal wall and dorsally by the descending colon. Depending on the degree of filling, the bladder may also contact the abdominal wall laterally. In the cat the colon is so moveable that when filled it can lie lateral to the bladder. In this case a well-circumscribed bolus of feces could be mistaken for a bladder stone, but a bladder stone cannot be compressed.

In dogs and cats the bladder is almost always palpable if the abdominal wall is not too tense. If it is only slightly filled, the bladder is recognized as an accumulation of fluid surrounded by a supple wall. If the bladder is tense and stiff, there is an increased degree of contraction of the detrusor muscle, which must always be considered abnormal. An empty bladder will be felt as a ball of tissue. The position of the bladder is naturally much dependent upon the degree of filling. A moderately filled bladder will be found in the ventral and medial hypogastrium, while a very markedly filled bladder can reach into the epigastrium.

In large dogs, two-handed palpation beginning at the top of the abdomen is best. In small dogs and in cats the bladder can be palpated easily from the ventral side with one hand. The degree of filling can be determined by superficial palpation. By somewhat deeper palpation one can sometimes detect bladder stones or abnormalities of the wall due to tumor.

Prostate

The normal prostate lies in the pelvic cavity and hence is not detected by abdominal palpation. When it is markedly enlarged the prostate is found in the hypogastrium as a firm, usually rounded mass of tissue. Enlargement due to cyst formation can be mistaken for

the bladder. This is particularly so when the cyst arises from the remnant of the Müllerian duct, lying in the dorsal capsule of the prostate (paraprostate cyst).[7] Sometimes both the bladder and the cyst can be palpated but in other cases further examination is needed, such as repeating the palpation after emptying the bladder by catheterization.

12.2.3 Rectal palpation

Rectal palpation has been described in § 11.2.5. Here we are concerned with using it to examine the urethra and prostate.

Urethra

The urethra lies on the median line on the floor of the pelvis and can be palpated per rectum in the male dog from the caudal border of the prostate until it turns over the edge of the pelvis. In the female dog the urethra can be palpated over its entire length. A normal urethra feels smooth and supple and is fairly easy to move over the floor of the pelvis.

Prostate

In the noncastrated male dog which has reached sexual maturity the prostate is easily palpated rectally. A sulcus can almost always be felt on its dorsal midline. This corresponds to a medial septum that divides the prostate into left and right lobes. As the animal ages the prostate becomes enlarged by hypertrophy. As a result of severe hypertrophy the prostate can gradually become more abdominal in position. This displacement can be so great that the prostate is no longer palpable per rectum without other maneuvers. After castration the prostate atrophies markedly but is often still palpable per rectum.

While palpating as described in § 11.2.5, the opposite hand is used to slightly raise the hypogastrium during rectal palpation to help in evaluating the size and displacement of the prostate. For this purpose the hand is placed flat against the abdominal wall just in front of the pelvis. By pressing upward on the abdominal wall with this hand one lifts the prostate up slightly and brings it more into the pelvic canal. This considerably increases the possibility of examining the prostate per rectum. Rectal examination is rarely performed in the cat. The fifth finger is used and sometimes sedation is required. There are far fewer indications for this examination in the cat than in the dog.

12.2.4 Penis and prepuce

The glans penis of the dog is divided into a bulbus and a pars longa. The pars longa is the distal three-fourths. The more proximal bulbus is a cavernous expansion of the corpus spongiosum. During erection the dorsal part in particular is swollen enormously. The urethra passes ventrally through the corpus spongiosum and is partly enclosed by the os penis.

The prepuce is largely attached to the ventral abdominal wall. Only the tip hangs free. In the absence of erection the prepuce encloses the pars longa and part of the bulb of the penis. Congestion of the extended penis preventing its withdrawal back into the prepuce results in paraphimosis. The preputial mucosa contains lymph follicles which are most numerous where the mucosa is reflected around onto the penis.

Inspection of the penis and prepuce is mainly important if there is a history of blood loss independent of micturition. Sometimes the lesions which are the source of the bleeding can only be found by very careful inspection of the mucosa of the penis and prepuce. Under normal conditions the mucosa is pink, smooth (except for the lymph follicles), and moist. In many male dogs the mucosa is slightly inflamed, which causes a slightly red color and the accumulation of some purulent exudate in the preputial opening.

Inspection is performed with the dog lying on its side. Holding the dog with its back slightly arched will tip the pelvis slightly forward. This makes the exposure of the penis easier (Fig. 12.5). A finger placed against the fold of skin between the prepuce and the abdominal wall can push the prepuce caudally over the pars longa of the penis. This movement also points the penis in a more ventral direction and the prepuce can be brought back over the bulbus. This exposure of the penis should not meet any noticeable resistance.

12.2.5 Vulva and vagina

This subject is also covered in Chapter 13. Here we cover only a few aspects that are of importance in connection with function of the kidneys and urinary tract.

Vulva

Attention is given to the position of the vulva. A more cranioventral position can be an indication of



Fig. 12.5 With the dog in lateral recumbency, the penis can be exposed by pushing against the fold between the prepuce and the abdominal wall.

intersexuality, in which case an enlarged clitoris can also be found. Attention is also given to the skin and hair coat immediately surrounding the vulva. Moist hair and skin changes can be associated with urinary incontinence.

Vagina

In larger female dogs with a large enough vagina, the urethra can be felt on the pelvic floor by palpating with a finger. The urethral orifice can be felt as a small depression in the ventral vaginal wall at the height of the ischial arch. Cranial to this the urethra can be felt as a stiff cord with a diameter of about 0.5 cm.

The urethral orifice is examined closely during vaginoscopy. Attention is given to possible deformities and also to the appearance of the adjacent mucosa.

12.3 Further examinations

In order to increase levels of practice, the following procedures can be used:

- urine examination (biochemistry and sediment)
- blood examination (for renal function)
- plain radiographs
- ultrasonography
- bacteriological examination of urine, with antibiotic sensitivity testing
- quantitative measurement of protein loss
- renal function studies (including endogenous creatinine clearance)
- CT and/or MRI

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13 Female reproductive tract

A.C. Schaefers-Okkens and H.S. Kooistra

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An important consideration in this examination is that not only the condition of the female reproductive tract but also the animal's behavior depends on the stage of reproductive function (estrous cycle: anestrus, pregnancy, parturition, postpartum period). In addition, ovariectomy or ovariohysterectomy results in considerable change.

The animal's age and breed are also important. The frequency of gynecological abnormalities in the bitch increases with age. There is on average a smaller number of relatively heavier pups delivered in smaller breeds of dogs than in larger breeds. This can have major effects on parturition, certainly if the size of the bitch's pelvis and the shape of the pups are not compatible, as in some brachycephalic breeds.[1]

If, after the general history and formulation of the problem, the diagnostic plan includes examination of the female genital system, the next step is to take a specific history concerning this system. The physical examination then begins with external examination of the vulva and its surroundings and of the abdomen. This is followed by internal examination of the vagina and possibly palpation per rectum. It may be necessary to repeat the physical examination one or more times, e.g., on alternate days to determine the optimal time for mating.

13.1 History

After the general history, detailed questions concerning the functioning of the reproductive system are asked. The information of interest includes any observation of vaginal discharge, any change in the size of the abdomen, estrous cycles, attempted matings, and parturition and the postpartum period.

13.1.1 Symptoms

One of the most frequent symptoms of a gynecological problem is an abnormal vaginal *discharge*. A distinction must be made between a physiological and a pathological discharge. The latter is usually the result of inflammation of the uterus (endometritis or pyometra), but vaginitis, tumors of the vagina, and urological disorders can also cause an abnormal vaginal discharge. Particularly in middle-aged and older bitches, inflammation of the uterus can develop directly or shortly after estrus. Treatment with progestagens to prevent estrus or with estrogens to prevent pregnancy after an unwanted mating increases the chance of endometritis. The owner must be asked about the amount and character of the discharge. The discharge from an endometritis is usually yellow (mucopurulent). Chocolate-colored (hemopurulent) discharge indicates a severe inflammation, the color resulting from the mixture of blood with the purulent exudate. This discharge almost always has a characteristic nauseating odor, which has also been noted by the owner.

Physiologic discharges occur at the time of parturition, during the postpartum period, and during the estrous cycle. The normal discharge after parturition lasts 2–3

weeks in the dog. In dogs and cats the placenta is usually expelled directly after delivery. The color of the discharge in the dog is red–green shortly after the end of parturition, becoming red after 1–3 days, then rust-colored, and finally colorless and mucoid at 8–14 days after parturition. The green component of the discharge directly after parturition is the result of the release of hemochlorine from the green zone at the edge of the placenta. In the cat the discharge is red for a few days after parturition, but quickly becomes lighter in color and then finally becomes colorless and transparent. Usually there is no discharge after 7–10 days postpartum. Involution of the uterus takes about 12 weeks in dogs but much less in cats.

The period in which the female is in heat—attractive to males—includes proestrus, estrus, and about the first two days of metestrus. It lasts 2½ to 3 weeks and is characterized by a discharge which is initially serosanguinous, gradually changing to pink, then light yellow, and finally colorless and mucoid. In some dogs the vaginal discharge remains serosanguinous throughout the heat. At the end of the heat or during the first days of metestrus the discharge ceases. The blood comes from the endometrium and its presence in the lumen is explained by the loss of red blood cells from the capillaries by diapedesis. In the cat the vaginal discharge during estrus is much less noticeable but a small amount of clear serous fluid is observed.

The *size of the abdomen* can increase as a result of pregnancy, pyometra, or tumors of the reproductive system.

Abnormalities of the *estrous cycle* are observed quite often. Certain gynecological disorders are related to the stage of the cycle. It is important to obtain information about (1) the time and duration of proestrus and estrus, (2) the length of the interval between estrous periods, (3) the nature and amount of the discharge, (4) the animal's breeding behavior, (5) matings during estrus, and (6) other notable information such as the occurrence of pseudopregnancy during metestrus in the bitch and any hormone therapy to prevent estrus or to prevent pregnancy after unwanted matings.

A short summary of the estrous cycle in dogs is given below. The first estrous period in a bitch can be expected at around 6–9 months of age. The dog is *monestrous*: its sexual cycles occur at intervals of 6 months to a year. In monestrous animals the luteal phase is followed by anestrus of at least 1–2 months, prior to the follicular phase of the next cycle. In some breeds, such as the basenji and the Tibetan mastiff, estrus usually occurs only once a year.

The phases of the estrous cycle can be classified according to the behavior of the bitch (proestrus, estrus, and metestrus) or according to the hormonal and ovarian changes (follicular phase, ovulation, and luteal phase) (Figs 13.1 and 13.2).[2,3] The follicular

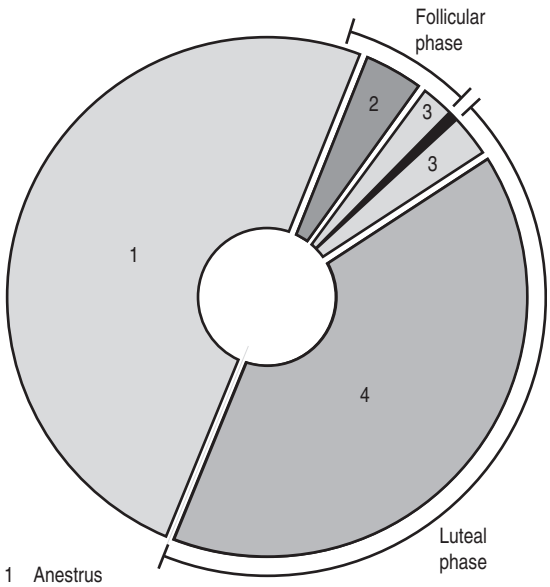


Fig. 13.1 Diagram of the estrous cycle and anestrus in the dog.

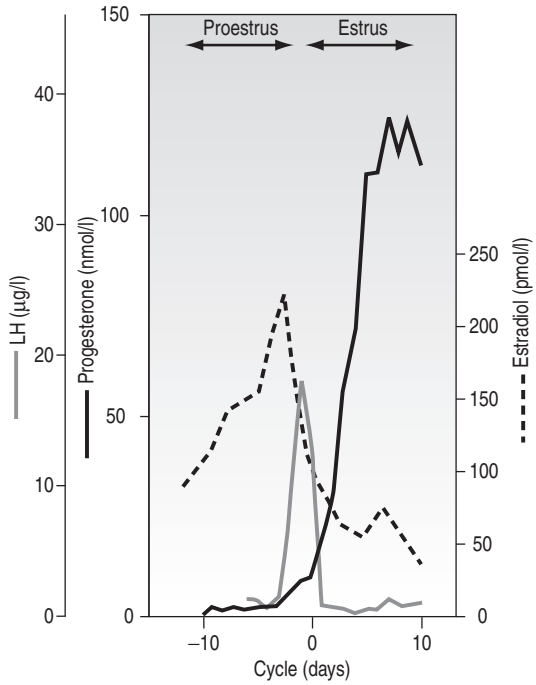


Fig. 13.2 Concentrations of estradiol, LH, and progesterone in blood plasma in relation to estrus behavior of the bitch.

phase comprises the end of anestrus, proestrus, and the first part of estrus. The luteal phase begins with ovulation and comprises the second part of estrus, including the fertilization phase and metestrus.

- *Proestrus*. The average duration of this phase is 9 days (range 3–16 days) and its onset is marked by the first discharge of blood. There is considerable ovarian follicular activity and thus production of estrogens. The blood supply to the genital tract increases and various parts of it increase in size (the vulva swells, the diameter of the uterus increases,[4] and the vaginal mucosa swells).
  The bitch's behavior changes and her pheromones attract male dogs but she does not allow mating. Proestrus is thus a clearly recognizable and unmistakable phase of the cycle in the dog. It is also quite long in the dog, in comparison with other species, but certainly should not be confused with estrus.
- *Estrus*. The average duration of this period is also 9 days (range 4–12 days). In part the signs are the same as those in proestrus, but the most important characteristic is that *the bitch now accepts being bred*. The discharge gradually changes from red to pink and then becomes colorless. Ovulations usually occur on the second, third, and/or fourth day of estrus. During these days the bitch usually displays the optimal standing reflex, also called the tail reflex. When the bitch is touched around the vulva she holds her tail away from the body and to one side, while the vulva is turned toward the other side by contraction of the constrictor vestibuli muscle.
- *Metestrus*. This period lasts for about two months. It begins when the bitch will no longer allow mating and it ends when the corpora lutea are no longer active and the plasma progesterone concentration decreases to the basal level. The swelling of the vulva and the vaginal mucosa gradually decreases in this period.
  Pseudopregnancy often occurs during metestrus.[5]
- *Anestrus*. This is primarily a rest phase. There is little activity in the ovaries.[6] The vulva is small, the diameter of the uterus is small, and the vaginal mucosa is not swollen. Anestrus continues until the next follicular phase. Since domestic dogs are in estrus every 6 or 7 months on average, anestrus lasts 3–4 months, but there are large differences both within and between breeds. Anestrus is relatively short in German shepherd dogs (21 weeks[7]) and relatively long in collies (47 weeks). As noted above, in the Tibetan mastiff and the basenji estrus occurs only once a year.

When there are problems during parturition in dogs and cats, an adequate history must be obtained concerning the pregnancy and *the course of parturition* thus far. Information should also be obtained about the sire and the mating and about the number, dates, and course of earlier deliveries (normal, abnormal, full term, size of litter, perinatal deaths, therapeutic interventions, etc.). If problems appear following delivery, questions are also asked about the *postpartum period*.

13.1.2 Living conditions

The surroundings can have a great influence on the progress of parturition. Anxiety and restlessness can markedly retard the process.

Information about the health and general condition of other animals in the surroundings (e.g., in a kennel) should be included in the history. Bitches living closely together in kennels can mutually influence the onset of their estrous cycles.

13.2 Physical examination

13.2.1 External examination

The external examination consists of examination of the vulva and its surroundings and then examination of the abdomen.

Vulva and perivulvar area

It is noteworthy that in the dog, in contrast to many other animal species, the distance between the anus and vulva is fairly great (Fig. 13.3). From the vulva the vaginal vestibulum rises steeply in a craniodorsal direction to the junction between the vestibulum and vagina, just under the level of the anus. The vestibulum in the dog lies just beneath the body surface and hence a space-occupying structure within it (e.g., a tumor, or a fetus during delivery) causes a rounded elevation between the anus and the vulva. This is noticeable during the inspection and can be palpated.

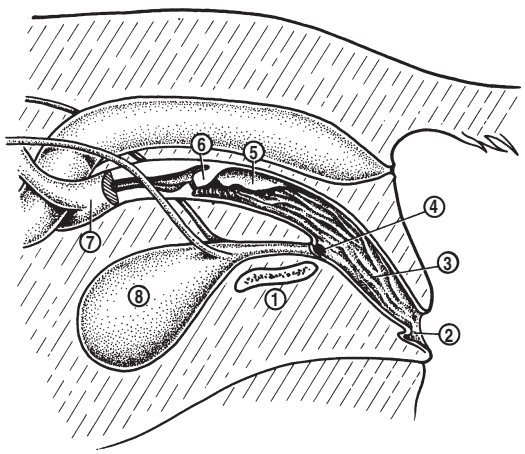


Fig. 13.3 Schematic sagittal section through the vestibulum and vagina in the bitch. 1 pubis, 2 clitoral fossa and clitoris, 3 vestibulum, 4 urethral orifice, 5 dorsal medial fold, 6 cervix, 7 uterus, 8 bladder.

In a dog with *vulvar discharge* the underside of the tail and the skin around the vulva can be soiled, especially in those too ill to clean themselves by licking. To enable good inspection it may be necessary to cleanse the perivulvar area and to clip away the hair.

The vulvar opening and especially its ventral commissure can be examined for the presence and characteristics of a discharge by use of a white gauze pad. Physiological and pathological types of discharge were mentioned briefly in § 13.1.1. Pathological discharge can be further characterized as mucopurulent (white to yellow), purulent, hemopurulent, ichorous (rotting, green to red-brown, from dead fetuses), or hemorrhagic. It is especially important to note the odor of the discharge. As indicated in § 13.1.1, in a dog or cat with endometritis the discharge usually has a very characteristic nauseating odor. There may be particles of tissue in the discharge, as can result from a tumor in the vagina.

The examiner evaluates the *shape and size of the vulva*. Changes in shape and size occur especially in the bitch. During anestrus the vulva of the bitch is small and well closed and the vulvar opening is largely covered by a fold of the skin between the vulva and the anus, called the dorsal fold. During estrus the vulva swells, sometimes becoming so large that the dorsal fold disappears (Fig. 13.4). Both the ventral and the dorsal commissures are then visible. During metestrus the vulvar swelling gradually decreases. At the end of pregnancy and around the time of parturition the vulva is also markedly swollen. Vulvar swelling also occurs in a few pathologic processes in the reproductive tract, such as inflammation. Sometimes the lips of the vulva are not well closed (e.g., due to a vaginal tumor or extensive edema (vaginal fold prolapse) of the floor of the posterior vagina).

By carefully *spreading the lips of the vulva* one can examine the mucosa of the vulva and the most caudal part of the vestibulum in the bitch. During anestrus this mucosa is pink and nonglossy, and small blood vessels are usually visible. When there is inflammation of the uterus or birth canal the mucosa is often eroded, possibly because the animal repeatedly licks and abrades the vulva. In contrast, during estrus the mucosa is pale pink and has a glossy, edematous appearance. Under the influence of estrogens, the 2–3 cell layers increase to 20–30.

An impression smear of the vaginal vestibulum may indicate the prevailing hormonal influence and thereby of the stage of the cycle. During the early follicular phase, there are a few superficial cells but mainly large and small intermediate and parabasal cells, neutrophils, and erythrocytes. A few days after the beginning of proestrus, the picture is dominated by superficial cells and a variable proportion of large intermediate cells and erythrocytes. The cytological picture does not change until the beginning of metestrus, thus remaining the same through the follicular phase, ovulation, and the first part of the luteal (fertilization) phase. The cytological changes may not be synchronous with the behavioral changes of the transition from estrus to metestrus. During metestrus and anestrus varying proportions of large and small intermediate cells, parabasal cells, and neutrophils are observed (Figs 13.5, 13.6, and 13.7). During anestrus basal cells can also be found. Cytological examination thus allows recognition of (1) the early follicular phase, (2) the advanced follicular phase up to and including the beginning of the luteal (fertilization) phase, and (3) the beginning of metestrus. The time of ovulation, which is needed to determine the optimal period for mating, cannot be identified by this method.

Abdomen

The external examination of the abdomen is very important in the dog and the cat. The normal nonpregnant uterus passes through the dorsal mesogastrium and hypogastrium to the pelvis and is about 5 mm thick. During proestrus, estrus, and much of metestrus in the dog, the uterus is slightly thicker.[4] When the uterus increases considerably in circumference for physiologic or pathologic reasons



Fig. 13.4 The vulva of a beagle bitch during anestrus (left) and proestrus (right).

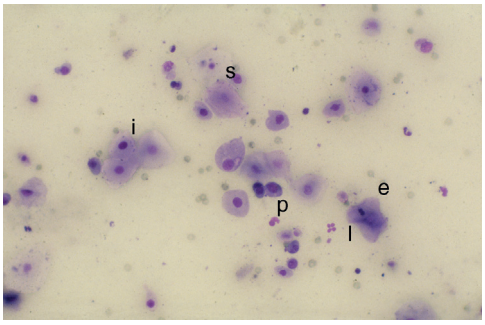


Fig. 13.5 Cytology of the vaginal vestibulum of a bitch during the early follicular phase: mostly intermediate cells (i), a few superficial (s) and parabasal (p) cells, erythrocytes (e), and leukocytes (l). (x200, May-Grünwald-Giemsa stain).

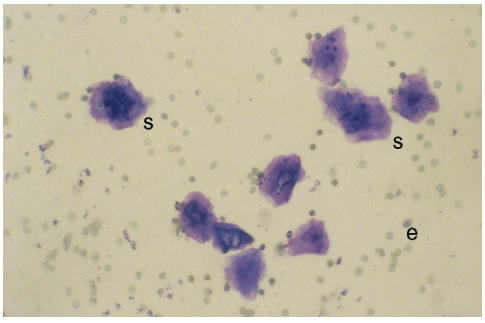


Fig. 13.6 Cytology of the vaginal vestibulum of a bitch during the second part of the follicular phase, the time of ovulation and beginning of the luteal phase: superficial cells (s) and erythrocytes (e).

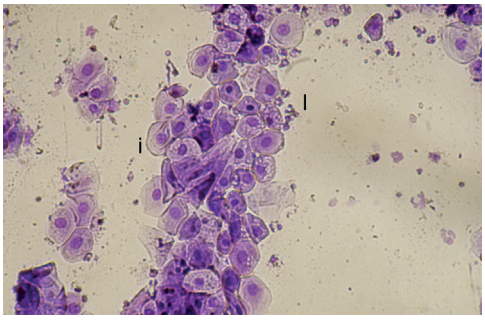


Fig. 13.7 Cytology of the vaginal vestibulum of a bitch during metestrus, beginning 6–10 days after the preovulatory LH peak: intermediate cells (i) and leukocytes (l).

(e.g., pregnancy or pyometra), it can be felt in a large part of the abdominal cavity.

The examination of the abdomen consists of inspection and palpation.

During *inspection* attention is given to the circumference and shape of the abdomen. The circumference can be increased by pregnancy, pyometra (sometimes with sunken flanks), or tumors. The enlargement of the abdomen is then usually symmetrical.

Even *superficial palpation* may reveal certain abnormalities. In animals in advanced pregnancy it may be possible to feel the curvatures of the uterine horns or the fetuses, or even the movements of a fetus. Parts of the tense surface of the uterus enlarged by pyometra can also sometimes be felt during superficial palpation. In this case deep palpation should not be performed because of the considerable risk of rupturing the inflamed wall of the uterus, which may be very thin.

Two-handed *deep palpation* is performed as described previously (§ 11.2.3 and § 12.2.2). Palpation of the uterus is very difficult in nervous animals which strongly contract their abdominal muscles and in obese animals. A normal, nonpregnant uterus is not palpable in dogs and cats. Palpation is often possible when the circumference of the uterus increases for physiologic or pathologic reasons.

Under normal conditions the ovaries of the dog and cat cannot be palpated but they may be palpable when pathologically enlarged by cysts or tumors. The normal ovary is located in the dorsal mesogastrium at the level of the third lumbar vertebra, just caudal to the kidney. When the ovaries are pathologically enlarged, they can sag lower in the abdomen because of their weight.

By means of two-handed abdominal palpation it is possible to diagnose pregnancy at certain stages. Firm, round or oval gestational vesicles can be palpated at about 25 days postcoitus in the dog and at 21 days in the cat. These ovoid enlargements increase in circumference and by 33 days postcoitus in dogs (about 5 days earlier in cats) the uterus is homogeneously thickened and flexible, so that a reasonably reliable diagnosis of pregnancy is no longer possible. However, by about 45 days postcoitus the skeleton of the already fairly large fetus becomes ossified and palpation of the fetus is possible. Sometimes it is necessary during parturition to determine by abdominal palpation whether all of the pups or kittens have been delivered or whether one or more is still present in the uterus. This is sometimes very difficult because the uterus contracts strongly and hence feels firm. Most of the time a fetus can be recognized due to its size and bony structure.

13.2.2 Internal examination

If there is an indication for bacteriological examination of the vagina, the sample should be collected before the internal examination.

In the bitch a vaginal examination is usually performed first and thereafter a rectal examination is performed if indicated. There are generally no serious risks associated with the vaginal examination. There are seldom injuries to the birth canal during delivery which

result in inflammation, as can occur in large animals. Rectal palpation of the reproductive tract of the bitch usually provides no additional information when vaginal examination can be carried out satisfactorily. A simple internal examination is usually not possible in the cat or can at best be only partly performed.

Vaginal examination

As noted above, the vestibulum passes from the vulva steeply in the craniodorsal direction until near the opening of the urethra it joins the vagina, which is initially horizontal and then slants down in a cranioventral direction (Fig. 13.3). Caudally in the ventral wall of the vestibulum, about 2 cm cranial to the vulva, there is a fairly large blind pouch, the clitoral fossa (Fig. 13.8). This is bordered on the upper side by the clitoral fold and the clitoris. The transition of vestibulum to vagina (at the level of the ischiadic arch) is called the cingulum[8] and it is a narrowing of the entire 360° circumference. In many bitches this junction is also contractile. In some, especially young, bitches vaginal examination is impossible because of a too narrow vulva and/or a too narrow junction between the vestibulum and vagina.



Fig. 13.8 Vulvar lips of a bitch spread apart to show the clitoral fossa, in the ventral part of the vestibulum.

Performing vaginoscopy. In the bitch this examination should be performed with a 12 mm diameter pediatric proctoscope. The speculum has an occluding stylet with a knob, which makes it easier to introduce and also prevents any secretion in the vagina from entering the vaginoscope.[9]

In exceptional cases sedation is required. The patient stands during the examination and must be well supported under the abdomen. Sudden sitting during vaginoscopy can result in injury.

After the vulva has been cleansed and antiseptic lubricant has been applied to the speculum, the speculum is introduced into the vestibulum as close as possible to the dorsal commissure. Because of the normal direction of the vestibulum, the speculum is introduced as steeply as possible, almost vertically (Fig. 13.9, left). Introducing the speculum along the dorsal wall of the vestibulum prevents it from entering the clitoral fossa, which is extremely painful.

When the tip of the speculum is just under the level of the anus, it is turned cranially (Fig. 13.9, right). With light pressure and rotation, the speculum is pushed cranially until greater resistance is felt. Here the stylet is removed, the light is placed in the speculum, and under visual guidance the speculum is gradually retracted from the vagina. In the first part of proestrus the speculum glides rapidly into the vagina but during estrus it passes somewhat stiffly.

During vaginoscopic examination the cervix is almost never well visualized. This is partly because of the



Fig. 13.9 Introducing a speculum into the vagina of a bitch. Note the angle of the speculum during passage through the vestibulum (left). When the tip of the speculum is just below the level of the anus, it is turned cranially (right).

presence of a dorsomedial mucosal fold in the wall of the vagina. This fold extends from about 2–3 cm caudal to the cervix to the cervix itself.[3,10] A speculum introduced into the vagina usually passes no further than the caudal edge of this fold, except during parturition. A small diameter speculum (e.g., 6 mm) can pass this fold and allow observation of the cervix. Such a speculum is also used for endoscopic artificial insemination, in which a catheter is introduced into the cervical canal.[11]

During vaginoscopic examination, attention is given, insofar as possible, to:

1. The mucosa of the vagina. Cyclic changes are best observed on the dorsal medial fold in the cranial vagina.[3,10] During anestrus the mucosa is pink or a patchwork of red and white, neither glossy nor swollen. There are shallow longitudinal folds in the caudal part but the proximal part is usually smooth. During the follicular phase the vaginal mucosal folds are pale, swollen, and smoothly rounded, resembling balloons (Fig. 13.10). The increased concentrations of estradiol frequently cause hypertrophy of the floor of the posterior vagina just cranial to the urethral orifice and therefore folding over and covering it. At the end of the follicular phase, during the decline in estradiol and the rise in progesterone concentrations in plasma, shrinkage begins in response to reduced estradiol-dependent water retention. These cyclic changes are most marked in the dorsal median fold, and precede those of the midvaginal mucosa. Shrinkage of the vaginal mucosa begins midway in the follicular phase and continues through the phase of preovulatory luteinization and ovulation, when many longitudinal folds can be observed. During oocyte maturation, shrinkage of the vaginal mucosa continues and increasing numbers of sharp-edged summit profiles appear (Fig. 13.11). At this stage the mucosa resembles crepe paper. In the transition period from estrus to metestrus, the mucosa thins and the profiles become rounded. At the start of metestrus, there is a patchwork of red and white (Fig. 13.12). The appearance in vaginitis is similar, probably because vaginitis usually occurs during metestrus.
2. The presence of secretion and its nature.
3. Neoplasia.
4. Lacerations. In the dog lacerations seldom occur in the birth canal during parturition. There are occasionally lesions after mating. Perforations in the cranial portion of the vagina result in an open connection with the abdominal cavity.
5. An open cervix. As noted above, the cervix is usually difficult to observe. Around the time of parturition it is possible to see whether the cervix is open. When the cervix is partly or completely open, fetal membranes are often visible. When the cervix is closed only the vaginal mucosa can be seen.

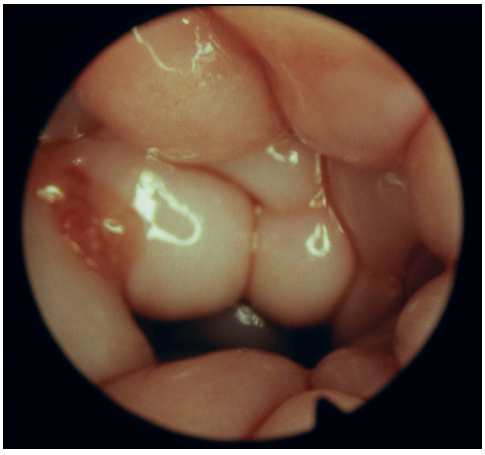


Fig. 13.10 Vaginoscopic appearance in a bitch during the early follicular phase. Note the pale, swollen mucosal folds with smooth, rounded surfaces resembling balloons, and the hemorrhagic fluid between the folds.

A glove is worn for *vaginal palpation*. Antiseptic lubricant is placed on the middle finger or forefinger and the finger is introduced via the dorsal commissure through the vestibulum to the vagina. Usually the cranial edge of the pelvic floor can be reached, provided that the vulva and the transition from vestibulum to vagina are not too narrow. The cervix in the dog is located cranial to the pelvic inlet and cannot be reached. During this examination notice should be taken of:

- narrowing[12] due to strictures and/or a septum
- neoplasia
- lacerations
- abnormal shape of the ventral part of the pelvic inlet, which is so important for parturition
- the urethra, normally a supple cord up to 8 mm thick and palpable on the pelvic floor
- the presence of a fetus in the pelvic canal or palpable at the pelvic inlet and any abnormalities in its posture or size
- foreign bodies

Rectal palpation

Rectal palpation is only performed:

- to examine a tumor in the vagina, especially if located in the dorsal wall
- when vaginal palpation is impossible because of narrowing or tumor

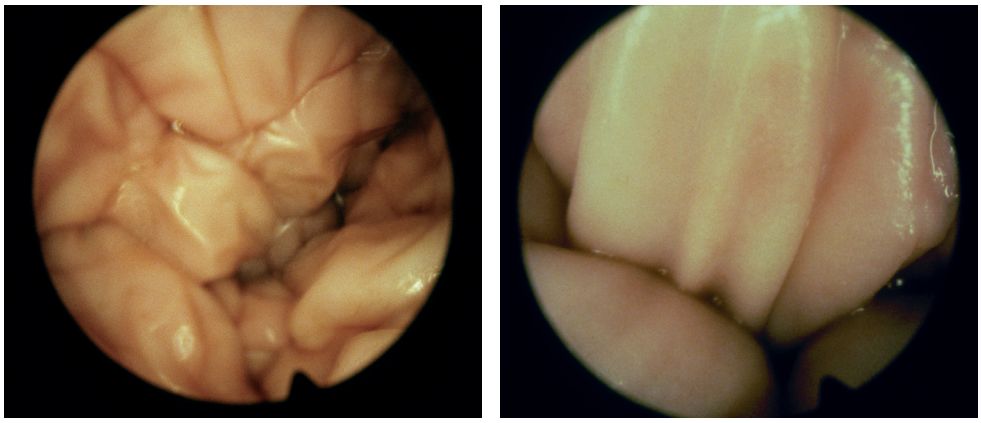


Fig. 13.11 Vaginoscopic appearance in a bitch at the time of ovulation (plasma progesterone concentration: 22 nmol/l). The shrinkage of the mucosa has led to longitudinal folds (left). The close-up view on the right shows the shrinkage of the longitudinal folds of the dorsal median fold of the cranial vagina.

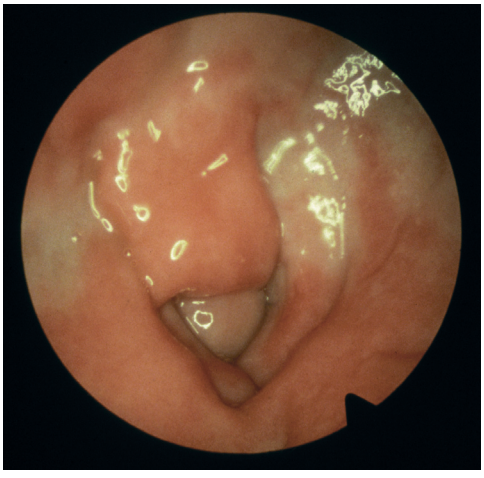


Fig. 13.12 Vaginoscopic appearance in a bitch in metestrus. Note the flattening of the folds and the patchwork appearance of alternating red and white.

13.3 Further examination

Possibilities for further examination include:

- blood examination (routine hematology and biochemistry)
- ultrasonography (for pregnancy diagnosis and some gynecological abnormalities)
- bacteriologic examination of vaginal secretion
- cytology (vaginal smears to estimate the stage of the cycle (Figs 13.5, 13.6, and 13.7)
- hormone measurements (plasma progesterone to determine optimal time, e.g., for mating (Fig. 13.2), plasma estradiol with GnRH stimulation to detect ovarian tissue after incomplete ovariectomy)
- laparoscopy
- radiography (to determine the number of fetuses)
- biopsy of a lesion or tumor

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14 Male reproductive tract

J. de Gier and F.J. van Sluijs

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The indication for examination of the male reproductive tract is usually provided by a breeding problem or by signs that appear to arise from an abnormality of this system. It is also becoming more common that examination of the male's reproductive system and semen is requested before the animal is used for breeding. Furthermore, examination of the reproductive tract is imperative before semen is to be collected and frozen for transport or for storage and later use.

The history is extended by questions directed to this organ system. The physical examination includes an external examination of the scrotum, testes, epididymis, spermatic cord, prepuce, and penis, and, in the dog, examination of the prostate by rectal palpation. The examination is completed with collection of semen, but this should be done prior to the physical examination, which may diminish libido so much as to prevent semen collection.

14.1 History

The general history is extended by asking specific questions about the animal's libido and fertility, and then questions about the animal's living conditions and about previous disorders concerned with reproduction.

14.1.1 Libido

The owner is asked whether the dog has shown signs of pain during mating. Then questions are asked about the dog's behavior during mating and, if abnormalities are described, when these first appeared. If possible, it is preferable to observe a mating and preferably in the male dog's own usual surroundings. For further examination of pain occurring during mating, see Chapters 17 and 18, concerning locomotion and the nervous system, respectively. For examination with regard to behavioral abnormalities during mating, see Chapter 22.

14.1.2 Fertility

Questions about fertility are related to the animal's age, because problems are more likely to occur in animals that are extremely young or extremely old.

If the animal has already been used for breeding, questions are asked to determine how often it has been used, what percentage of the matings resulted in pregnancy, and how large the litters were. A low percentage of pregnancies or small litters are reasons

for asking how the time of mating has been chosen and how often and at what intervals this male has been mated with a given female during the same estrus. Information is also obtained about the females, including age, parity, and results of previous matings.

14.1.3 Living conditions

The environment in which the male has been reared is very important to libido.[1-3] Males reared alone not infrequently have a lack of libido.[1] A male cat that is transferred to new, unfamiliar surroundings can lose its libido for months.[4] This may also happen when a male cat is confined to a cage.[5]

14.1.4 Past history

Information about previous disorders and treatments, especially any hormone therapy (when it was administered, the preparation used, the dosage, and the result) can be very important for correct interpretation of the information.

14.2 Physical examination

14.2.1 Libido

A successful mating requires first of all that the male has adequate libido. Although it is difficult to measure this objectively, in dogs there are a few useful indications.[3]

For this examination it is preferable to bring the male into contact with a bitch in estrous in the male's normal surroundings. Within a short time, usually after a period of playing, copulation is initiated. The interval between bringing the two animals together and the start or achievement of copulation can be used as a measure of libido. The male's perseverance in attempting to copulate is also a measure. Sometimes it is necessary to exclude from the area all persons unfamiliar to the male dog. This is even more important for the male cat.

14.2.2 Scrotum

In the male dog the scrotum is located between the thighs and is clearly visible from behind. The skin is thin, pigmented, and sparsely haired. The subcutis contains no fat. The scrotal septum forms a visible raphe on the midline. The scrotum of the male cat is located just below the anus. It is furred and is not pendulant, as is that of the male dog (Fig. 14.1).

The scrotum is carefully inspected and palpated to assess the presence, size, symmetry, and abnormalities of the testes. The scrotum is small if the testes have not descended or are retracted, and it can be enlarged by pathologic changes. Thickening or other abnormalities of the scrotum can interfere with thermoregulation, resulting in higher scrotal temperatures. This can lead to degenerative changes in the testes and hence a reduction or even cessation in spermatogenesis for three weeks or more after the onset of the increase in temperature.

14.2.3 Testes

The testes are round to oval. Thermoregulation of the testes is determined by the following factors:[2,6]

- the absence of subcutaneous fat in the scrotum
- cooling of the arterial blood by cooler venous blood in the pampiniform plexus



Fig. 14.1 Rear view of a male dog (left) and a male cat (right), with the tail raised. In dogs the scrotum is hairless and is located between the thighs, so only the caudal part is visible. In cats the scrotum is furred and is located just below the anus.

– the distance of the testes from the abdominal wall, regulated by the cremaster muscle

Palpation is performed to determine the presence of both testes and their size, consistency, and painfulness. If either or both testes cannot be felt in the scrotum, they have either not descended or are retracted, providing that they have not been removed surgically. One can attempt to confirm the latter by looking for a surgical scar or by detecting a spermatic cord by palpation. In most male dogs the testes can be palpated in the scrotum by 5–6 weeks of age.[7,8] However, a definitive diagnosis of cryptorchidism can only be made when the animal is 6 months old. Until that age the inguinal canal is still open to allow testicular descent.[9]

Retraction of the testes is attributed to a very effective cremaster reflex. Particularly in pups, it may be difficult to distinguish between cryptorchidism and retracted testes, but the latter can be massaged into the scrotum.[2]

In the cat the testes are present in the scrotum at birth but movement in and out of the inguinal canal is possible for a few months. The testes are usually permanently in the scrotum by the age of 12–14 weeks and certainly by the age of 6 months.[2]

In the male dog the size of the testes depends on the breed, varying from 1.5 × 1.5 × 2 cm in the smallest breeds to about 3 × 3 × 5 cm in the large breeds. The volume can be estimated with an orchidometer (calibrated ovoid beads; see § 4.2, Fig. 4.5).

In the sexually mature male cat the diameter of the testes is about 10 mm, but there are differences among breeds. The normal consistency is similar to that of rubber (firm and elastic). Palpation of the normal testes does not cause pain. If one testis is found by palpation to be abnormal in size and consistency, the spermatic cord should be palpated to determine whether there is a torsion.[10]

14.2.4 Epididymis

The epididymis of the dog is firmly attached along the dorsolateral surface of the testis and can be palpated to assess its consistency, size, and temperature, and to determine whether it is painful. Absence of the epididymis is extremely rare.[2,11] Its normal consistency is similar to that of hard rubber (slightly firmer than the testis). The tail of the epididymis lies on the caudal pole of the testis in the male dog and is relatively large in comparison with that of other species.

In the male cat the epididymis is on the craniolateral aspect of the testis and the tail is dorsal. Palpation of the normal epididymis does not cause pain.

14.2.5 Prepuce

The prepuce of the dog forms a complete sheath around the cranial end of the penis. In the cat the prepuce has an orifice with thick edges and is directed caudally and located under the scrotum. During inspection of the prepuce attention is given to the size of the orifice, the presence of discharge, and the appearance of the mucosa.

The preputial orifice must be large enough to allow the penis to emerge. Purulent discharge from the prepuce occurs frequently in intact male dogs. Although not normal, it is not considered a serious abnormality. The mucosa contains many lymph follicles and its normal appearance is light pink, glossy, and smooth.

14.2.6 Penis

The penis of the dog is more or less cylindrical and contains two corpora cavernosa separated by a septum. Following birth the os penis develops in the distal part of the septum and can be as long as 11 cm in a large dog. The caudal end of the os penis is thicker than the cranial part and is attached to the corpora cavernosa. The cranial end terminates in a tapered fibrocartilaginous tip. The urethra lies in a groove on the ventral side of the os penis and is surrounded by the tube-shaped corpus spongiosum penis.

The glans penis of the dog consists of a bulbus glandis and a pars longa glandis (Fig. 14.2). The venous plexus of the glans penis is continuous with the spaces of the corpus spongiosum. The pars longa glandis surrounds the long terminal part of the os penis. The short, caudally located bulbus glandis surrounds the wide caudal part of the os penis and projects mainly dorsally. The swelling of the glans penis and especially the bulbus glandis occurs during copulation and results in the tying together (copulatory lock) of the dog and the bitch.

The erection of the penis is primarily a vascular process. During sexual excitement the blood flow to the penis is increased while at the same time the efferent vessels are partly compressed. Aided by the relaxation of the retractor penis muscle and the drawing back of the prepuce, the penis is exposed and extended and inserted into the vagina. Thereafter



Fig. 14.2 The distal portion of the penis (glans penis) of the dog consists of an elongated cranial part (pars longa) and a round basal part (bulbus glandis). During erection both parts increase greatly in size.



Fig. 14.3 The cone-shaped penis of the male cat (left) has keratinized papillae, which disappear after castration (right).

pressure on the superficial veins, muscle contractions, and pressure of the penis against the ischiatic arch result in further erection of the bulbus glandis penis.

The penis of the cat is ventral to the scrotum and is directed posteriorly (Figs 14.1 and 14.4). The groove on the ventral side of the os penis is more shallow than in the dog. The glans penis is not divided and is conical. On the cranial two-thirds of the penis there are 100–200 keratinized spines (papillae), 0.75–1 mm long and directed toward the base of the penis. They are fully developed at puberty. They are thought to have an important role in inducing the preovulatory LH peak during mating.[12] Castration causes them to regress in 5–6 weeks.

For examination the penis should be exposed as far as possible, for which purpose the male dog should be lying on its back or on its side. The pelvis is tilted slightly forward by curving the dog's back and then the prepuce is retracted caudally. This exposes the penis for examination with regard to shape and size. The mucosa is inspected for trauma. In certain anatomical abnormalities the penis is difficult or impossible to expose, as when there is a persisting penile frenulum.[13,15] Finally the penis of the dog is palpated in order to detect possible deformities.

14.2.7 Accessory sex glands

The prostate is the most important accessory sex gland in the dog. The dog does have ampullae of the vas deferens but they are small and not all authors consider them to be accessory sex glands. The canine prostate lies on the cranial part of the pubic symphysis, about 1–2 cm caudal to the neck of the bladder and surrounding the cranial part of the urethra. In older dogs the prostate sags cranioventrally out of the pelvic canal. It is divided into right and left lobes. In the cat the prostate does not cover the ventral side of the urethra, as it does in the dog. In addition, the cat has two bulbourethral glands (Fig. 14.4), located dorsolateral to the urethra proximal to the base of the penis.

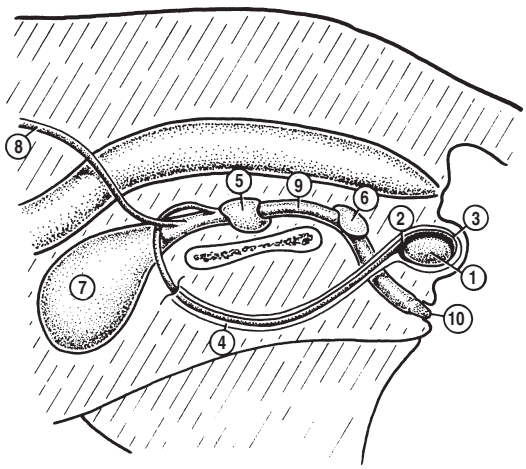


Fig. 14.4 Diagram of the urogenital system of the male cat. 1 testis, 2 head of epididymis, 3 tail of epididymis, 4 vas deferens, 5 prostate, 6 bulbourethral glands, 7 bladder, 8 ureter, 9 urethra, 10 penis.

In the dog the prostate is examined by rectal palpation (§ 11.2.5 and § 12.2.2). The hand not being used for palpation applies pressure to the ventral side of the abdomen just before the entrance to the pelvic canal. This aids palpation of the prostate in larger breeds. The size, surface, and consistency of both lobes are examined. Note should also be taken of any signs of pain caused by palpation of the prostate. The size varies according to the size of the dog. The surface of both lobes is quite smooth and the consistency is similar to that of soft rubber. Palpation of the normal prostate does not cause pain. Examination of the prostate and bulbourethral glands is not performed routinely in the cat because rectal palpation is less well tolerated than in the dog. It can be performed when indicated in exceptional cases, but sedation is usually required.

14.3 Collection of semen

Semen can be collected by three methods.

1. *Manual ejaculation*. The prepuce can be encircled by the hand and the penis lightly massaged. As soon as the penis begins to become erect the prepuce is pushed caudally so that the penis can be held between the thumb and forefinger just behind the bulbus glandis. The dog will quickly begin making copulating movements and develop a full erection. Ejaculation then occurs. The ejaculate consists of three fractions.[14] Fraction 1 is secreted by the prostate, contains few cells, and has a small volume (0.5–5.0 ml). Fraction 2 is the sperm-rich fraction released from the tail of the epididymis and is also small in volume (0.5–4.0 ml). The third fraction is secreted by the prostate and contains few cells, but has a large volume (up to 80 ml). Each of the three fractions is collected in a separate glass container, warmed to body temperature. Especially when the male has little libido, it will be necessary to have a bitch in estrus present. This method requires no special equipment and is not difficult to perform, and the semen does not come into contact with noxious substances.
2. *Ejaculation using an artificial vagina*. After an erection has begun to be aroused, as just described, an artificial vagina is placed over the penis. Then the penis does not have to be held with the hand. The artificial vagina is about 20 cm long and has a diameter of about 6 cm. The temperature should be about 40°C. Also with this method the presence of a bitch in estrus can be helpful.
3. *Electroejaculation*. With the dog under anesthesia, rhythmic electrical stimuli can be applied per rectum at the level of the prostate. This method is less often successful and there is a great chance that urine will be added to the ejaculate. This method is obviously not suitable for use in private practice. In some European countries electro-ejaculation is prohibited by law.

14.4 Further examination

14.4.1 Semen examination

A logical sequel to the history and physical examination is laboratory examination of the collected semen. Macroscopic examination includes evaluation of the volume, color, odor, viscosity, and any abnormal additions, and is followed by microscopic examination in which the motility, concentration, and percentage of abnormally formed spermatozoa are determined. The pH, osmolarity, and the concentration of alkaline phosphatase can also be measured.[6,16,17] Bacteriological examination is also especially useful.[18]

14.4.2 Ultrasonography

Ultrasonography of the testes, epididymides, and prostate may reveal nonpalpable neoplasms, abscesses, or cystic changes.[14] Under guidance by ultrasonography, fine-needle aspiration biopsy can be performed.

14.4.3 Testicular biopsy

In cases of oligospermia or azoospermia, biopsy of the testicle can be considered. In view of the invasive character of the procedure and the limited diagnostic value of the findings, it is only performed in exceptional cases. However, when a testicular neoplasm is suspected, a fine-needle aspiration biopsy is the first step in diagnosis (see above).

14.4.4 Hormone measurements

It is possible to measure FSH, LH, and testosterone. These measurements can be important in differentiating between primary and secondary hypogonadism, although in companion animals this has not yet been adequately defined. If hormone measurements are to be performed, it is important to collect several samples, preferably before and after stimulation (e.g., with GnRH). Plasma hormone concentrations may fluctuate with time.[19]

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15 Skin, hair, and nails

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15.1 Structure and function of the skin and adnexa

The skin functions as an anatomic and physiologic barrier between the body and its surroundings. The skin offers protection against physical, chemical, and microbiologic influences and also makes it possible for the animal to perceive temperature differences, pain, and touch. The skin is composed of two layers, the outer layer or epidermis and the inner layer or dermis (Fig. 15.1).

15.1.1 Epidermis

The epidermis has five components, differing in thickness. The keratin layer or stratum corneum consists of flattened cells without nuclei and is only a few cells thick. This layer, consisting of keratin, is continuously replaced and thereby removes noxious materials. At the same time it prevents unnecessary loss of body fluid. The stratum lucidum consists of a thin, compact layer of dead cells without nuclei and is completely keratinized. In the dog and the cat this layer is only present in the skin of the foot pads and sometimes also the nasal plane. The stratum granulosum is mainly present in hairless areas of the skin and is a few cells thick. The cells are flat, retain their nuclei, and contain keratohyalin granules.

The next layer is the stratum spinosum, formed by the cells of the stratum basale. This layer consists of slightly rounded, more or less cuboidal, nucleated cells and is one to three cells thick. In the skin of the foot pads and the nasal plane the intercellular connections, the tonofibrils arising from the desmosomes in the cell wall, are clearly visible. The cells in the stratum spinosum produce keratin.

The basal layer or stratum basale consists of a simple row of columnar or cuboidal cells on a basement membrane and separates the epidermis from the underlying dermis. The basal layer consists chiefly of keratinocytes which continually divide and maintain the keratinizing process of the skin, which progresses upward until the keratinocytes are shed as dead keratinized cells. In healthy dogs this process takes about 22 days.

Keratinocytes produce two kinds of keratin: soft keratin which forms the keratin layer of the epidermis, and hard keratin which forms the nails and the outer layer of the hair. In the process of keratinization the

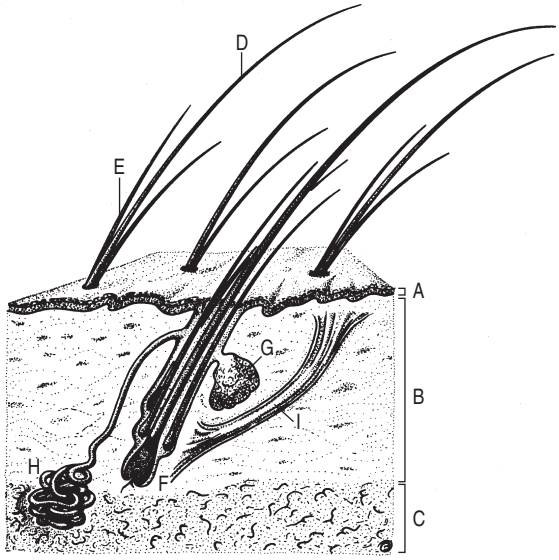


Fig. 15.1 The skin: A epidermis, B dermis, C subcutis, D primary hair, E secondary hair, F hair root, G sebaceous gland, H apocrine sweat gland, I arrector pili muscle.

keratohyalin granules form an intercellular adhesive rich in lipoproteins but poor in sulfhydryl groups. This intercellular substance, called glycocalix, provides the connection between the keratinocytes via the tonofibrils and is the primary component of soft keratin.

Melanocytes are the second type of cells in the basal layer. They occur in very small numbers in the normal dog and in the cat they only occur in the skin of the scrotum, the nipples, the prepuce, the circumanal region, and the pinna. The melanocytes are stimulated to produce melanin-containing granules under influence of sunlight, irritation, or inflammation.

15.1.2 Epidermal adnexa

The adnexa arise from the epidermis during embryonal development and proliferate into the dermis. They include the sebaceous glands, the apocrine and eccrine sweat glands, the nails, and the hair follicles.

Sebaceous glands are simple alveolar holocrine glands usually associated with the hair follicles. In the cat they are only present in the haired skin but are very large on the dorsal aspect of the base of the tail (the supracaudal organ or tail gland), on the lips, and in the submental organ under the chin. In the dog they are more numerous and larger in the area of the tail gland.

The secretion of the sebaceous glands (sebum) is released by the complete disruption of the sebaceous gland cells, probably under hormonal regulation. Testosterone causes hypertrophy of the glands and cortisol and estrogen can cause their involution.

The synthesis of sebum is also under the influence of hormones: androgens in low doses increase the production and estrogens in high doses decrease it. This fatty secretion contains chiefly cholesterol and cholesterol esters, produced from waxes and residuals of fatty acids. The emulsion formed on the surface of the skin keeps the skin supple, maintains optimal hydration, gives gloss to the coat, and forms a chemical barrier against potential pathogens.

Apocrine sweat glands lie deep in the dermis and are part of the hair follicle complex. They are present in the dermis on all parts of the body except the nasal plane. Apocrine sweat is a protein-like material that is formed continuously. It is released by myoepithelial contraction, a process under the influence of the sympathetic adrenergic system. On the surface of the skin it is mixed with sebum and thereby contributes to the chemical and physical barrier.

Eccrine sweat glands occur only on the foot pads in dogs and cats. They lie deep in the dermis at the junction with the subcutis but their excretory ducts traverse the dermis to the surface of the foot pads. In the dog and cat they have no thermoregulatory function.

The nails or claws are special structures which are direct extensions of the epidermis and dermis. They originate from histologically typical epidermis at the side of the foot pad but consist entirely of a thick layer of hard keratin (Fig. 15.2).

The skin of dogs and cats is covered with hair except on the nose, the foot pads, and the mucocutaneous junctions. A hair is composed of the shaft and the root. The hair shaft, which reaches above the skin surface, consists of dead material and can be divided into the cuticle, the cortex, and the medulla. The cortex consists of keratin.

The development of the hair and the types of coats in dogs are described in § 8.3.4. The coat of the cat can be the long-haired Persian type or the short-haired type. The hairs of both dogs and cats exit in bundles through the surface of the skin but the distance

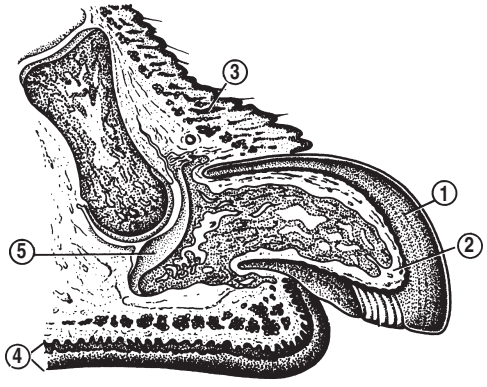


Fig. 15.2 Sagittal section of the toe of the dog: 1 horny layer of the nail, 2 dermis, 3 skin, 4 epidermis of the foot pad, 5 joint cartilage.

between bundles is greater in the cat. In both species but especially in the dog, the coat is more thick and dense on the dorsal surface of the body than on the ventral surface. In the cat there are many more secondary than primary hairs and they are thinner and have a thinner medullary space than do those in the dog.

15.1.3 Dermis

The dermis is of mesodermal origin and its primary function is the support and nutrition of the epidermis. The dermis consists of fibers, ground substance, and cells but it also contains the epidermal adnexa, the arrector pili muscles, blood and lymph vessels, and nerve fibers.

The fibers are collagenous, reticular, and elastic; about 90% are collagenous. The ground substance is the major component of the dermis. It consists of a soluble mucous gel produced by fibroblasts and formed from protoglycans, the most important components of which are hyaluronic acid and chondroitin sulfates. The ground substance functions as an adhesive between the cells and other structures in the dermis.

Fibroblasts, mast cells, and histiocytes predominate in the dermis of the healthy animal. Fibroblasts are responsible for the production of tropocollagen fibrils which are the precursors of the dermal collagen fibers. The production of collagen and ground substance is mainly under endocrine regulation. Cortisol and estrogens decrease the production (contributing to skin atrophy) and androgens increase it.

15.1.4 Subcutis

The subcutis or hypodermis consists primarily of lipocytes but also contains blood vessels, nerve fibers, and connective tissue.

In dogs and cats the fat deposits in the foot pads have a shock-breaking function. The subcutis provides for the storage of fat and for heat insulation. Together with the epidermis and the dermis, the subcutis also determines the body contours.

15.2 History

When there are indications of a skin problem, it is given specific attention in the history. The general history (Chapter 6) is followed by detailed questions about the skin, coat, and nails.

The dermatological history begins with identifying the primary problem, its initial location, and the age at which it began. For example, scabies is associated with intense pruritus, mainly on the head and the auricles of young animals. In contrast, problems caused by fleas occur mainly on the caudal part of the body. If the skin problems have been present for a long time, questions are asked about the current problems and their location, since they may differ considerably from the original manifestations. In atopic (allergic) dermatitis the pruritus may be confined to the head and legs initially, but often has become generalized by the time of examination.

Questions are then asked about the course of the skin problem, whether it has remained unchanged, or become worse, or whether it is seasonal, as can be expected in atopic patients.

15.2.1 Symptoms

If there is pruritus, its severity and distribution are considered in order to determine whether it is associated with visible skin lesions. Pruritus is an irritating, unpleasant sensation that arises in the epidermis and the upper layer of the dermis and gives rise to scratching, rubbing, and licking. The mediators that induce pruritus affect the finely branched network of nerve endings, the pruritus receptors, located at the transition from dermis to epidermis.

Stimuli from the pruritus receptors are transmitted to the dorsal root of the spinal cord via nonmyelinated C-fibers, which have a diameter of 0.5 micron. The signals cross via the ventrolateral spinothalamic tract and the ventral posterior nucleus in the thalamus to terminate in the central posterior cortical gyrus.

Severe pruritus can be expected in scabies or allergic dermatitis. Pruritus does not usually accompany endocrine skin changes, although it may develop later as a result of secondary microbial infection. It is also worth remembering that although pruritus is usually a manifestation of a dermatologic problem, it can also be the consequence of a neurological or behavioral problem.

Pruritus is an important iatrotropic problem. Other skin problems that may lead to veterinary consultation include thinning of the hair coat, alopecia, a change in the color of the skin, and a disagreeable skin odor.

15.2.2 Living conditions

The causes of several dermatologic problems can be found in the milieu in which the animal lives and hence it is necessary to obtain information about these living conditions, including factors both inside and outside the house. We must ask where the dog sleeps, what kinds of materials are in its environment (the dog's bed and blanket, furniture, the floor covering, food bowl), and what kind of cleaning agents and other household materials are used. It is equally important to ask about the outdoor area used by the animal and the associated vegetation. Because of the possibility of food allergy, the owner is asked to list all foodstuffs given to the animal, taking into account that allergy may also develop for food that the animal has received for a long time.

With regard to the possibility of infectious etiology, questions are asked about other animals in the house and

possible contacts with either animals or persons having pruritus or other skin problems. If the animal has been in southern Europe, leishmaniasis should be considered.

15.2.3 Past history

Information about past disorders can be important in interpretation of the findings. This information should include all diseases which the dog has had, including those other than skin problems that do not at first seem to be important. Some examples are lesions in the oral mucosa, which can occur in autoimmune diseases, and such problems as conjunctivitis, rhinitis, and 'reverse sneezing' (§ 9.1.1), which can occur in atopy. It is also important to ask about disorders in the relatives of the patient and to be aware of the skin disorders known to be associated with this breed.

Finally, questions are asked about previous medications and their effects. Corticosteroids may completely mask the original manifestations and so if they are known to have been used it may be necessary to ask the client to return when their effects can be expected to have disappeared.

15.3 Physical examination

A general examination (Chapter 8) is performed prior to the dermatologic examination. For the examination of the dermatologic patient a room with sufficient light is quite important. Although daylight is best, artificial light can be used if it is clear and uniform. Before beginning a detailed inspection of the abnormalities, one should look at the patient from a distance, noting any abnormal odor or other abnormalities which immediately catch one's attention, and also noting the general appearance of the coat.

15.3.1 Skin odor

The skin of the normal dog or cat usually gives off an odor that it is not unpleasant. The odor is determined by a mixture of sebum, apocrine sweat, and products of bacteria. On the healthy skin of the dog there are mainly coagulase-negative staphylococci, aerobic micrococci, alpha-hemolytic streptococci, and *Acinetobacter* sp. The last three groups also occur on the skin of the cat. Under the influence of a great variety of factors, including metabolic factors, allergens, ectoparasites, and altered living conditions, this bacterial flora can be partly replaced by coagulase-positive staphylococci. The production of sebum and its composition can change and there can be an increased epidermal turnover (seborrhea). In patients with seborrhea the sebum contains less esterified wax but greatly increased amounts of free fatty acids, which probably contribute most to the abnormal odor.

15.3.2 Haircoat

In the inspection of the coat attention is given to its thickness, stiffness, gloss, odor, composition (guard hairs and undercoat), whether it appears dry or oily, and the ease with which hairs can be plucked out. Occasionally there are hairs with a sebum cuff around the shaft ('follicular casts'). This may indicate a keratinization defect. Also note whether there are broken hairs (trichorrhexis), loose hairs, or hairless areas (alopecia), or a change in the color of the coat.

Alopecia is the absence of hair in areas where it is normally present. Alopecia can be partial or complete, diffuse or localized. A generalized partial alopecia is called hypotrichosis. An excess of hair (usually local) is called hypertrichosis.

It is important to examine the hairs that are still present. Broken hairs are usually the result of scratching and rubbing. In some endocrine disorders (see Chapter 21) there is a generalized skin atrophy which is first apparent to the owner because of the gradual thinning of the coat. Sometimes the first change noticed is that shedding of hair has stopped. Gradually the coat becomes thinner, until there are bald areas.

15.3.3 Skin

Inspection of the skin is made much easier by using a forceps to lay the hairs to one side so that the underlying skin can be seen more easily (§ 8.3.4, Fig. 8.8).

During the inspection take note of the color of the skin and the presence of any lesions. Melanin is a dark pigment that is responsible for the naturally occurring generalized or localized pigmentation of the skin and, with pheomelanin (pheo = brownish), it determines the color of the hair. It is formed by melanocytes. In the melanosomes, the small pigment-forming organelles in the melanocytes, tyrosine is converted to dihydrophenylalanine by the enzyme tyrosinase. Subsequent oxidative steps result in the formation of melanin.

The pigmentation of the skin is determined by the number, size, and distribution of melanosomes. Collections of melanosomes form the melanin granules, which can also be transmitted to the keratinocytes via an as yet unknown mechanism.

Either hyperpigmentation or hypopigmentation can occur. As in other animals, melanocyte-stimulating hormone (α-MSH), formed in the intermediate lobe of the pituitary, probably plays a role in regulation of the function of the melanocytes. Local hyperpigmentation can occur under the influence of ultraviolet light, chronic irritation, and inflammation.

The description of the lesion includes not only its morphology but also its configuration and distribution, as well as whether it is primary or secondary. *Primary*

lesions develop spontaneously and directly reflect the underlying disorder. *Secondary* lesions develop from the primary lesions, but can also develop as artifacts induced by trauma or medications.

In chronic conditions the primary lesions may be completely masked by secondary lesions caused by scratching. In addition, papules can change into vesicles or pustules, either of which, because of their fragility, may be short lived. Hence, they may be absent by the time of examination or present in only small numbers.

Primary lesions

The following primary lesions are distinguished on the basis of their morphology (Figs 15.3 and 15.4):

Macules. A macule is a circumscribed area that is not elevated but differs in color from the surrounding skin. Macules result from accumulation of melanin, depigmentation, hyperemia (erythema), or hemorrhage (purpura).

Papules. A papule is a small, solid elevation with a maximum diameter of 2.5 mm. It results from changes in the epidermis (hyperplasia, edema) and/or subepidermal reactions (infiltration with inflammatory cells from an infectious or sterile process, tumor cells, metabolic deposits, or edema).

Plaques. An extensive, relatively flat elevation is called a plaque. It can be caused by confluence of papules or it can be neoplastic.

Nodules/nodes. A solid mass with a diameter of less than 1 cm is called a nodule and one of larger size is called a node. They result from inflammation, hyperplasia, neoplasia, or deposits of fibrin or crystalline material.

Wheals (urticarial lesion). A wheal is a circumscribed elevation with a flat surface, caused by edema in the dermis due to an allergic reaction. Diffuse or peripheral hyperemia may also be present.

Vesicles. A vesicle is a circumscribed elevation filled with fluid. Vesicles can be intraepidermal as a result of hydropic degeneration, spongiosis, and acantholysis, or they can be subepidermal as a result of edema and degenerative changes in the stratum basale. Vesicles greater than 5 mm in diameter are called bullae.

Pustules. A pustule is a small, circumscribed elevation filled with pus from infectious or sterile inflammation. An example of pustules due to sterile inflammation are those which occur in the autoimmune disease pemphigus foliaceus. Pustules can occur in both the epidermis and the dermis. They can develop from vesicles and their color and association with hair follicles depend on the pathogenesis. For example, in furunculosis there are often hemorrhagic pustules.

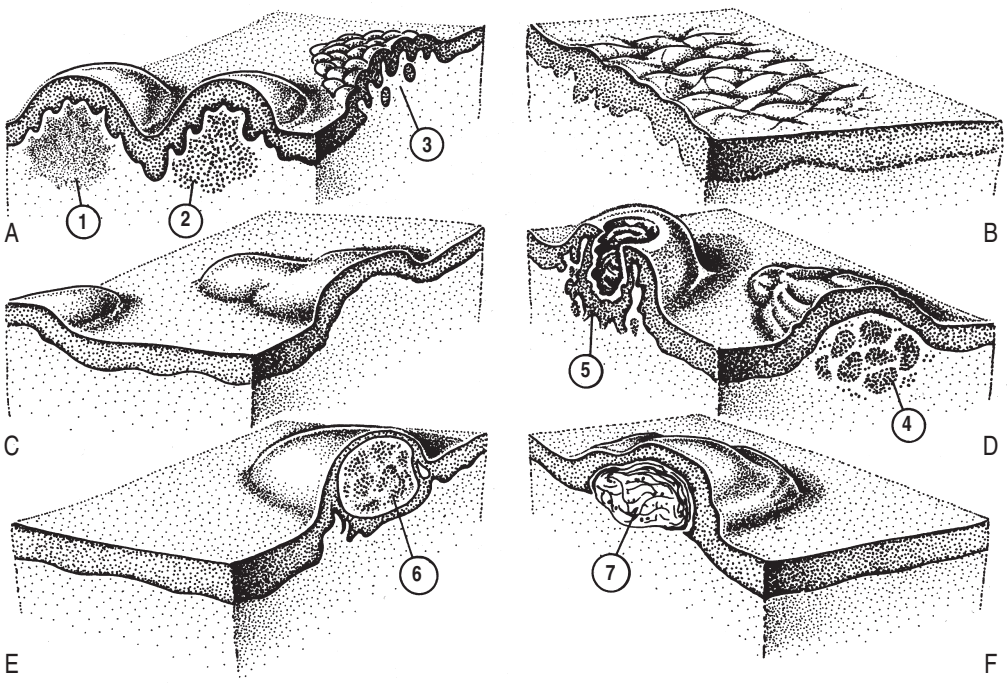


Fig. 15.3 A–F Morphology of skin lesions. A: papules caused by 1) dermal metabolic deposits, 2) dermal inflammatory infiltrates, 3) local epidermal and/or dermal hyperplasia. B: plaque. C: urticarial wheal. D: nodule of 4) dermal and/or subcutaneous origin, and 5) epidermal origin. E: pustule in a follicular or 6) an epidermal location. F: vesicle in an intraepidermal location or 7) at the transition between dermis and epidermis.

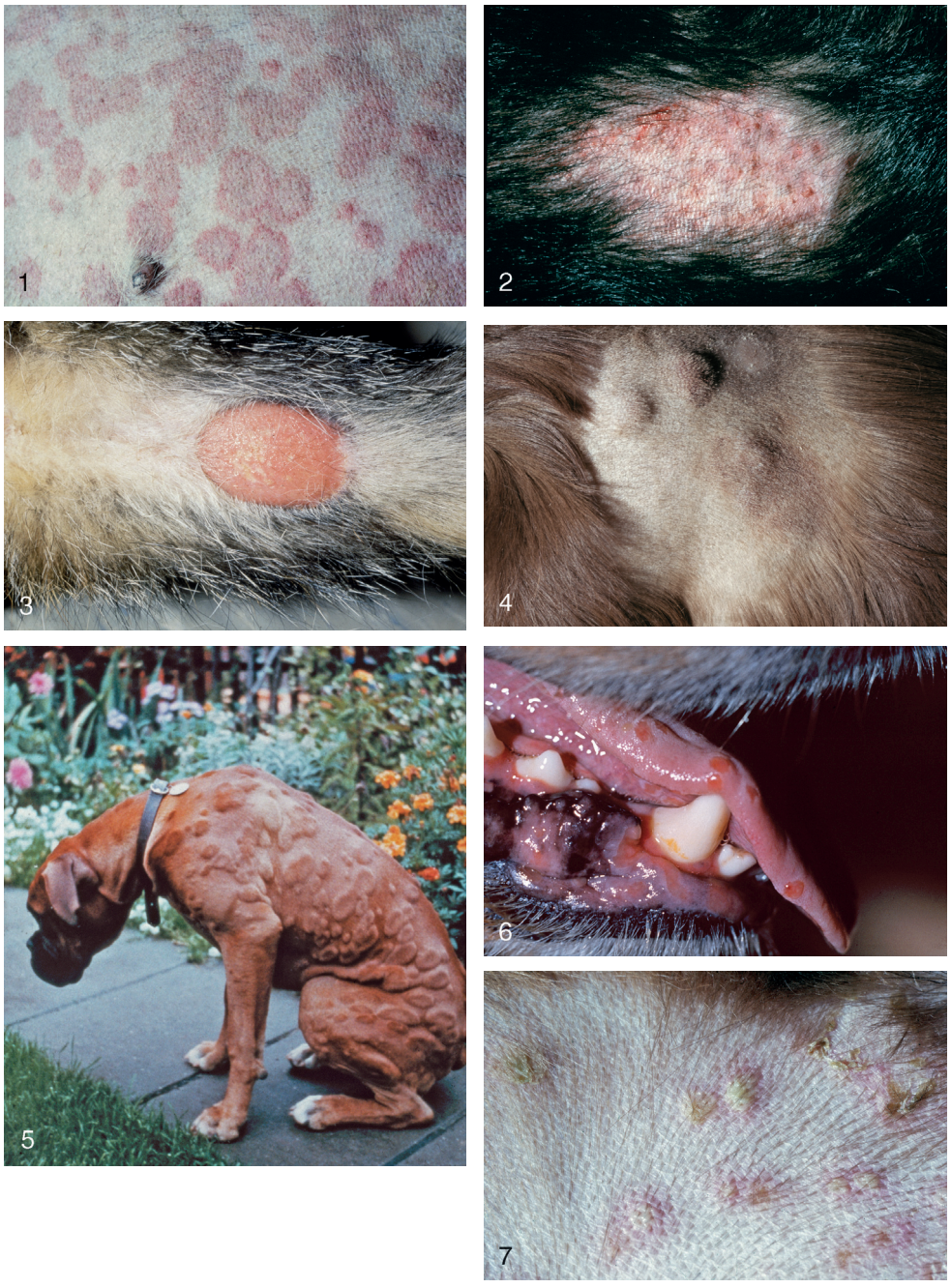


Fig. 15.4 Examples of primary skin lesions. 1 Macules as manifestation of hypersensitivity to a drug. 2 Papules due to inflammation (coat has been partly clipped). 3 Plaque due to inflammatory infiltrate with many eosinophils, as can occur in cats with allergic dermatitis (food allergy, atopy). 4 Nodules due to multiple tumors. 5 Widely-distributed wheals (urticarial lesions) due to an allergic reaction. 6 Vesicles on the tongue associated with an autoimmune dermatosis (pemphigus vulgaris). 7 Pustules occurring with a bacterial dermatitis.

Secondary lesions

Secondary lesions (Fig. 15.5) include:

Scales (squamae). Scales are loose flakes of keratin on the surface of the skin between the hairs.

Collarettes. A collarette is a circular collar of loosely attached epidermal tissue around a skin defect. This collar is the remainder of the covering of a ruptured vesicle or pustule, but is also seen in epidermal necrosis.

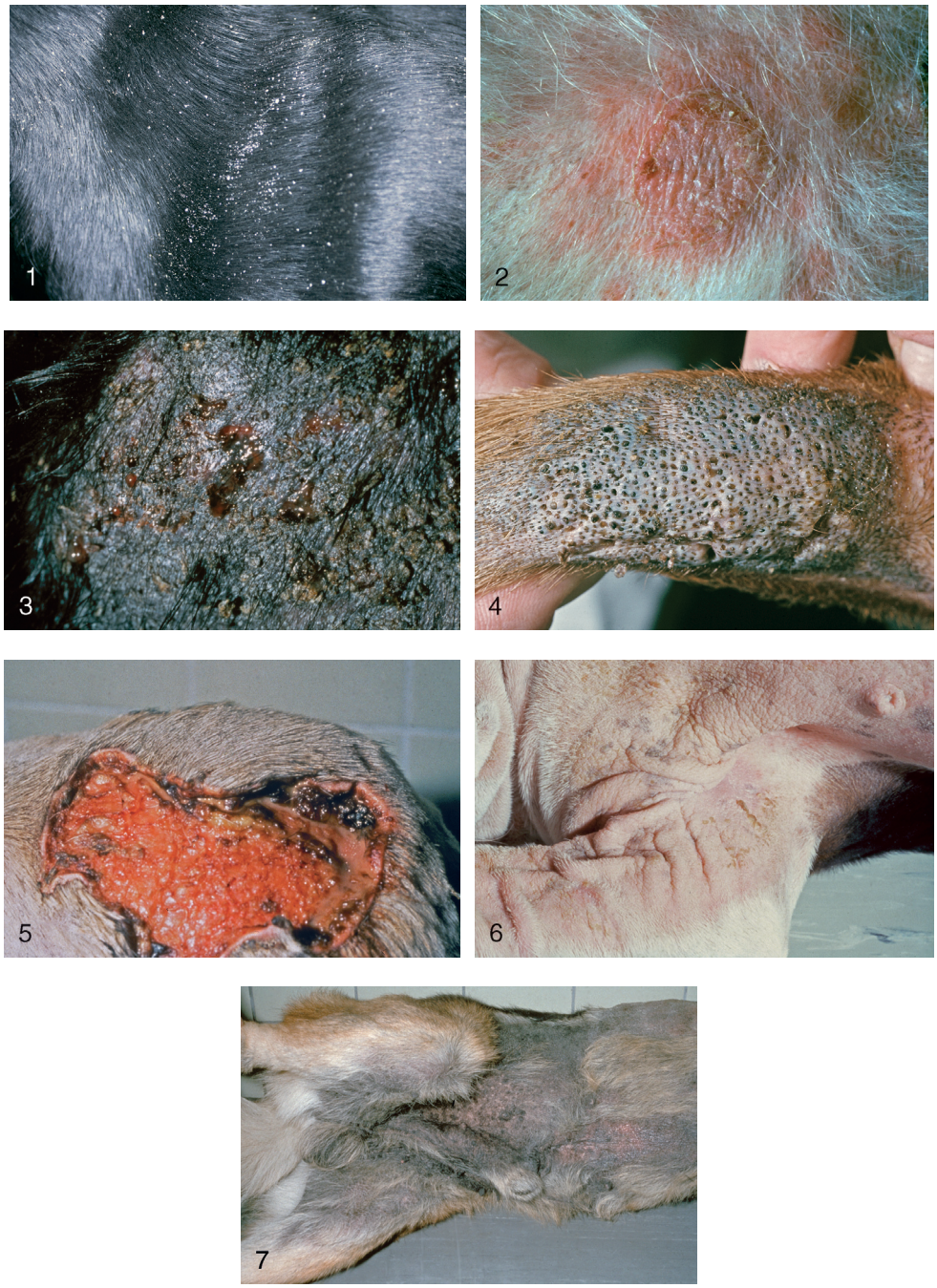


Fig. 15.5 Examples of secondary skin lesions. 1 Scales (squamae) from a parasitic infestation (cheyletiellosis). 2 Collarette, the remnant of a ruptured pustule, with inflammatory erythema in the center. 3 Crusts. On the right there is dried exudate. On the left and in the center there are skin defects and hemopurulent exudate. 4 Comedones on the dorsum of the base of the tail. The dilated hair follicles are filled with sebum and keratin. 5 Ulcer due to inflammation of subcutaneous fat (panniculitis). 6 Lichenification in the axilla. The thickening and folding of the skin are the result of chronic dermatitis and frequent scratching. 7 Hyperpigmentation due to chronic irritation of contact dermatitis.

Crusts. A crust consists of keratin mixed with dried exudate. Hemorrhagic crusts, brown or dark red, are seen in deep skin inflammation.

Comedones. A comedone is a plug of keratin and sebum within the dilated orifice of a hair follicle.

Ulcer. An ulcer is a deep defect with loss of the epidermis and involvement of the dermis. More superficial defects without disruption of the epidermis are called erosions or excoriations.

Lichenification. This is an extensive thickening of the skin in which the normal relief or surface profile becomes much more visible. It is the result of chronic trauma or inflammation.

Hyperpigmentation. Hyperpigmentation is a brown, gray, or black coloring of the skin, often visible on areas where alopecia has developed. It can result from increased activity of the melanocytes in the epidermis or melanocytes and melanophages in the dermis.

Configuration of lesions

Lesions can occur in a solitary, grouped, annular (ring-shaped), linear, arciform (arch-shaped), or polycyclic (confluence of round lesions) configuration. The configuration can be characteristic of the disease: a linear configuration is consistent with a scratching lesion (excoriation) and a polycyclic configuration is often the result of confluence of several pustules.

Distribution of lesions

In addition to giving the exact location of the abnormality, we can describe its distribution as being localized, regional, generalized, multifocal, symmetrical, or asymmetrical.

During palpation of the affected and unaffected skin, note its consistency, elasticity and sensitivity. The turgor should be determined in an area of unaffected skin.

15.3.4 Nails, foot pads, and nasal plane

The nasal plane and the foot pads are examined in the same way as the skin; this examination includes the nails and the bordering cuticle. During inspection of the nasal plane attention is given to the reticular pattern. It can disappear as a consequence of lupus erythematosus or neoplastic epidermal infiltration.

Two terms are used to describe specific abnormalities of the nails or claws: (1) onychomadesis, the complete loss of the horny structure of the nail, and (2) onychorrhesis, the breaking down (crumbling) of the nail.

15.4 Notation

The distribution of alopecia and lesions can be sketched on the drawings provided on the record forms. An example is shown on the DVD.

15.5 Further examination

15.5.1 Skin scraping

The collection of skin material for microscopic examination for the presence of parasites or fungi is performed with a curette (Fig. 4.7). Scraping with the sharp edge of a curette several times over the surface of the skin obtains sufficient material. If a deep scraping is necessary, curetting is continued until there is capillary bleeding. The material obtained by scraping is cleared in 10% KOH solution and then a smear is made on a glass slide for microscopic examination.

If the skin is dry, it is helpful to clip hair at the site of the scraping. A little oil on the curette will help to adhere the sample.

15.5.2 Additional examinations

Depending on the problem, the examination can be extended to include:

- mycological and bacteriological examination
- microscopic examination of dust from the coat and/or the animal's bed
- trichography: microscopic examination of depilated hairs
- laboratory examination of blood and urine
- cytological examination
- histological examination of biopsies of skin and mucous membrane
- allergy examination
- immunologic examination

There are two special methods of examining the skin

1. Diascopy. Using a transparent flat object such as a plastic spatula, slight pressure is applied to erythematous skin. If the color changes to white, the erythema is caused by vasodilatation. If the red color remains, it is due to cutaneous bleeding.
2. Nikolsky's sign. A blunt instrument such as a spatula or the upper part of a thumb forceps is used to lightly wipe normally appearing skin or skin bordering a vesicle or ulcer. If the most superficial layer of the skin is easily traumatized or can be pushed on edge, there is poor cellular cohesion, which is an indication of an autoimmune disease, for example toxic epidermal necrolysis, or burns.

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16 Mammary glands

G.R. Rutteman and E. Teske

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For examination of the mammary glands the history and physical examination must be concerned with more than these glands alone. Both the form and the function of the mammary glands are very dependent on the stage of the estrous cycle and so this must also be taken into consideration. In addition, abnormalities of the mammary glands include neoplastic growth which can spread and have far-reaching consequences.

16.1 History

16.1.1 Symptoms

When a change in the form and/or function of the mammary glands is reported by the owner, we must ask about the nature of the change:

- Does it concern one or more swellings in the glands? If so, how long ago was this first noticed by the owner?
- Does it concern one or more than one gland/nipple, and are there signs that it is increasing (in number/size) and changing (in form and consistency)? If so, how quickly has this occurred and has the owner observed a connection with the estrous cycle, with administration of drugs to prevent estrus, or with recent parturition and lactation?
- Is there secretion from the gland? If so, for how long and is it related to reproduction? Is the secretion from only one nipple or from more than one? What is the nature of the secretion: clear fluid, milky, hemorrhagic, purulent, or otherwise?
- Are there skin defects (ulcers)?
- Does the animal show signs of pain (licking/biting at the mammary glands, pain during palpation, or when standing up or walking)?

When the history reveals an irregularity in the estrous cycle, the nature of this should be determined (see Chapter 13). When did the last estrus occur or, if estrus has been prevented, what drug was used and when was it last administered? If the animal has been pregnant, the number of pregnancies and lactations should be noted, as well as when the last pregnancy occurred and how it progressed.

Depending on answers to questions in the general history, further questions are asked about the animal's endurance and the occurrence of coughing or of fever. Also, in connection with systemic consequences of disorders of the mammary glands, questions must be asked about the appetite, weight loss, change in size of the abdomen, and problems in walking.

16.1.2 Living conditions

These questions are mainly concerned with whether the animal is used for breeding.

16.1.3 Past history

Especially if you are not very familiar with this patient, questions must be asked to discover whether there have

been any previous problems with the mammary glands and how these have been treated. If the animal has been ovariohysterectomized, it is important to know whether there was anything unusual in connection with the ovariohysterectomy.

16.2 Physical examination

16.2.1 Introduction

The mammary glands are arranged in two rows and are identified by their nipples (Fig. 16.1). In the dog there are usually five on each side: two thoracic, one abdominal, and two inguinal. Sometimes there are four glands and then usually the abdominal gland is missing.

Occasionally there are more than five glands on each side. The mammary tissue in the adult dog is unevenly divided. The caudal glands are larger and the tissue of the two most caudal glands is usually continuous.

In the cat there are four glands on each side, with clear borders and less difference in size than in the dog.[1,2]

Interpretation of abnormalities in the mammary glands requires familiarity with the lymphatic drainage (Fig. 16.2). The three caudal glands, and in some dogs also the caudal thoracic ('second') gland, drain to the superficial inguinal lymph node on the same (homolateral) side (sometimes called the supramammary node). There can at the same time be a connection with the lymph node on the opposite (heterolateral) side. From the superficial inguinal node(s) there is drainage to nodes lying just cranial to the pelvic canal (deep inguinal node, sacral nodes, hypogastric nodes) and from there to lymph nodes in the abdomen.



Fig. 16.1 Ventral view of a bitch with five nipples on each side.

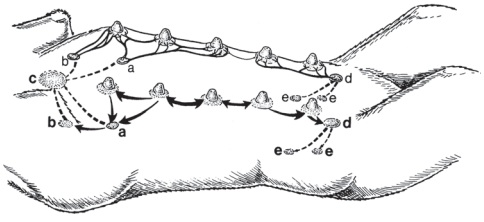


Fig. 16.2 Superficial lymphatic drainage (—), deep lymphatic drainage (– –), and lymphatic drainage sometimes present (↔). a accessory axillary lymph node, b axillary lymph node, c sternal lymph node, d superficial inguinal lymph node, e deep inguinal lymph node and hypogastric lymph node.

The two cranial glands (when there are four in total) or the three cranial glands (when there are five in total) drain to the main axillary lymph node and to the accessory axillary node. In some dogs the cranial inguinal ('fourth') gland drains to the axillary lymph node(s). From these lymph nodes and in some dogs probably also directly from the three cranial glands there is drainage to the sternal lymph node and sometimes even to the prescapular lymph node.[1-3]

With regard to the blood supply, there can be venous connections between the cranial and caudal glands via the cranial and caudal epigastric veins.

In the course of the estrous cycle there are, especially in the dog, clear influences on the development and activity of the mammary gland tissue. The long time that hormones (especially progesterone) can exert influence can result in a marked increase in volume, via which at about eight to twelve weeks after the onset of estrus there can also be secretion. This is a physiologic occurrence that sometimes causes a problem for the owner, particularly with the change in behavior which occurs at the same time (pseudopregnancy).

In cats mammary gland development is also promoted during the luteal phase but, in contrast to dogs, a corpus luteum develops only after mating, regardless of whether the mating is fertile. Thus in cats enlargement of the mammary glands occurs only after mating.[4]

Drugs with progestin activity can promote the development and activity of the mammary gland tissue in both dogs and cats.

16.2.2 Technique

Depending on the shape and size of the animal and its cooperation, the examination of the mammary glands is carried out with the animal lying either on its side (first completely examine one side, and then the other) or on its back (Fig. 16.3). The mammary glands are examined from cranial to caudal. Inspection and palpation are used to determine the location (in which gland) any abnormality is located. Then the position within the gland located and described (see § 4.1.2).

The size of any lesion (nodule or cyst) is measured in three dimensions with the help of calipers or a ruler. The shape of the lesion is shown as well as possible in a sketch. The consistency is described by use of an ordinal scale, as explained in § 3.1.2. In addition to information in the history about the painfulness of the lesion(s), painfulness can be defined by inspection and palpation while observing the animal's reactions. The



Fig. 16.3 Ventral view of a bitch, showing the scar from removal of a tumorous mammary gland and nipple on the right side and a tumor with red discoloration of the skin on the left side.

moveability of the lesion in relation to the trunk is evaluated, as well as whether the overlying skin is fixed or moveable. In defining the borders of the lesion, it may be possible to determine the degree to which an indistinct border is caused by secondary changes such as edema and/or inflammation. Inflammation may affect the color and temperature in the area.[5] If there are defects in the skin they are described in terms of their type and extent. If lymphatics in the lesion are involved, they are sometimes palpable as subcutaneous strings. Next, the regional lymph nodes are examined. The lymph nodes in the pelvis and dorsal hypogastrium can be reached by rectal palpation and palpation of the hypogastrium. They are only palpable if they are markedly enlarged.

If fluid is being secreted from one or more nipples, the color can be judged by milking a little of the fluid onto white gauze or a microscope slide.[6]

By a systematic examination such as described in § 4.1.2, a picture of the abnormality is obtained without repeating the not completely harmless or painless palpation procedure.

16.3 Notation

For a uniform notation the glands are numbered from cranial to caudal (Fig. 16.4). If there are six glands present, the most caudal gland is thus number 6. The

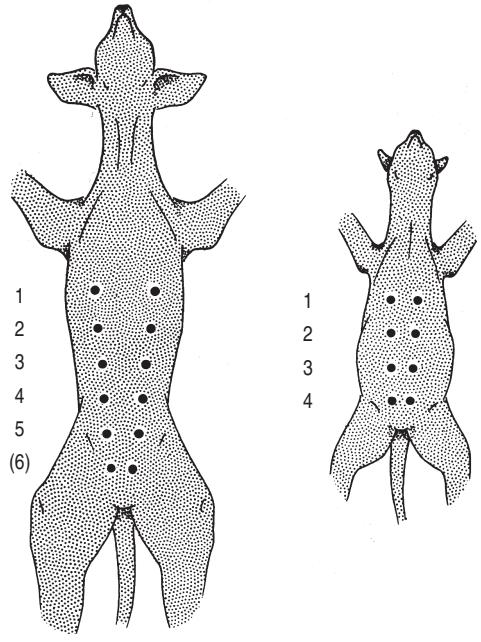


Fig. 16.4 Numbering of the mammary glands in the dog and the cat.

abnormalities that are found are sketched in the picture on a form such as that on the DVD. Further description of the changes can be done by using the numbering system. The use of the rows of boxes on the form has been described under Notation for the General Examination (§ 8.4).

16.4 Further examination

To be considered are:

- leukocyte count and differential
- bacteriologic examination of secretion
- radiographic examination of the thorax
- ultrasonography of the abdomen
- cytologic examination
- endocrinologic examination

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17 Locomotor system

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17.1 Introduction

The locomotor system can be divided into an abaxial part and an axial part. The abaxial part includes the anatomical structures of the extremities: bones (including diaphyses, epiphyses and apophyses, growth plates, metaphyses, sesamoid bones), joints (including menisci), tendons, ligaments, and muscles. This part of the locomotor system provides support and protection, and offers the possibility of standing and moving around. The axial part includes the vertebral bodies, vertebral joints, intervertebral discs, ligaments, tendons, and muscles. The vertebral column protects the spinal cord and forms a connection with the caudal extremities via the iliosacral joints.

Examination of the locomotor system can be undertaken in the course of (1) a general physical examination, without locomotor abnormalities having been observed by the owner (e.g., certification of health for sale or for breeding), (2) an abnormal locomotion, arising from an abnormality in the locomotor system, or (3) an abnormality of the locomotor system (with or without lameness) that arises from an abnormality outside the locomotor system (e.g., suspected endocrine disease or immune-mediated disease). Abnormalities of the locomotor system can result in lameness and this can be the primary reason for the examination.[1-8] The vertebral column can be examined in connection with examination of the locomotor system or examination of the nervous system. It should be obvious that this examination, especially because of the direct involvement of the spinal cord in abnormalities of the vertebral column, requires extreme care.[9]

By means of the history and physical examination of the locomotor system, an attempt is made to obtain:

- a functional diagnosis (mechanical limitation, painful process)
- an anatomical diagnosis (location of the disease process)
- insight into the pathogenesis (congenital abnormality, developmental disorder, trauma, inflammation, abnormality of other organ systems, neoplasia)

The examination of the locomotor system described here is directed above all at functional and anatomical diagnoses. When the general examination has led to formulation of a problem and a diagnostic plan that includes examination of part or all of the locomotor system, the history is explored further in this direction. The animal is observed moving in quiet surroundings and then inspection, palpation, and manipulation are performed while the animal is standing on the examination table. Next follows inspection, palpation, passive movements, and specific manipulations while the animal is lying on its side or on its back. The examination of the spinal column includes inspection, palpation, percussion, and passive movements that can be performed while the animal is standing or lying down. If necessary, rectal palpation can be performed and other examinations can be carried out. On the basis of the results of all of these examinations, a plan for further diagnostic studies can be made.

17.2 History

An effort is made to determine as accurately as possible when the problem started. The conditions at that time (e.g., being struck by an automobile, playing, falling, etc.) must be drawn out in the process of taking the history.

It is often helpful to have the owner describe exactly the situations in which the locomotion problem is most obvious (e.g., mainly after animal rises from its bed, or when it runs off, or while walking on a gravel path, or when jumping over a fence). This applies also to signs of pain: whether they occur during brushing the coat over the lumbar vertebrae, or while the animal is crawling under a fence, just getting ready to jump, eating out of a dish on the floor, stepping down from a sidewalk, or when it is raising its tail during defecation, etc.

An accurate description of the progression of the symptoms during the day (lame when getting up from bed, better during walking, worse after excessive exercise—versus an increase in severity of signs during a walk) can give an indication of the location and nature of the abnormality. This also applies to the progression of the problem over a period of days or weeks. We can make the following distinctions:

- permanently present (always equally severe)
- recurrently present (periods of recovery and then recurrence of problems)
- intermittently present (alternating lameness and normal locomotion)
- progressive (worsening)
- migrating (changing from place to place or leg to leg)

Questions are also asked about the living conditions (guide dog, guard dog, police dog, house pet), feeding (an impression of the composition of food, including supplements), therapeutic measures (general nursing or handling by the owner, training, medication by the owner or another veterinarian, and results of these measures), similar problems in the parents, littermates, or others of the same breed.

17.3 Observation of stance and motion

Although in the General Impression (Chapter 7), the animal was observed while standing and walking, this is repeated after taking the additional history but with another purpose and more specific observations. In these observations the examiner tries to obtain an

impression of the degree and the nature of the locomotor disturbance and the limb(s) involved.

17.3.1 Examination at rest

In the examination at rest, attention is given to the stance and the weight bearing of the extremities, and to the posture of the head, neck, and vertebral column. The stance of the extremities is determined by the structure or form of the limb and by the position the animal takes with the limbs. The structure or form of a limb can differ markedly per species and per breed (Fig. 17.1), but can also be abnormal as a result of pathologic changes such as deformed growth, fractures, and muscle contractions.

The position is largely determined by the extent and painfulness of a process and/or the character of the animal. The bearing of weight by both front limbs and by both rear limbs must be equal in an animal at rest in a normal position. About 60% of the body weight rests on the front feet and 40% on the rear feet.

In most dogs the lumbar and thoracic parts of the vertebral column are either horizontal or slant slightly downward toward the sacrum. For the sacrum to be higher than the beginning of the thoracic part is considered abnormal.

Technique

The animal should be standing in a quiet area, preferably on the floor, although small animals can be placed on the examination table. The animal can be on a leash if necessary but it should not be pulling at the leash or leaning against the owner or the wall. The examiner observes the animal for a short time from all sides, taking note of:

- the stance of the limbs
- the relative positions of the limbs, head, and vertebral column
- the bearing of weight on the limbs

In addition to noting the degree, type, and location of the abnormality while the dog is standing, we also observe the dog for characteristic abnormalities in the way it stands (Fig. 17.1). A few characteristic abnormalities which have consequences for the stance have been given the following names:

varus: an angular deviation of part of the leg toward the median line, in the sagittal plane

valgus: an angular deviation of part of the leg away from the median line, in the sagittal plane

The abnormalities are named according to the origin of the deviation: in animals whose hind legs form an X there is varus from the hips and valgus from the knees, and in those whose hind legs form an O there is valgus from the hips and varus from the knees.

torsion: twisting of a part of the skeleton or a bone on its long axis

endotorsion: turning inward (medially) of the distal part of a long bone

exotorsion: turning outward (laterally) of the distal part of a long bone

There are a few characteristic abnormalities in the *positioning* of the limb relative to the body which affect the way in which the animal stands:

rotation: turning of a limb in a joint on its long axis

exorotation: lateral turning of a limb or part of a limb (Fig. 17.1)

endorotation: medial turning of a limb or part of a limb

abduction: entire limb moved sideways away from the median line

adduction: entire limb moved sideways toward the median line

Some abnormal forms of *weight bearing* by limbs are:

hyperextension: overstretching of joint(s)

hyperflexion: overflexion (bending) of joint(s)

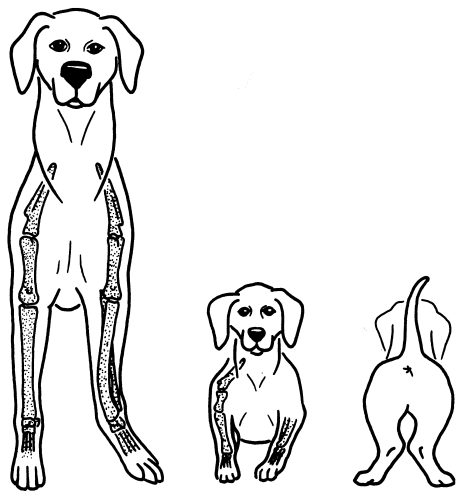


Fig. 17.1 The Labrador and the dachshund illustrate breed differences in the structure and shape of the front leg, as shown by the right front leg in this figure. The stance of the left front leg of each animal is abnormal: the Labrador's leg is in valgus position and the leg of the dachshund is in varus position. Both rear legs of the dachshund are in a French stance due to exorotation.

17.3.2 Examination during motion

What is meant by one step is the complete movement of one limb from one point in the movement cycle, through the cycle, and back to the same point. From the support phase (Fig. 17.2) and the take-off point, the foot goes through the swing phase to the contact point. The step should be square; the left and right limbs should each be brought forward in one plane. Some dogs with long

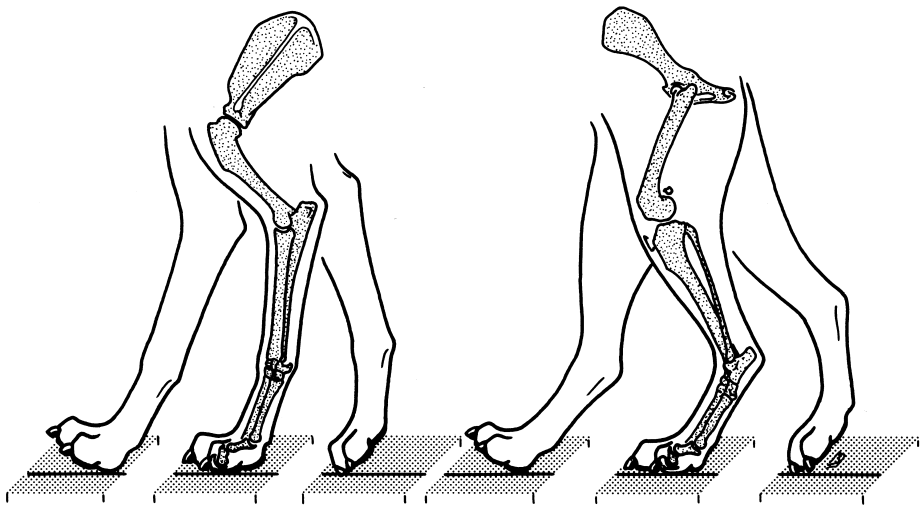


Fig. 17.2 The support phase of both the front leg and the rear leg is from the contact point to the takeoff point.

legs prefer to trot in a slightly angled movement, with one rear foot placed between and the other beside the front feet. Three types of movement can be distinguished: walking, trotting, and galloping.

In *walking*, the body is supported by two or three limbs (Fig. 17.3). The walk should be strong and quick. Depending on the body form of the animal, the steps can be large or small. In *trotting*, usually two feet that are diagonal to each other are moved forward and put down. Before this pair of feet is put down the other rear foot can already lift the body up in such a way that for a moment the entire body is suspended, out of contact with the ground (as in the suspended trot) (Fig. 17.3). In some dogs the *pacing* gait can be observed, in which the body is supported by two feet on one side and then the two feet on the other side, sometimes interrupted by a suspended phase. In this gait the center of gravity and thus also the head are displaced to the supported side, which gives the impression that the animal is swaying from side to side.

During the *gallop* the dog has one suspended phase in the normal gallop and two in the suspended gallop, followed by support phases that are gone through rapidly. When an animal is running in this way, its head is thrown high and the body leaves the ground as the result of a simultaneous stretching of the back and both rear legs. The body comes back down on both front legs equally but not always simultaneously.

Technique

In order to evaluate the gait, the dog is taken along by the owner on a leash of sufficient length that the dog neither pulls on nor is pulled by the leash. To evaluate the gait of a cat, the examination has to be adapted to the possibilities.

The observation must be in a quiet area, on a hard but not slippery surface. For the dog a distance of 10 meters on a sidewalk or garden path is very suitable.

The examiner must give the owner clear instructions about the tempo and distance. The dog is walked a few times toward and away from the examiner. This is repeated at a relaxed trot. The animal is usually not examined in a gallop because of the short phase of support by each foot. The observations can, however, be extended to include quick turns, stepping up and stepping down, and even climbing up and down stairs, or other movements that might seem to be useful on the basis of the history.

The examiner observes the movements of the animal from the front, from the back, and from the side, and observes whether the movements are regular and strong, coordinated, and in harmony. At the same time, the examiner listens for the occurrence of abnormal sounds.

Abnormalities in the gait

During the observation an impression is obtained of the type, severity and location of the lameness at that moment, and abnormal sounds can be heard. In order to reduce the load on a painful front limb, the animal will move the center of gravity caudally by raising its head during the weight-bearing phase on the affected limb. When weight is borne on the unaffected limb, the head will be lowered: 'falling on the healthy limb'. To reduce the load on both front limbs, both rear limbs will be brought forward under the body, causing the back to be arched (kyphosis).

In order to try to reduce the load on one rear limb, the head will be held down when the affected limb bears weight. Since there are always only two legs

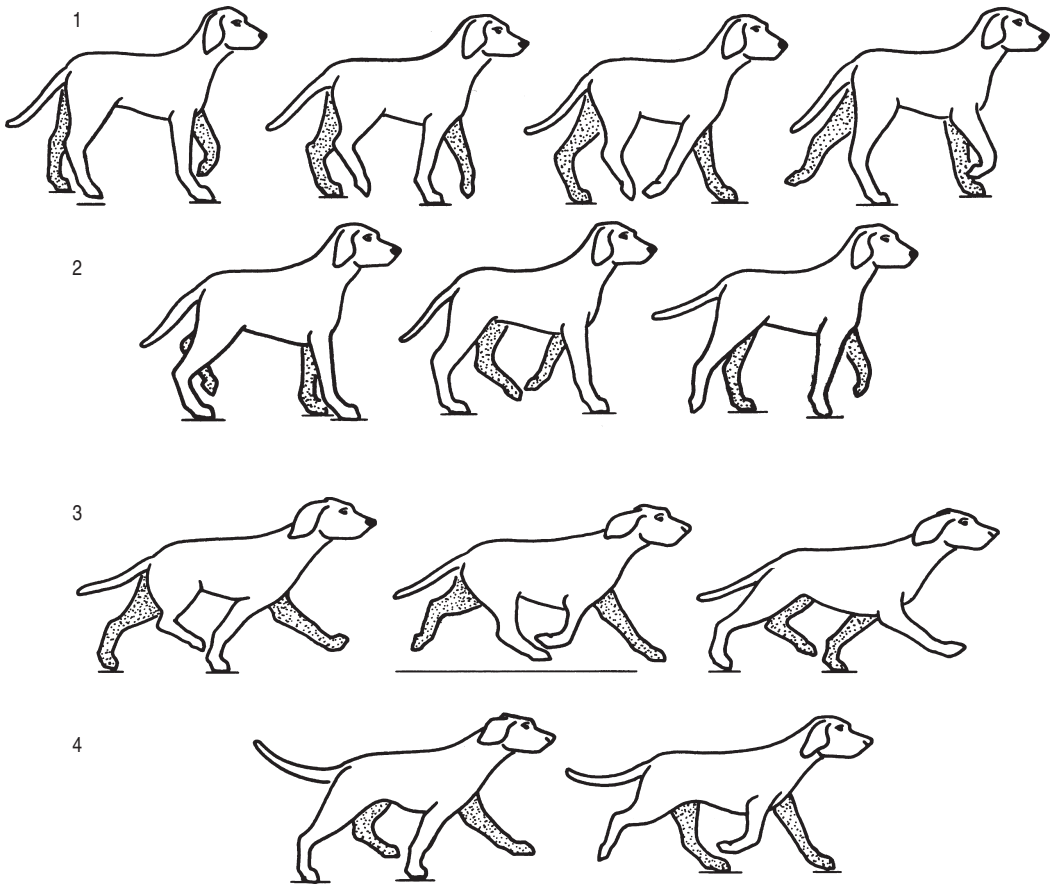


Fig. 17.3 In walking the body is supported by two, three, or four legs (rows 1 and 2). In trotting (row 3) the body is alternately supported by the right and left diagonal legs; only during suspended trotting (middle in row 3) is there a brief suspended phase. In some dogs, pacing (row 4) can be observed, in which the body is alternately supported by two legs on the same side.

bearing weight during trotting, the movement of the head is more pronounced during trotting than during walking. When the animal is jumping, an irregularity can be observed in the use of the rear legs during take-off and in the use of the front legs when the animal lands on the ground again. Pain can also occur as a result of the stretching of the back.

The *type* of lameness can be classified as permanent or intermittent, as decreasing or increasing during locomotion, and as resulting in sparing of the limb or making normal use of the limb impossible.

Locomotion can be divided into a support phase and a suspended phase. Abnormalities in the support phase lead to weight-bearing lameness, whereas those in the suspended phase lead to movement lameness. Usually no distinction is made between these two forms of lameness in companion animals because there is usually an abnormality in both phases. In addition, the distinction is complicated in smaller animals by the rapidity with which the phases of locomotion follow one another.

An ordinal scale (§ 3.1.2) can be used to grade the *severity* of the locomotor disturbance. Grading is especially helpful in following the progress of a lameness.[1,2] This classification is particularly valuable in cases in which the course of the lameness is observed for some time. The scale is as follows:

grade I	barely disturbed locomotion
grade II	locomotion disturbed but limb(s) still bearing weight
grade III	lameness with limb(s) not always bearing weight
grade IV	no weight bearing on limb(s)

The *location* is described as being on one side or on both sides, in the front or rear limb(s), and localized or migrating.

Abnormal sounds, apart from the scraping of the toenails on a hard surface, usually consist of a dry snapping sound during the weight-bearing phase of a rear limb. This can only be heard in a quiet place.

Table 17.1 A few characteristic abnormalities in the gait

- hip-wagging gait, an increased lateral movement in the lumbar area
- lateral circumduction, a circular movement laterally during the suspended phase of a leg without flexion of the elbow or stifle joint
- medial circumduction, a circular movement medially during the suspended phase of a rear leg
- intermittent loading of a rear leg, alternating with exorotation of the raised limb from the knee

A few examples of characteristic abnormal gaits are given in Table 17.1. None of these characteristic abnormalities is, however, to be taken as pathognomonic.

If during walking, trotting, or especially during sudden turns, there is a suggestion of possible paresis and/or ataxia, a neurologic examination is performed. Sometimes both an examination of the locomotor system and a neurologic examination (Chapter 18) will be necessary.

17.4 Examination of the standing animal

If it is decided to proceed with examination of the locomotor system, the animal is placed on the examination table in standing position. The animal is given some attention to help it to relax and the owner is given an explanation of what is going to be done. It is advisable to restrain the animal, the degree of restraint depending on the character of the animal and the expected reactions.

Inspection, and later palpation, are carried out from proximal to distal. The reason for this is that decreased use of the leg results in muscle atrophy which is usually most apparent proximally. This will quickly reveal which limb is lame, an important finding if the animal was not lame when observed in locomotion. Another reason is that the palpation from proximal to distal goes with the direction of the hair, which is more pleasant for both the examiner and the animal than going against the hair.

Inspection

The two front limbs and the two rear limbs are inspected at the same height by standing in front of and behind the animal respectively. The standing position affords good comparison of left and right. Inspection may be hampered by a long haircoat. The following points are noted:

- The contours of the muscles should be flowing and continuous. The sizes of muscles depend on the age of the animal and on such factors as training. In breeds such as greyhounds the musculature can be very well developed. No rhythmic contractions (tremors or myoclonia) should be visible.
- Only a few tendons and ligaments can usually be examined by inspection in the dog and cat: the patellar ligament, the Achilles tendon, the tendon of the triceps muscle, the tendon of the flexor carpi ulnaris, the lateral collateral ligament of the elbow joint, and the medial and lateral collateral ligaments of the stifle and tarsocrural joints. In some cases, abnormal outlining and loss of tension can be seen.
- Each bone has a characteristic form, which varies among breeds. In adult animals the contour of the bone, as far as uncovered by muscles, should have a flowing line. In young animals the area of the growth plate and the adjacent bone (epiphysis and metaphysis) can have the appearance of a local thickening.
- In dogs and cats only the contour of the elbow and knee joints and of the joints distal to these can be inspected. The normal contour of a joint is referred to as 'dry'.
- When the dog is standing the toenails should just miss touching the table surface or floor. In the standing cat the claws are usually not visible. The length of the nails or claws and the way in which they are worn off on one foot can be compared with those aspects on the contralateral foot to give an impression of the degree and the way in which the foot is used and bears weight in walking over hard surfaces.

Palpation

Palpation is performed with both hands from proximal to distal, so that both limbs can be compared at the same level. The following features are noted:

- The muscles should have a flowing contour and no abnormal temperature, consistency, or tonus. Deeper palpation should not cause pain.
- The tendons and ligaments should have smooth contours without local pain, thickening, interruptions, or loss of tension.
- The bones must have smooth contours without swelling, crepitation, looseness, pain response to palpation, or increased temperature.
- The joints should have a normal temperature and a smooth contour, and palpation should not cause pain.

17.4.1 Front limb

Shoulder

The most proximal edge of the scapula (scapular cartilage), the scapular spine, and the acromion are examined by inspection and palpation. This is followed by inspection and palpation of the supraspinatus and infraspinatus muscles. Then the examiner's forefinger is

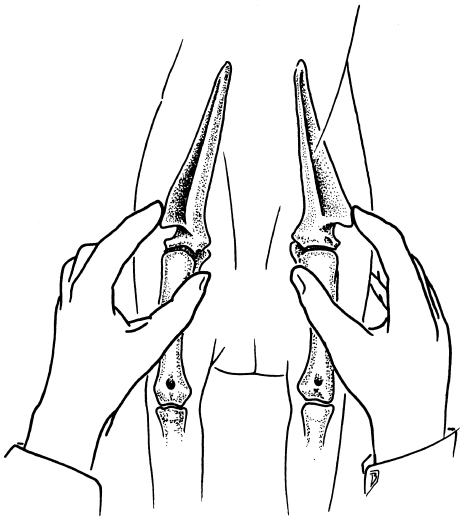


Fig. 17.4 On the left and on the right the forefinger is placed on the acromion and the thumb is placed medial to the major tuberosity in order to compare the distance.

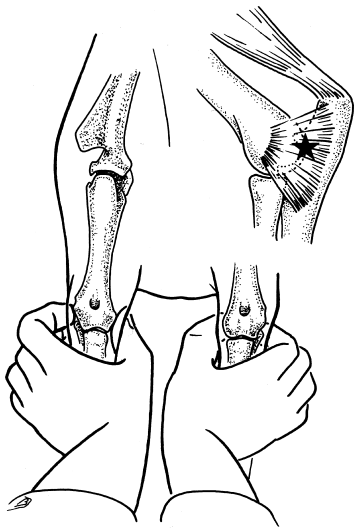


Fig. 17.5 The left hand shows how the width of the elbow joint is examined: the thumb is placed on the medial epicondyle while the forefinger feels the junction between the humerus and the radius on the lateral side. The right hand shows how the elbow joint can be examined for warmth, effusion, and painfulness. The forefinger is placed at the level of the anconeal muscle (insert).

placed on the acromion and the thumb is placed medial to the major tuberosity of the humerus, to compare the distance between these structures on the left with that on the right (Fig. 17.4).

Upper leg

Inspection and palpation begin with the proximal humerus at the major tuberosity and then proceed to the muscles around the humerus, the tendon of the triceps, and the olecranon.

Elbow

The distance between the lateral and medial epicondyles is determined by palpation. The forefinger is placed on the lateral epicondyle and the thumb on the medial (Fig. 17.5; left). Then the lateral side of the junction between the humerus and the radius is palpated.

The elbow joint can be inspected and palpated for effusion only at the level of the anconeal muscle, in a straight line from the lateral condyle to the point of the olecranon (Fig. 17.5; right).

Lower leg

The lower leg is inspected and palpated superficially from proximal to distal; the ulna is mainly palpable proximal-laterally and the radius distal-medially. In young animals the examiner must consider whether the metaphysis is of normal or excessive width.

Carpus and metacarpus

The carpus comprises the antebrachiocarpal joint (radiocarpal and ulnocarpal), the intercarpal joints, and the carpometacarpal joints. The angle in the carpal joint between the radius and the metacarpus is 185–190° in the dog. Inspection and palpation of the various parts of the carpal joint are mainly limited to the dorsal surface. The accessory bone is palpated and its position and the tension of the attached tendon of the flexor carpi ulnaris muscle is evaluated. The metacarpal bones and their joints are inspected and palpated.

Toes

The position of the toes is examined. The animal should bend the toes when standing and the nails should not touch the surface of the table. The phalanges and their joints are inspected and palpated. Then the metacarpal bones of one foot are grasped and the foot is strongly pressed on the table (Fig. 17.6), and any sign of pain is noted.

17.4.2 Rear limb

Pelvis

The examination of the pelvic area includes inspection and palpation of the iliac crests, gluteal muscles, greater trochanter, and ischiadic tuberosity, giving attention to the symmetry of the triangle of the iliac crest, greater trochanter, and ischiadic tuberosity. At the same time, the thumb is placed between the major trochanter and

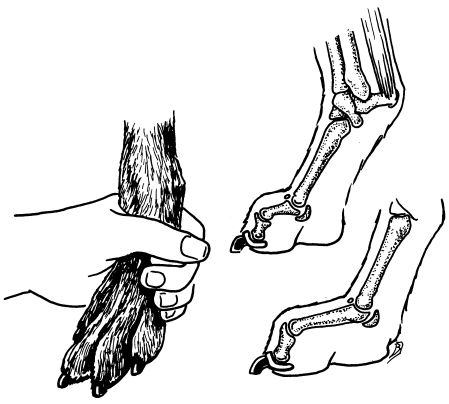


Fig. 17.6 The foot of the dog can have various forms: upper right: the so-called 'cat foot', lower right: the so-called 'rabbit foot'. In neither of these cases should the nails touch the table surface. The metacarpus of one foot is grasped in order to place the foot firmly on the table.

the ischiadic tuberosity on both sides to compare the distances (Fig. 17.7). Both rear limbs are lifted up and extended caudally while the thumbs continue to evaluate this distance. Relatively heavy dogs must be supported by a helper holding an arm under the abdomen. If there is no assistant to provide this support, the examiner can grasp both thighs or stifles, lift the dog, and extend both legs backwards, but this will not allow the distance to be checked with the thumbs. The length of the legs is compared by comparing the location of the calcanei or the large foot pads (Fig. 17.8). The comparison can be quite erroneous if, unintentionally and unnoticed, the two limbs are not extended to the same degree.

The iliopsoas muscles are examined by simultaneously palpating the muscle belly, extending the hip joint, and endorotating the femur. The iliopsoas muscle is a fusion of two muscle bellies: the major psoas muscle (origin: transverse processes of lumbar vertebra), and the iliacus muscle (origin: ventral side of the ileum). The iliopsoas muscle inserts on the minor trochanter of the femur. The examiner stands on the contralateral side of the dog, brings one hand over its back, and grasps the muscle bellies proximally in the groin. The other hand grasps the femur on its cranial side and lifts the leg with backward extension and endorotation. With the hip so extended and with deep palpation, the psoas major muscle can be examined lateral to the lumbar vertebral column, the iliacus muscle can be examined on the ventral side of the ileum, and the iliopsoas muscle can be examined at the level of its insertion on the minor trochanter. Attention is given to possible pain and muscle contracture.

Upper leg

The musculature around the femur is inspected and palpated. The tail is held to one side so that the adductors can be seen and compared.

Stifle joint

First the tibial crest is located to simplify location of the patellar tendon, which is attached to it. Effusion in the stifle joint and/or thickening of the joint capsule is mainly detectable medial and lateral to the patellar tendon. The examiner stands behind the animal and palpates the tendon with the thumb and forefinger (Fig. 17.9).

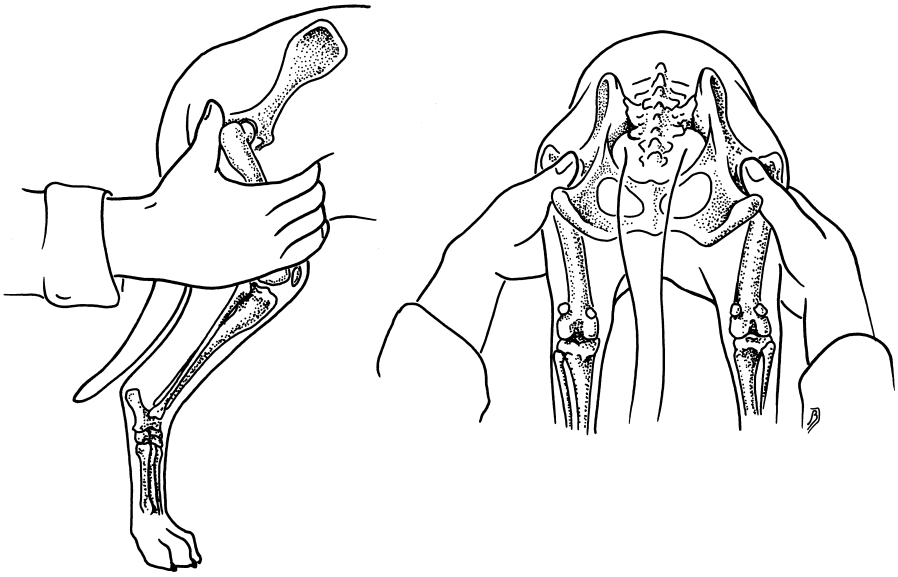


Fig. 17.7 The thumbs are placed on both sides between the greater trochanter and the ischiadic tuberosity in order to compare the distances.



Fig. 17.8 Both rear limbs are lifted up and extended caudally. The thumbs remain in the same place. The length of the legs is compared on the basis of the position of the point of the calcaneus and/or the metatarsal pad.

The patella is located by following the patellar tendon proximally from the tibial crest. The stability of the patella in the femoral-patellar joint is determined by pushing the patella medially and laterally with the thumb and forefinger while the stifle is held extended. It should not be possible to push the patella over the edge of the trochlea and there should be no crepitation. The extension of the stifle is possible when the examiner stands against the edge of the table behind the dog and holds the dog with its ischiadic tuberosities against himself. With the outer edge of the hand, the tibia is pressed caudally at the level of the tibial crest. At the same time the thumb and forefinger carry out and evaluate the horizontal movements of the patella.

If the patella is already found to be luxated, then one determines whether the stifle can be extended and the patella replaced in the trochlea. If the patella is luxated or can be luxated, laterally or medially, the shape and depth of the trochlea are evaluated and attention is given to the occurrence of crepitation. If the patella is present in the trochlea, the edges of the trochlea are palpated along their outlines, the thumb on the lateral edge and the forefinger on the medial side.

By moving the thumb laterally and the forefinger medially and both a little distally, the width of the stifle can be evaluated: medially at the level of the tibial plateau and laterally at the level of the lateral collateral ligament (between the lateral epicondyle of the femur and the head of the fibula).

Lower leg and hock

Over the entire length of its medial side the tibia is not covered by muscle and is therefore easily inspected and palpated. Part of the Achilles tendon is inserted on the calcaneus and extends the hock, while another part runs as the superficial flexor tendon over the calcaneal tuber to the toes.

The examiner stands behind the dog. The examination comprises inspection and palpation of the tibia, cranial tibial muscle, Achilles tendon, and

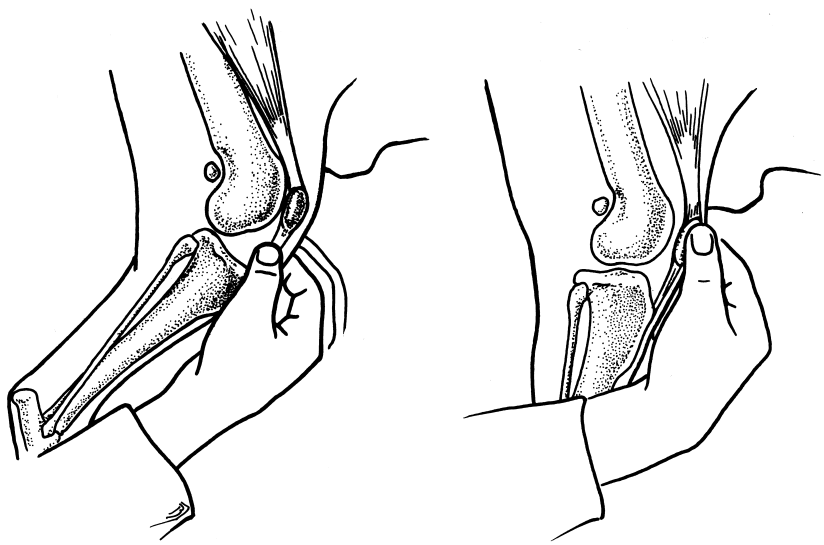


Fig. 17.9 The patella can be located by following the patellar tendon proximally from the tibial crest (left). The patella is pushed medially with the thumb while at the same time the stifle is overextended, in order to check for luxation (right).

calcaneus. The calcaneal tuber and the tendon cap of the superficial flexor tendon are also palpated.

Tarsocrural joint

The tarsocrural joint comprises the joints between tibia/fibula and talus/calcaneus, the intertarsal joints, and the tarsometatarsal joints. Overfilling of this joint can be detected cranial and caudal to the collateral ligaments. These ligaments are attached proximally to the medial or lateral malleolus. The latter is the distal extension of the fibula. Sometimes an effusion is also palpable in the space between the anterior side of the base of the calcaneus and the posterior side of the distal tibia. The thumb and forefinger of each hand are placed before and behind the lateral collateral ligaments of the tarsocrural joint.

If necessary, both hands can be used to palpate before and behind both collateral ligaments of one joint simultaneously (Fig. 17.10). This can be used especially to detect fluctuation due to effusion. All tarsal articulations are also inspected and palpated.

Foot

The reader is referred to what has been described for the front foot.

17.5 Examination of the recumbent animal

The animal is placed on its side, so that the upper leg, which is not being held by the assistant, can be examined thoroughly. In the same position, the foot and carpus or tarsus can be compared with that of the contralateral leg. Comparison of the more proximal structures will have been done while the animal was standing or can be carried out when the animal is placed on its other side.

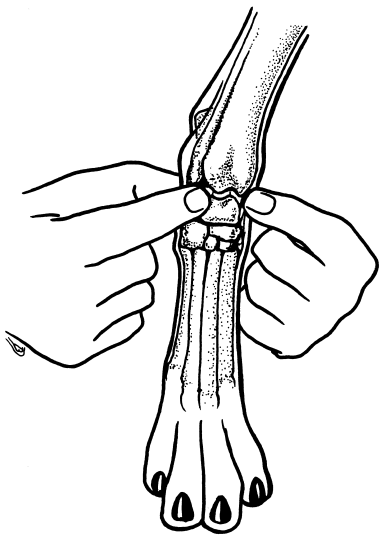


Fig. 17.10 The forefingers are placed before and the thumbs behind the collateral ligaments of the tarsocrural joint.

When lameness is unilateral the contralateral leg can be examined first, to accustom the animal to being manipulated and to obtain an impression of its response to this. Palpation and manipulation of possibly painful processes is omitted initially, to avoid early pain reactions and resistance.

The examination of the recumbent animal includes (1) inspection especially of the structures that could not be seen easily before (e.g., the foot), (2) careful palpation of the limb while it is not bearing weight and deep palpation of structures that are partly superficial, such as long bones, and (3) the passive movements of all joints.

Inspection, palpation, and passive movements are carried out in the recumbent animal from distal to proximal. The reason is that one can move the distal joints without bringing the more proximal joints into movement. Here also, any movements that are expected to be painful are delayed until last.

One must take care to limit deep palpation to the specific structure to be examined: for example, in deep palpation of a long bone with the thumb, the fingers must not at the same time put pressure on the muscle on the other side. The examination of the joints in the recumbent animal includes:

Passive movements

Active movement is the result of the animal's own muscle contraction. Passive movement is the result of an external force that leads to a particular movement.[10] In examining passive movements of joints in different directions, attention is given to:

1. range of motion (ROM)
2. crepitation
3. signs of pain

Within physiologic limits the manipulation of a joint, the passive movement, should proceed smoothly. The movement should be neither hindered nor appear to be possible in a direction that under normal conditions is not possible. The passive movements are carried out repeatedly in order to (1) eventually overcome muscular resistance of the animal and (2) detect fine crepitation. Neither in flexion or extension nor in hyperflexion or hyperextension should crepitation be observed. Crepitation occurs when hard irregularities scrape along each other. As it is easier felt than heard, the examiner should place the fingers as close as possible to the site being examined (joint, fracture). A single audible sound during hyperextension (like stretching one's own fingers) can be considered normal, especially in the shoulder joint. Other sounds that occur during passive movements are abnormal.

The movement of the joint within physiologic limits should not result in pain. Pain will occur, however, if hyperextension or hyperflexion results in excessive stretching of joint ligaments and/or capsules, even under normal conditions. Such examination is only justified if it can be expected to contribute to the correct diagnosis.

Pain reactions are not always easy to interpret: there are species differences (dog and cat), breed and individual differences, and changes with age. Manifestations of pain may include:

- aggression (with severe pain)
- vocalization (yelping in dogs and hissing in cats)
- holding breath or panting
- licking and smacking lips (dogs)
- increased muscle tension
- pupil dilatation (increased sympathicotonus)

When a pain reaction is observed during palpation, its reproducibility should be examined. This must be done carefully. If the pain reaction is not reproducible, it should be regarded as false positive (see also § 3.1.5).

The examination of the joints in the recumbent animal includes:

1. repeated bending, stretching, adduction, abduction, and rotation in the direction characteristic of the joint being examined
2. slightly exaggerated repetition of the same movements
3. maneuvers specifically developed for the relevant joint, in which abnormal moveability, crepitation, and pain reactions can be considered abnormal if they appear to be reproducible

The following descriptions are applicable to the limbs on the right side. The examination of the left front and rear limbs is carried out in the same manner.

17.5.1 Front limb

Foot

If present, the first digit is also examined. The examination is begun with inspection and palpation of the nails, cuticles (lift the hair up!), foot pads (also the accessory), and the volar and dorsal interdigital skin.

Each toe is subjected to passive movements separately. If this causes abnormal moveability (increased or reduced), crepitation, and/or pain, this examination is intensified phalanx-by-phalanx.

Extreme bending of the toes is usually painful and unnecessary. Hyperextension must be carried out: with the thumb and forefinger one toe is stretched excessively while the thumb of the other hand is used to place pressure over the location of the sesamoid bones of this toe (Fig. 17.11). Attention is given to signs of pain and local crepitation.

The metacarpal bones are checked for pain and crepitation by palpation and also for the presence of abnormal contours.

Carpus

The movements which are possible in the carpal joint, and also largely in the antebrachiocarpal joint, are mainly extension and flexion and only to a small extent rotation, abduction, and adduction.

The degree of moveability is determined in part by the age of the animal. Excessive hyperflexion of the carpus is usually painful and should be performed cautiously.

Extension and flexion are performed by using the right hand to move the foot relative to the radius and ulna while at the same time palpating the carpus with the left hand. Hyperextension, rotation (pronation = endorotation, and supination = exorotation of the

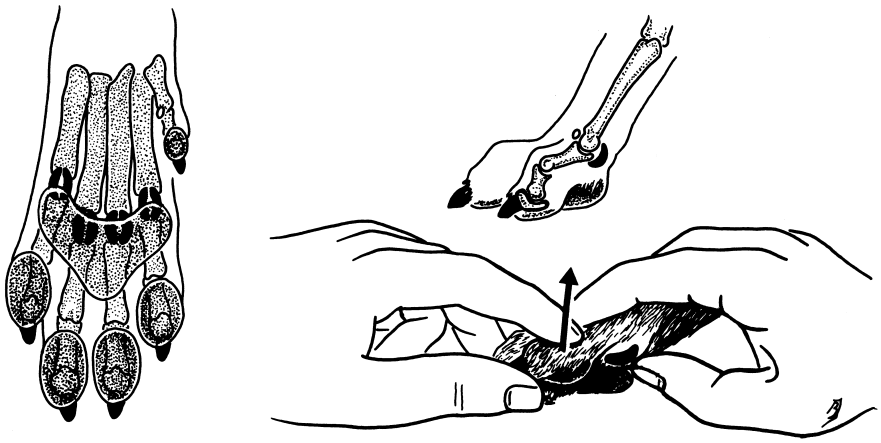


Fig. 17.11 The sesamoid bones, shown at the left, are located at the junctions of the metacarpal bones and phalanges. They are examined by hyperextension of the toe and simultaneous palpation followed by pressure with the right thumb.

foot), abduction, and adduction are evaluated. The moveability of intercarpal and carpometacarpal joints is checked by holding the antebrachiocarpal joint bent halfway and pushing the metacarpus forward parallel to the table. This is a physiological drawer movement, comparable to the pathological drawer movement of the stifle joint, see § 17.5.2. The physiological drawer movement should completely disappear when the carpus is extended. The position of the carpal accessory bone is checked.

Lower leg

Superficial and then deep palpation of the radius and ulna are carried out as follows in order to avoid simultaneous palpation of the musculature. The radius is palpated distally on the medial side with the fingertips, while the heel of the thumb rests on the lateral surface of the leg (Fig. 17.12). Subsequently the thumb of the other hand is used for deep palpation on the lateral side of the proximal part of the ulna, while the fingers, held flat, support the lower arm (Fig. 17.12).

Elbow joint

The distal radius and ulna are encircled with one hand while the thumb of the other hand is placed on the anconeal muscle (Fig. 17.13). Flexion, extension, hyperflexion, and a single, carefully-controlled hyperextension are performed. Then the radius and ulna are exorotated in relation to the humerus, with the elbow joint extended. This is done by pressing the thumb against the olecranon and using the other hand to grasp the radius and ulna distally and to exorotate (Fig. 17.14). Endorotation and exorotation of the elbow are evaluated further by holding the elbow and carpal joints bent at 90° to supinate and pronate the radius and ulna.

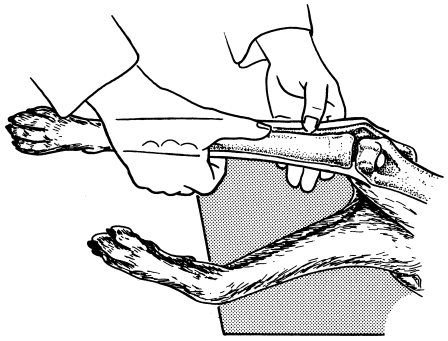


Fig. 17.12 Palpation of the radius and ulna. The right hand demonstrates deep palpation of the radius with the fingertips, during which the heel of the thumb rests on the lateral surface of the bone. The left hand demonstrates how the thumb is used to palpate the proximal part of the ulna, while the extended fingers support the lower leg.

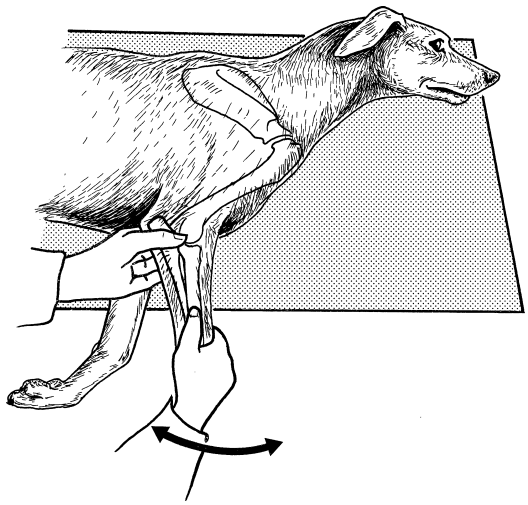


Fig. 17.13 Passive movement of the elbow joint in the recumbent dog, in which the thumb is placed on the anconeal muscle to detect any crepitation.

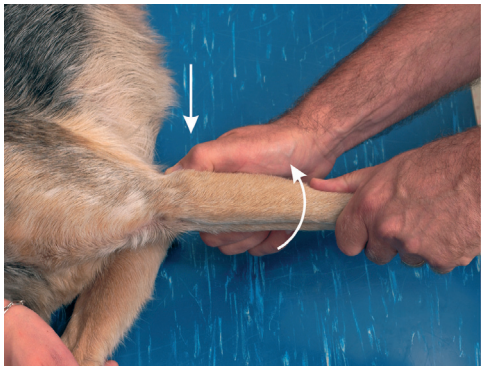


Fig. 17.14 Exorotation of radius and ulna with extended elbow joint is carried out by pushing the thumb against the olecranon (straight arrow) and exorotating with the other hand holding radius and ulna distally (curved arrow).

Upper leg

Only the most distal part of the humerus can be palpated, and then only on the lateral side because the ulnar nerve crosses the humerus on the medial side. Palpation of the latter causes unnecessary pain (in humans: 'funny bone'). In addition, the major tuberosity can be palpated.

The diaphysis of the distal humerus is palpated by placing the thumb on the bone and keeping the fingers extended in order to support the humerus. The musculature of the humerus is also examined.

Shoulder joint

The shoulder joint is not palpable through the muscles that surround it. Crepitation occurring during passive

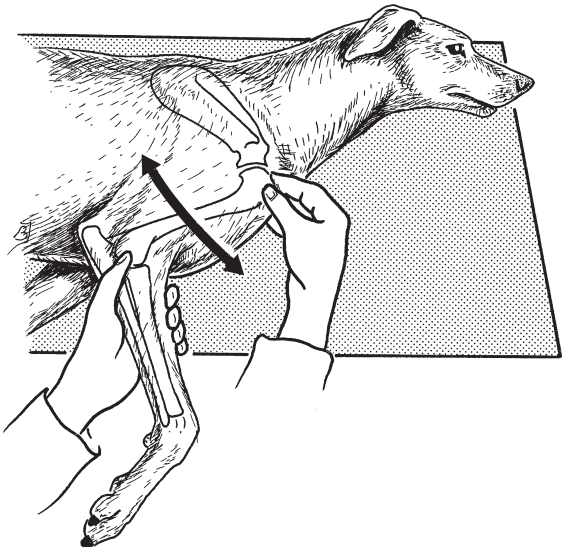


Fig. 17.15 To detect crepitation in the shoulder joint during passive movements, the fingers are placed on the proximolateral part of the major tuberosity.

movement of the joint can be felt on the major tuberosity, which is easily palpated (Fig. 17.15). The joint can be flexed and extended and also to some extent rotated, adducted, and abducted. If hyperextension or hyperflexion is painful, the animal will increase the muscle tension to fix the angle between the scapula and humerus and there is a great chance that the examiner will thus move the shoulder blade in relation to the thoracic wall. As a result, actual hyperextension or hyperflexion of the joint will not occur and the painfulness will be missed; the hands must be placed in a special way to prevent this.

To examine the right shoulder joint the examiner stands ventral to the recumbent dog and places the fingers of the right hand on the major tuberosity while the left hand grasps the proximal radius and ulna.

To avoid causing pain, the left hand should not grasp into musculature surrounding the humerus. With the left hand the shoulder is flexed and extended and with the right hand it is palpated (Fig. 17.15). The stability and moveability of the shoulder joint can be assessed by rotating the leg relative to the scapula, and by abduction and adduction.

After repeated flexion and extension, hyperextension is performed. For this purpose only the right hand is moved, to the cranial edge of the scapula, so that the scapula remains fixed in relation to the thoracic wall. The examiner stands in front of the dog on the ventral side. The radius and ulna are extended obliquely forward until the spine of the scapula, the humerus, and the radius/ulna form a straight line, or until the patient shows that this is painful (Fig. 17.16).

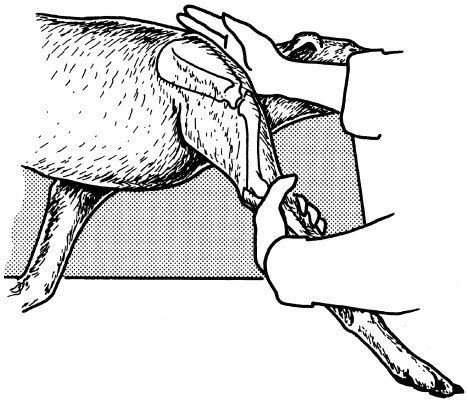


Fig. 17.16 Hyperextension of the shoulder joint is achieved by placing one hand against the front edge of the scapula in order to fix the scapula in relation to the thoracic wall, while the leg is extended until the spine of the scapula, the humerus, and the radius and ulna are in line.

For hyperflexion of the right shoulder joint only the right hand is moved, to the dorsal edge of the scapula, so that the animal does not roll away when hyperflexion is performed. The examiner stands ventral to the dog. The elbow, which may not be bent more than 90°, is moved in the direction of the spinal column (Fig. 17.17).

Finally, the tendon of the biceps muscle is examined for tension and pain. The biceps begins on the scapular tuberosity and inserts cranially and proximally on the radius and ulna. Examination thus includes simultaneous movements of the shoulder and elbow joint. Abnormalities (inflammation, rupture) of the biceps tendon or its sheath result in pain when tension on the tendon is increased. For examination of the right biceps tendon the left hand grasps the antebrachium. The humerus and radius/ulna are pulled caudally until they are in line and parallel to the thoracic wall. Thus the elbow joint is extended and the shoulder is flexed. At the same time, the fingers of

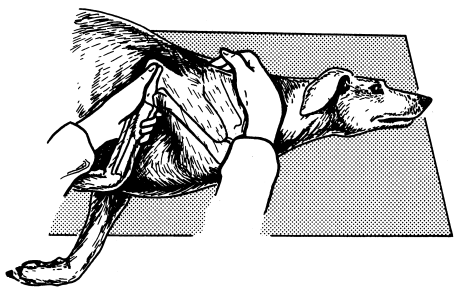


Fig. 17.17 Hyperflexion of the shoulder joint is achieved by moving the elbow joint in the direction of the vertebral column while at the same time fixing the dorsal edge of the scapula.

the right hand are used to press (deep palpation) medial to the proximal humerus and along the biceps tendon.

Scapula

The acromion, spine, and dorsal edge are palpable, as well as the supraspinatus and infraspinatus muscles. The acromion, spine, and cartilage are examined by palpation, manipulation, and pressure. Then the musculature is examined for consistency and tension. The scapula can be slightly abducted by grasping its cranial and posterior borders with the fingertips.

Axillary area

The axilla is palpated carefully to evaluate the form and outline of the first ribs and to detect possible thickening or pain in the lymph nodes or brachial plexus. For this purpose the front leg is abducted. The proximal axillary area can also be examined to some extent for pain or swelling by moving the fingers caudally close to the thoracic wall, medial to the front edge of the scapula, and by moving cranially from the caudal edge of the scapula. When in doubt about what is felt, it is helpful to compare with the contralateral side.

17.5.2 Rear limb

The examiner stands behind (caudal to) the animal, which lies in lateral recumbency with the side to be examined facing upward.

Foot

The examination includes inspection and palpation of the nails, cuticles, food pads, and interdigital skin, as well as passive movements of the toes and simultaneous palpation of the sesamoid bones and examination of the metatarsal bones. See the description of the examination of the front foot (§ 17.5.1).

Tarsocrural joint

The greatest moveability in the tarsocrural joint is in the joint formed by the tibia/fibula and the talus/calcaneus. The remaining moveability is in the intertarsal and tarsometatarsal joints. The tarsocrural joint can only be maximally flexed and extended, without simultaneously moving the stifle, if the stifle is held in maximal flexion. One thumb is held before and the other behind the lateral collateral ligament of the tarsocrural joint, with the forefingers on the medial side in front of and behind the medial collateral ligament (Fig. 17.18). By means of abduction and adduction and during rotation of the foot in relation to the tibia, the collateral ligaments and malleoli can be examined. The joint is hyperextended. Then the plantar contours of the tarsus are palpated. The examiner checks the stability, in other words the normally very small moveability, of the different intertarsal and tarso-metatarsal joints. The Achilles tendon must pass without interruption to its attachment on the calcaneus.

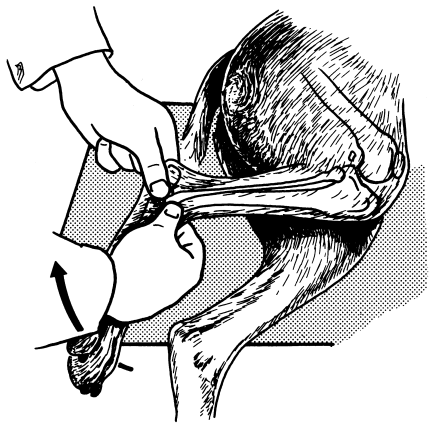


Fig. 17.18 In order to detect crepitation in the tarsocrural joint during passive movement in the recumbent dog, one thumb is held before and the other behind the lateral collateral ligament and the corresponding forefingers are held before and behind the medial collateral ligament.

Lower leg

Deep palpation is easily performed on the medial side of the tibia. The examiner must take care not to palpate the cranial tibial muscle at the same time. The tibia is palpated in the same manner as described for the radius and is checked for abnormal moveability. In young animals the proximal apophysis of the tibia is checked with regard to location, moveability, and painfulness. The surrounding musculature is also palpated.

Stifle

The patella is a sesamoid bone lying in the tendon of the stifle that inserts on the tibial crest. When the leg is extended (with relaxed quadriceps muscle) the patella can be displaced only very slightly medially and laterally, this movement being limited laterally by the retinaculum that passes from the patella to the fabella and by the joint capsule medial and lateral to the patella (Fig. 17.19). The fabellae, which are the sesamoid bones of the heads of the gastrocnemius muscle, are located on the caudal side, lateral and medial to the femoral condyles at the height of the patella.

The cranial cruciate ligament passes 'like a hand in the pants pocket' (from caudolateral to craniomedial), and the posterior cruciate ligament crosses it (Fig. 17.19). The cranial cruciate ligament prevents forward displacement of the tibia in relation to the femur and also limits endorotation of the tibia. The caudal cruciate ligament prevents caudal displacement of the tibia. The lateral collateral band, which passes from

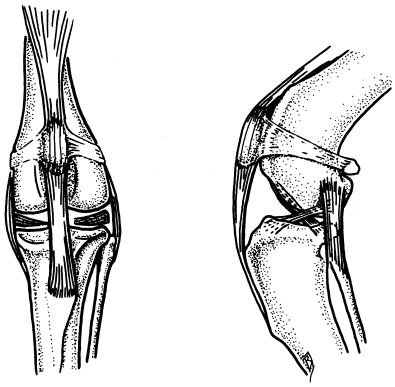


Fig. 17.19 The patella, which is the sesamoid bone of the stifle tendon, is stabilized in the transverse direction by the joint capsule and the medial and lateral retinaculum that passes from the patella to the fabellae, which are the sesamoid bones of the gastrocnemius muscle. The drawing on the left shows that the medial meniscus is attached to the medial collateral ligament (which passes from the femur to the tibia). The drawing on the right shows the path of both cruciate ligaments: the cranial ligament passing like the hand in the pants pocket from caudolateral to craniomedial, and the caudal ligament crossing the cranial one. The lateral collateral ligament passes from the femur to the head of the fibula.

the femur to the fibula, prevents adduction of the tibia in relation to the femur. The medial collateral ligament passes from the tibia to the femur and prevents abduction of the tibia. Hyperflexion, hyperextension, endorotation, and exorotation should not be painful. The menisci give relief to the tibial plateau and function as shock absorbers. The medial meniscus is firmly attached to the medial collateral ligament.

In the examination of the right stifle the right hand is used to grasp the distal tibia and the left hand is placed over the stifle joint.[1,2] The stifle is then extended and flexed and note is taken of the range of motion, crepitation, signs of pain, and the possible occurrence of a snapping sound. Local thickening, crepitation, and painfulness between the patella and the lateral fabella, just lateral to the edge of the trochlea, may indicate avulsion of the insertion of the long digital extensor muscle. Finally, the stifle is fully flexed (hyperflexion) and extended (hyperextension).

Next the examiner places the right hand around the metatarsus with the thumb medial to the calcaneus. The left thumb is placed on the lateral edge of the patella of the extended stifle. While the right hand exorotates the calcaneus and thereby endorotates the tibia in relation to the femur, the left thumb presses the patella in the medial direction (Fig. 17.20). The patella should remain in the trochlea and the endorotation should cause no evidence of pain. Then the thumb of the right hand is placed lateral to the calcaneus and the forefinger of the left hand is hooked around medially behind the patella. While the right hand exorotates the tibia in relation to the femur, the forefinger pulls on the patella while the stifle is still extended (Fig. 17.20). In healthy animals the patella remains in the trochlea and there is no sign of pain. If the patella is luxated, the depth of the trochlea is determined.

Then the examiner checks whether the cranial cruciate ligament is intact. There are two manual maneuvers for this, both of which are based on checking the forward moveability of the tibia in relation to the femur: (1) the drawer movement and (2) the tibial compression test. For the first of these, the examiner places the left forefinger on the patella, the left thumb behind the lateral fabella, the right forefinger on the tibial crest, and

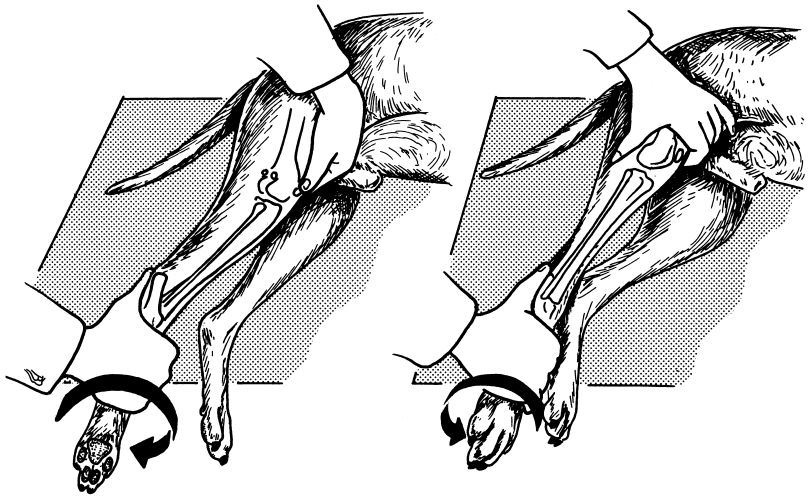


Fig. 17.20 With the stifle held in extension, the patella is pressed medially and the tibial crest is endorotated, while the calcaneus is exorotated and the foot is endorotated (left). Then the patella is pulled laterally with the forefinger and the tibial crest is exorotated, while the calcaneus is endorotated and the foot is exorotated (right). In both of these maneuvers, the patella should not luxate but remain in the trochlea.

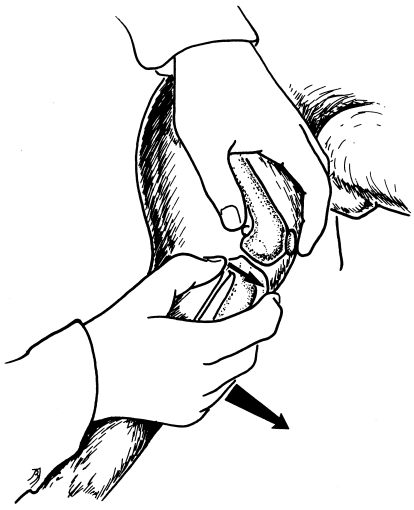


Fig. 17.21 The drawer phenomenon is tested by grasping the bony structures of the upper and lower leg. The left forefinger is placed on the patella with the thumb behind the lateral fabella, while the right forefinger is anchored on the tibial crest with the thumb behind the head of the fibula. With this thumb the tibia is pushed several times firmly forward relative to the femur.

the right thumb behind the head of the fibula. With the stifle extended, half flexed (45°), and then flexed, the examiner pushes the right thumb forward in the direction of the right forefinger; the left hand is *not* moved and serves as the reference point (Fig. 17.21). This movement is performed repeatedly, rapidly, and with appropriate strength. During this process the stifle is neither extended nor flexed and the tibia is not rotated, but rather an attempt is made to move the tibia forward parallel to itself. Sometimes the tibia is found to be permanently displaced forward and it must first be moved caudally and then again cranially in order to produce the drawer movement. The hand grip is such that only bony structures are grasped, so that a displacement of the right hand in relation to the left must represent a displacement of the tibia in relation to the femur. Attention is given to evidence of pain and to forward displacement and/or endorotation of the tibia in relation to the femur.

Following this, with the stifle extended, half-flexed and then flexed, an attempt is made to displace the right forefinger in the direction of the right thumb, to check the posterior cruciate ligament. Attention is given to evidence of pain and to caudal displacement of the tibia in relation to the femur. Testing for the drawer movement can be difficult in strongly muscled dogs which resist the examination and in such cases must be repeated under sedation or anesthesia.

A second test for damage to the cranial cruciate ligament is the tibial compression test (TCT).[11] If the hock is bent while the stifle is extended, the anterior cruciate ligament prevents cranial displacement of the

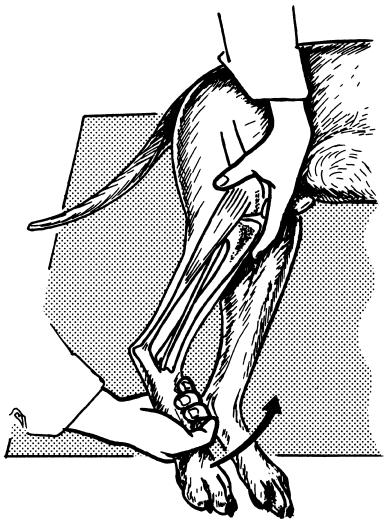


Fig. 17.22 The tibial compression test. Hyperflexion of the tarsocrural joint with the stifle held extended causes a forward movement of the proximal tibia if the cranial cruciate ligament is ruptured.

tibia. The metatarsus is grasped from below by the right hand and the forefinger of the left hand is placed over the patella, patellar ligament, and proximal end of the tibial crest (Fig. 17.22). This forefinger should detect no forward movement of the tibial crest if the hock is bent while the stifle is kept extended.

To check the collateral ligaments, the stifle is held almost fully extended (15°). The thumb of the left hand is placed on the lateral collateral ligament (Fig. 17.19), while the fingers of this hand support the stifle. The right hand is used to grasp the middle of the tibia and to adduct the tibia in relation to the femur (Fig. 17.23). This should not cause any widening of the lateral side of the joint space. To check the medial collateral ligament the forefinger of

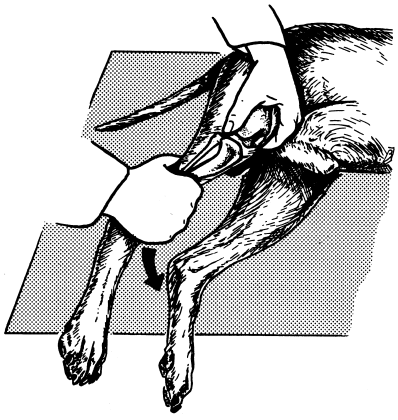


Fig. 17.23 The lateral collateral ligament can be tested by holding the left thumb slightly proximal to the head of the fibula, while the tibia is adducted with the right hand.

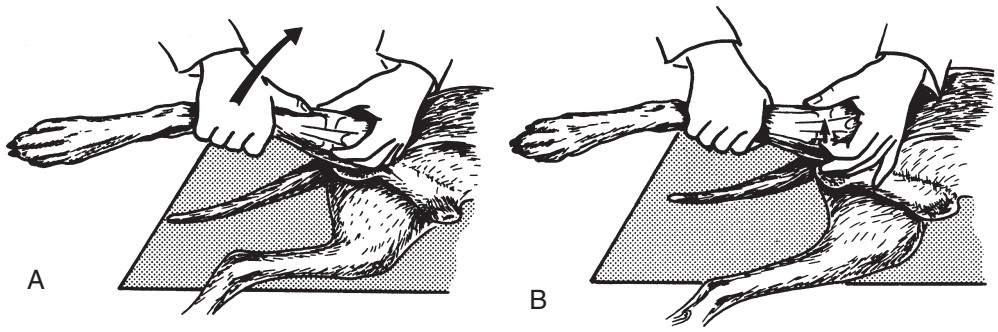


Fig. 17.24 A By using the right hand to abduct the tibia in relation to the femur, the tensing of the medial collateral ligament can be felt. B By palpating on and directly caudal to the medial collateral ligament, swelling and painfulness can be detected if there is a lesion of the medial meniscus.

the left hand is placed on the maximal medial protrusion of the tibial plateau. While the right hand, still in the same position, abducts the tibia, the left forefinger is used to feel whether there is displacement of the tibia and widening of the joint space (Fig. 17.24a).

Finally, the medial meniscus is checked for damage by pressing on it strongly with the forefinger directly caudal to the medial collateral ligament (Fig. 17.24b), taking note of any swelling and evidence of pain. A snapping sound as a result of contact between the femur and tibia in certain meniscal lesions can have been observed earlier in the examination (during extension and flexion).

Thigh

The greater trochanter of the femur can be palpated proximally and laterally. Otherwise the femur is only palpable (medially and laterally) at its distal end. The thigh is palpated superficially and deeply and checked for abnormal moveability and crepitation. Following this the easily palpated muscles are examined.

Hip joint

The hip joint is a ball and socket joint which is covered by the surrounding structures. The femur is held in the acetabulum by, among other things, the teres ligament and the tensed joint capsule. Painful processes in the hip joint can be associated with contraction (and later fibrosis) of the pectineus muscle.

The greater trochanter is palpated to detect possible swelling and painfulness. The right hand is used to grasp the stifle and the fingers of the left hand are placed on the greater trochanter. Flexion, extension, abduction, and adduction are carried out, with attention to the range of motion, painfulness, crepitation, and stability. The femur is also rotated on its long axis in various positions, with attention to possible crepitation (Fig. 17.25). The greater trochanter

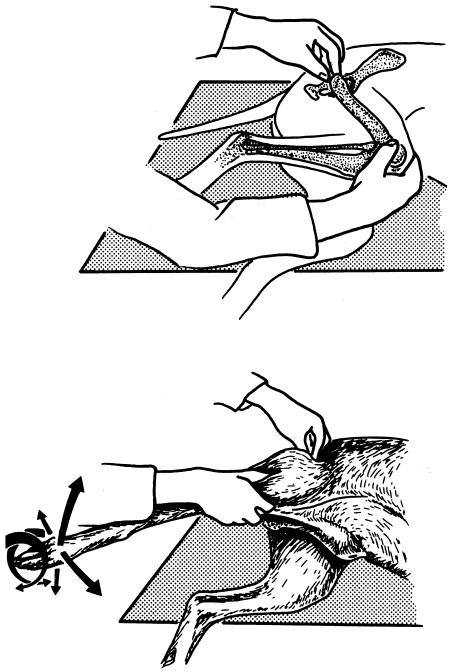


Fig. 17.25 Passive movement of the hip joint is performed with the hand that holds the stifle, while the fingers of the other hand maintain contact with the major trochanter. The degree of movement, painfulness, crepitation, and abnormal movement in the hip joint are detected by extension, flexion, abduction, adduction, and rotation of the femur.

is pressed medially in order to feel whether the femoral head can be displaced medially in the acetabulum relative to its resting position. If it can, there could be insufficient connection in a hip joint enlarged by effusion ('floating hip').

The next step is to check whether the femoral head makes a good connection in the acetabulum or whether the joint is loose (hip laxity). The test is performed in two phases: first the femur is adducted and then it is abducted.

Adduction of the femur. With the animal in lateral recumbency, the left stifle is taken in the palm of the hand, with the fingers supporting the femur. The fingers of the right hand are placed over the major trochanter to evaluate the connection of the femoral head in the acetabulum. The femur is adducted with the left hand by moving the stifle downward toward the table. Simultaneously, axial force is exerted on the femur in the direction of the hip joint. In this maneuver the femur must not be allowed to be extended but must remain perpendicular to the longitudinal axis of the pelvis. If the connection between the femur and acetabulum is loose, the femoral head may luxate (Fig. 17.26a). This can be felt with the right hand as a dorsolateral movement of the major trochanter, called a positive Barlow sign. The Barlow sign indicates luxation or subluxation of the femoral head. The angle between the femur and the table at the time the Barlow sign occurs is the *angle of luxation*.

Abduction of the femur. The femur is abducted while force is applied axially. If the connection of the femoral head in the acetabulum is loose, at some stage of abduction the subluxated femoral head will suddenly fall back into the acetabulum. The examiner will notice a 'snap' or 'plop', which is recorded as a positive Ortolani sign (Fig. 17.26b). The Ortolani sign indicates reduction of the femoral head. The angle of the femur when the positive sign occurs is called the *angle of reduction*. With the right hand on the trochanter, the examiner gives special attention to possible crepitation, which indicates cartilage lesions on the dorsal edge of the acetabulum. If the Ortolani sign does not occur, the test is recorded as negative.

Note that pain reactions during this test do not constitute a positive result. There is usually less pain when the animal is in dorsal recumbency (see below), but when the test causes too much pain and/or muscle tension, making the test unreliable or impossible, the animal should be sedated or anesthetized. Sometimes the Ortolani sign does not occur when the femur is perpendicular to the longitudinal axis of the pelvis but only when it is extended slightly. Repeated demonstration of the Ortolani sign during the same session increases the reliability of the result.

The test can also be performed with the animal in dorsal recumbency. It is supported by holding both of its front legs, with the owner standing by its head to give reassurance. The examiner places the left hand on the greater trochanter to detect possible luxation/subluxation or reduction of the femoral head while, starting with the femur perpendicular to the table, the right hand moves the stifle into adduction (Fig. 17.27a), neutral position, and abduction (Fig. 17.27b). The angle at which luxation or reduction occurs is the angle between the position of the femur and a line perpendicular to the table.

Finally, the tensing of the left and right pectineus muscles is checked by placing the femurs perpendicular to the table surface and then abducting them to the transverse level (Fig. 17.28). In this maneuver the stifles may *not* be moved cranially. It should be possible to abduct the femurs adequately and the pectineus muscle should not be palpable as a cord too early in the abduction.

Pelvis

The ilium, ischium, and pubis form the pelvis, which forms a cylinder and via the iliosacral joints provides a firm attachment between the rear limbs and the vertebral column. Following examination of the pelvis in the standing animal, the ilium and ischium are manipulated to determine whether there is any instability, crepitation, or pain.

17.6 Examination of the skull and the vertebral column

Observation of stance and motion

During the observation of stance and motion attention is given to:

- changes in posture or position, such as standing up, sitting or lying down, walking around and wagging the tail, all of which should be supple movements and certainly not stiff or painful

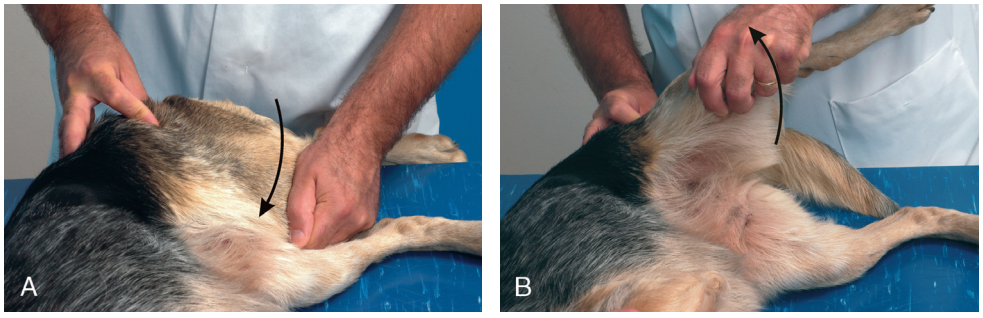


Fig. 17.26 Ortolani test in lateral recumbency. A Adduction. B Abduction.

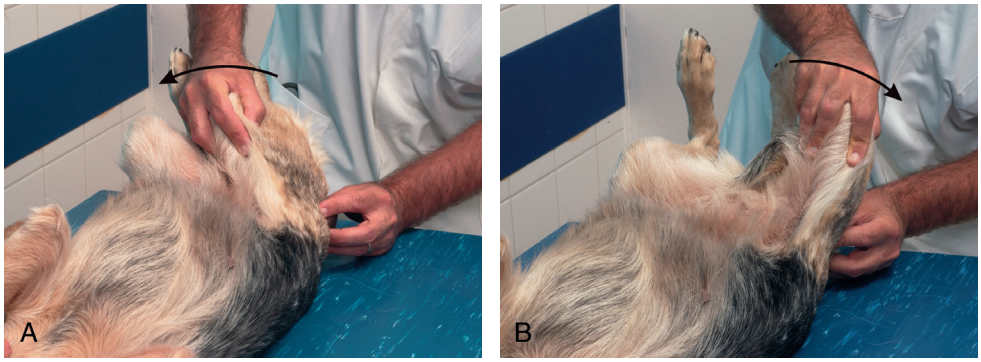


Fig. 17.27 Ortolani test in dorsal recumbency. A Adduction. B Abduction.

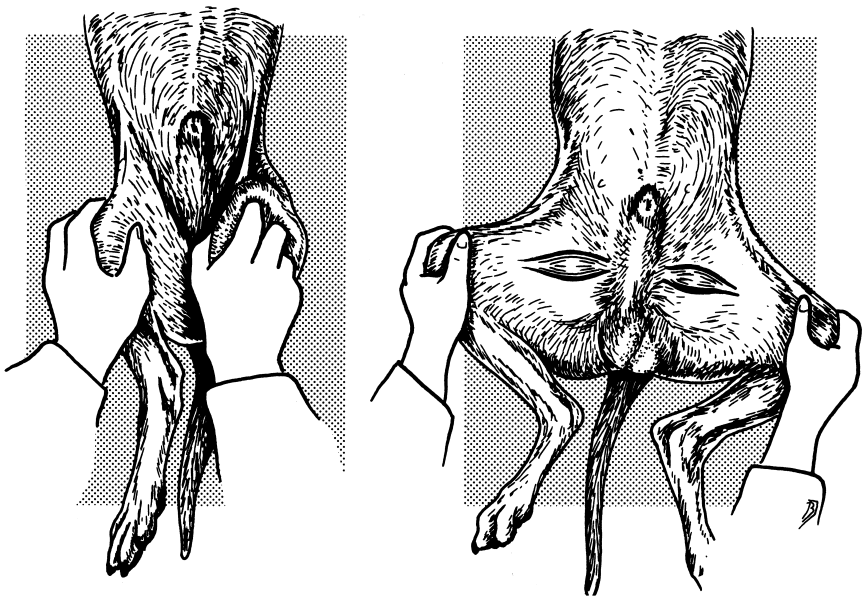


Fig. 17.28 Simultaneous abduction of the femurs in the transverse plane to check their moveability and the tension of the pectineus muscles.

- knuckling over of a foot while standing still, or straddle-legged, or in a low elbow position, or with a front or hind leg lifted, may indicate a radiating pain from a nerve root (root signature)
- coordination during walking and trotting, during which abnormalities related to the vertebral column can include excessive lateral swinging, ataxia, paresis, or foot dragging

Inspection

During inspection attention is given to:

- contours of the skull with special attention to the outlines of the bones (maxilla, mandible, neurocranium) and the musculature (masticatory muscles), as well as the closure of the mouth
- the outline of the entire vertebral column, which should be a smoothly flowing line
- the carriage of the head, neck, and tail, and the posture of the back

The carriage of the tail depends upon the tonus, possible painfulness, the breed, whether or not the tail has been docked, and the mood of the animal. Some of the abnormalities in posture include kyphosis (back curved dorsally), lordosis (back curved ventrally), scoliosis (back bent laterally), and torticollis (turning of the neck on the spinal axis).[3,9,10]

Palpation

The examiner stands before, beside, and behind the animal to palpate, cranial-to-caudal, the skull and the entire vertebral column, including the tail. Palpation is at first superficial (hence not firm), after which deep palpation can be performed if it appears to be necessary and at the same time not harmful.

Attention is given to the symmetry and smooth outline of the skull bones. If there is an abnormal outline, its consistency is also evaluated (tumor). Palpation of the skull bones should not elicit pain. The masticatory muscles are palpated for possible asymmetry and/or pain. The temporomandibular joint is examined on both sides.

Among points to be noted is whether the spinal processes of the thoracic, lumbar, and sacral vertebrae lie in one line without lateral or dorsoventral deviations. In dogs and cats there are seven cervical vertebrae, 13 thoracic vertebrae, and seven lumbar vertebrae. Three fused vertebrae form the sacrum. The number of coccygeal vertebrae varies. The wings of the first cervical vertebra (atlas) can be palpated. The dorsal outline of the broad spinal process of the second cervical vertebra (axis) can be palpated in the median line. Very little can be palpated on the remaining cervical vertebra because they lie deep under the muscles. Only in dogs and cats with supple muscles can the transverse processes be palpated, especially the pronounced transverse process of the sixth cervical vertebra.

The spinal processes of the 13 thoracic vertebrae are close together and easily palpated. A slight but distinct dip in the profile at the 11th thoracic vertebra is a normal anatomical feature and is a very useful point of reference. This vertebra is also called the anticlinal vertebra. It has a relatively short and almost vertical spinal process. The spinal processes cranial to it are directed caudally and those caudal to it are directed cranially. The last rib articulates with the 13th thoracic vertebra, thus caudal to the dip, and caudal to the dip the spinal processes diverge and are more pronounced.

The spinal process of the seventh lumbar vertebra is located between the ilial crests. Deep palpation is required because it is smaller than the spinal processes of the other lumbar vertebrae, e.g., that of L6. Here a second dip can be palpated, marking the transition from the last lumbar vertebra to the sacrum. Caudal to the serrated spinal process of the sacrum the vertebral column continues as the coccygeal vertebrae or tail. The entire tail is palpated, from the root to the tip, giving attention to tonus and moveability, as well as possible thickenings, abnormal contours, or pain.

Before the vertebral column is palpated, it is carefully brushed with the hands on both sides simultaneously from head to tail. Then, beginning cranially, the wings of the atlas are palpated and then the spinal process of the axis and the transverse processes of the other cervical vertebra. Then using the thumb and forefinger of one hand, the spinal processes of the thoracic and the lumbar vertebrae and the sacrum are palpated. Following this, deep palpation is carried out, using the thumb and forefinger to press firmly on both sides of each spinal process of the thoracic and lumbar vertebrae.

Percussion

Because muscles cover the cervical vertebrae, percussion is limited to the thoracic and lumbar vertebrae. Each of these vertebrae is percussed independently to determine whether pain is elicited.

The examiner stands beside the animal and uses the thumb and forefinger to locate each dorsal spinal process individually, beginning with the first thoracic vertebra. At the same time, a percussion or reflex hammer is used to percuss the process a few times with slightly increasing force.

Lumbosacral pressure test

The examiner stands behind the animal. First, the tail is overextended with one hand while the thumb of the other hand presses down on the lumbosacral transition (Fig. 17.29a). Next, the fingers of both hands are placed over the iliac crests, with the thumbs in the dip at the lumbosacral transition (Fig. 17.29b). Then both thumbs exert pressure. A healthy animal tends to respond by sitting down. Attention is given to possible pain reaction and to resistance. If the animal sits before very much pressure has been applied, the examiner can support the animal with the left hand under its abdomen while applying strong pressure in the dip with the thumb of the right hand.

Passive movements

Passive movements of the skull are confined to the temporomandibular joint, which functions as a hinge joint but also allows some lateral movement of the mandibles. The joint is examined for moveability (opening and closing the mouth), crepitation, and pain. Both joints are evaluated simultaneously by standing behind or beside the patient and placing the fingers at the base of the zygomatic arch on each side. The assistant or owner opens and closes the dog's mouth and then moves the mandible from side to side. Sedation or anesthesia is needed for further examination, and even for this part of the examination if the animal is excited or aggressive.

Passive movements of the vertebral column are only carried out if careful palpation and percussion have revealed no abnormalities. Passive movements have the

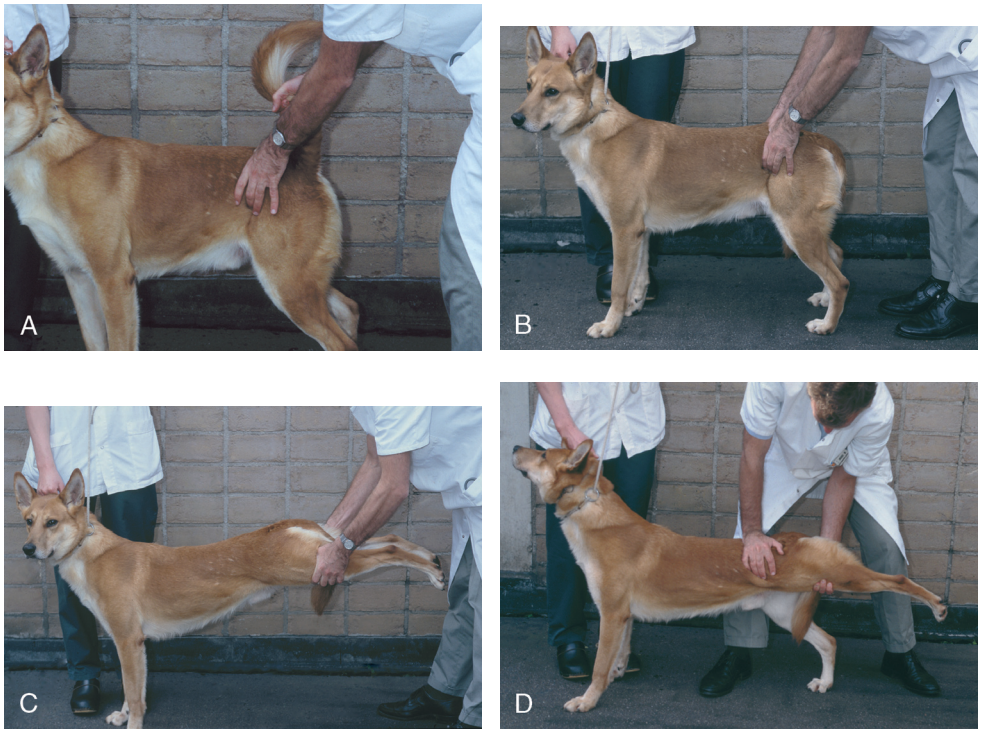


Fig. 17.29 A Extension of the tail with pressure on the lumbosacral transition.
B Lumbosacral pressure test.
C Extension of the lumbar part of the vertebral column in the standing dog by raising both femurs to a horizontal position, which forces lordosis.
D Separate extension of a hind leg with simultaneous pressure on the lumbosacral part of the vertebral column.

danger of causing lasting damage to the spinal cord. The animal's resistance to passive movements sometimes make the response difficult to interpret. Attention is given to moveability, crepitation, and/or pain.

The examiner stands on the left side of the animal and uses the left hand to grasp the muzzle (first tied securely if necessary), while the right hand fixes the neck just caudal to the second cervical vertebra (the axis). The head is now moved in the dorsoventral direction (nodding 'yes'). The head can also be moved laterally (shaking the head 'no'), or rotated.

The examiner now places the right hand on the spine at the level of the scapulas and then moves the head downward (flexion) and upwards (extension), slowly and carefully! Then the head and neck are moved laterally until each cheek touches the corresponding thoracic wall.

The thoracic vertebral column is rigid, primarily because of its position within the rib cage. This part of the vertebral column cannot be examined by passive movements.

Passive movements of the lumbar vertebral column and the lumbosacral area can be performed in small and medium-sized dogs and in cats on the examination table, while large dogs are examined standing on the floor. In both cases the examiner stands behind the animal and raises it by grasping the proximal femurs (small animals) or the distal femurs (large animals). Then the hind legs are slowly raised to a horizontal position, thus forcing a lordosis (Fig. 17.29c). This movement extends first the hip joints and then the lumbosacral area. An assistant presses down first on the lumbosacral transition and then on the thoracolumbar transition. Attention is given to resistance and any pain reaction. Animals with a painful process in the caudal part of the back will not allow this type of extension and will already resist when it is begun. The lateralization of the pain (left or right) can be examined by alternately extending the legs (Fig. 17.29d). Painful processes in the hip joints and pelvis may obviously hamper interpretation of the observation.

Next in the standing animal the vertebral examination is extended again and the examiner rotates the dog on the axis of the spinal column, first right and then left. The rear limbs are also moved in both lateral directions. In these movements it is helpful if an assistant supports the dog beneath the thoracolumbar area. The dog is turned to the left and to the right.

Finally, the caudal part of the spinal column must still be bent in the dorsoventral direction (flexion). Only in small animals is this carried out with the animal

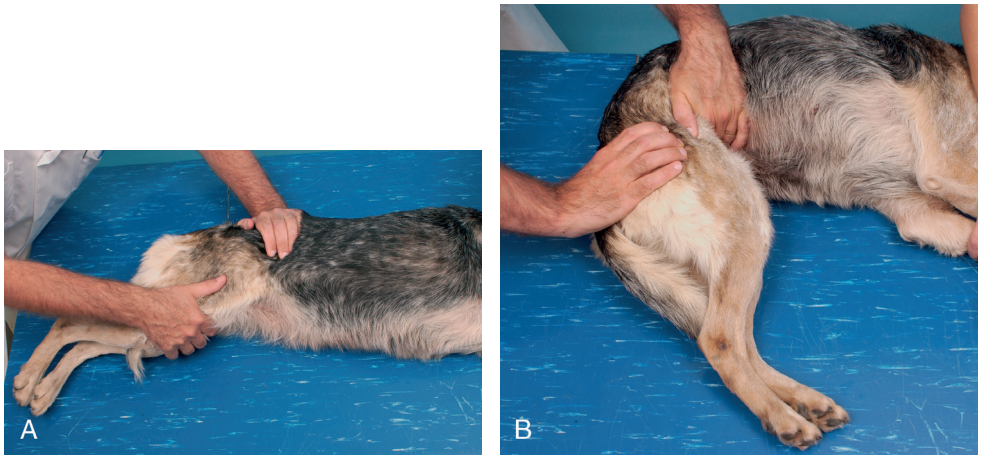


Fig. 17.30 A In dogs in lateral recumbency the vertebral column can be extended by placing the palm of the left hand on different lumbar vertebrae while both hind legs are extended. B The lumbar vertebral column can be flexed in both large and small dogs by pressing upward with one hand under the abdomen and simultaneously pressing downward with the other hand at the base of the tail.

standing. The examiner brings the left hand under the abdomen, just caudal to the costal arch, and places the right hand over the base of the tail. Now the dog is lifted with the left arm and kyphosis is produced by pushing the pelvis ventrally.

In heavy dogs the flexion and extension of the spinal column are performed while the dog is in left lateral recumbency, with the examiner standing beside its back. The examiner places the palm of the left hand on the last lumbar vertebra while the right hand curves around both of the animal's stifles and moves them caudally. The pelvis now tilts at the lumbosacral junction. The left hand is then moved cranially one vertebra at a time and the stretching of the stifles caudally is repeated (Fig. 17.30a). To hyperflex the spinal column, the left hand is held against the animal's abdomen while the right hand, placed over the base of the tail, tilts the pelvis ventrally (Fig. 17.30b).

Rectal palpation

Rectal palpation is performed if indicated by the clinical signs and/or abnormalities. Of special interest in this regard are the palpable pelvic bones and the roof of the pelvic canal formed by the ventral side of the sacral vertebrae and the first vertebrae of the tail. In a few cases the last lumbar vertebrae can also be felt. Attention is given to the outline, consistency, and painfulness of the palpable bones.

17.7 Further examination

The following possibilities exist for further examination:

- repeated examination together with neurological examination
- repeated examination under sedation or general or lumbar anesthesia, although this prevents checking for pain or reflexes, and in cases of vertebral trauma, examination under anesthesia should be performed with great care (stabilizing muscle tension is absent!) to prevent iatrogenic damage to the spinal cord
- radiographic examination: plain and contrast, as a rule in two directions and, if necessary, in projection and/or under stress, with sedation or anesthesia
- routine blood and urine examination and tests for rheumatoid factors
- synovial fluid examination (§ 17.8): cytology, bacteriology, analysis for rheumatoid factors and antibodies, biochemistry
- fine-needle aspiration biopsy from masses for cytology and bacteriology
- surgical biopsy of bone or muscle for histology and bacteriology
- bone marrow aspiration for cytology and bacteriology
- electromyography (EMG), electrostimulation and evoked potentials (EP)
- bone scintigraphy to detect increased bone activity
- surgical exploration
- arthroscopy
- imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), single-photon emission computed tomography (SPECT), and ultrasonography

17.8 Arthrocentesis

Introduction

Arthrocentesis is a relatively quick and simple diagnostic and therapeutic procedure. Cytological, biochemical, and bacteriological examination of the synovial fluid can be used for diagnosis. Therapeutic arthrocentesis is

performed to decompress joints enlarged by effusion and for intra-articular administration of drugs. The patient is restrained firmly and the leg of the joint to be punctured is also held firmly, for especially the penetration of the joint capsule is painful. The patient is sedated if not cooperative. The area is prepared aseptically (clipping, scrubbing, and disinfection) and sterile gloves are worn. Usually an 18–22G needle (see § 25.2.2), 3–6 cm long, is used with a 5- or 10-ml syringe. After insertion of the needle into the joint, the plunger is drawn back 2–3 ml and synovia slowly enters the syringe. It may be necessary to rotate the needle or to move it slightly back and forth to obtain the synovia. Traction on the plunger is released before the needle and syringe are withdrawn. The fluid is evaluated for volume, color, transparency, and viscosity.

The volume of the synovia varies considerably per joint. In healthy animals it is practically colorless, transparent, and viscous. Abnormal synovia is colored (e.g., yellow or red), opaque (cells or fibrin), and watery (less viscous). Abnormal synovia may indicate the presence of inflammation, which can be septic or aseptic. If blood is aspirated as soon as the joint is penetrated, there is bleeding in the joint (hemarthrosis). A small string of blood in the aspirated fluid indicates iatrogenic mixing and damage to a small vessel, and may hamper the cytological interpretation. The joints most often aspirated are those of the shoulder, elbow, carpus, hip, stifle, and tarsus. If there is severe joint effusion, aspiration can be performed at the site of maximal bulging. When there is less pronounced joint effusion, the following guidelines can be used.

Shoulder joint

The patient is in lateral recumbency with the joint to be punctured on the upper side and the leg partly flexed. The acromion of the scapula and the greater tubercle of the humerus are the reference points. The shoulder joint is entered from the craniolateral direction with a sufficiently long needle (Fig. 17.31). The needle passes the supraglenoid tuberosity caudolaterally, the greater tubercle proximolaterally, and the acromion ventrally. It enters the joint between the distolateral edge of the glenoid cavity of the scapula and the proximolateral side of the humeral head.

Elbow joint

The patient is in lateral recumbency with the joint to be punctured on the upper side and the leg partly flexed. The lateral epicondyle of the humerus, the anconeal muscle (lateral), and the olecranon are the reference points. The joint is entered from the caudolateral direction above the line between the lateral epicondyle

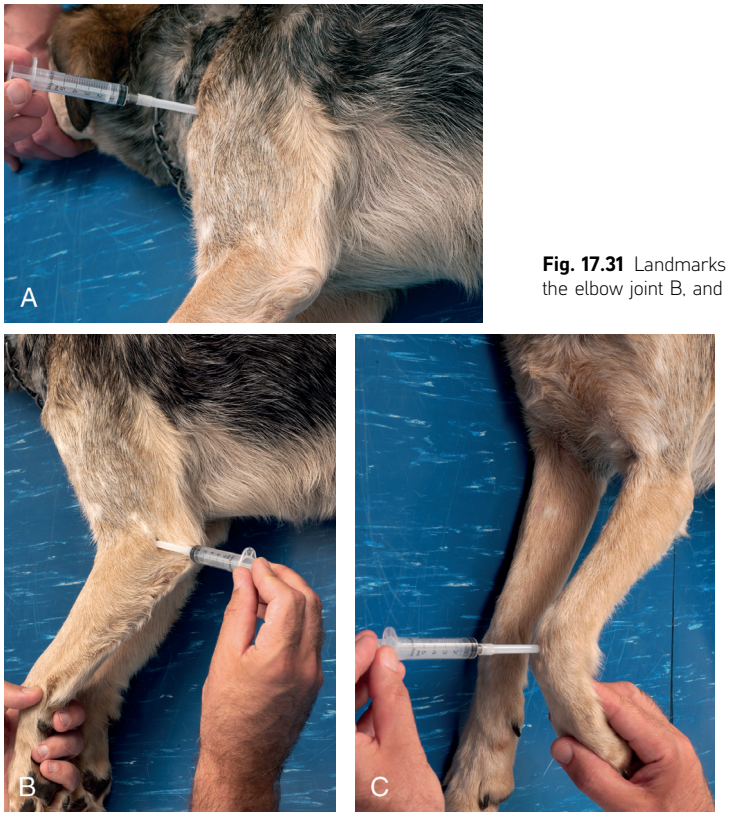


Fig. 17.31 Landmarks for aspiration of the shoulder joint A, the elbow joint B, and the carpal joint C.

of the humerus and the olecranon (Fig. 17.31b). The needle is inserted craniomedially, passing the olecranon laterally and the lateral humeral epicondyle medially, in the direction of the anconeal process.

Carpal joints

The carpal joints comprise the antebrachiocarpal (radiocarpal and ulnocarpal) joints, the intercarpal joints, and the carpometacarpal joints. Of these the radiocarpal joint is aspirated most frequently. A short needle is sufficient. All carpal joints are entered from the dorsal side (Fig. 17.31). The patient may be in dorsal or lateral recumbency, with the carpus flexed. In order to avoid damage to blood vessels, tendons, and nerves, the radiocarpal joint is entered just medial or just lateral to the midsagittal articular surface. The radiocarpal joint does not communicate with the intercarpal and carpometacarpal joints. The latter compartment is entered separately, between the radiocarpal bone and the second and third carpal bones (intercarpal).

Hip joint

The hip joint can be entered from either the dorsal or the ventral side. For the dorsal approach the patient is in lateral recumbency with the joint to be punctured upward. The reference point is the major trochanter of the femur. The stifle is grasped to slightly abduct and exorotate the femur. The needle is inserted proximal and cranial to the major trochanter and then moved caudally in the direction of the hip joint (Fig. 17.32a).

For the ventral approach to the hip joint the patient is in dorsal recumbency and the femur is abducted as far as possible and held perpendicular to the longitudinal axis of the body. The easily palpated belly of the pectineus muscle is the reference point. The ventral part of the hip joint is dorsal to it and the needle is inserted just caudal to it and moved from caudal to cranial into the hip joint, lateral to the ventral edge of the acetabulum and medial to the head of the femur. If inserted further, the needle will meet resistance from the ligament of the head of the femur.



Fig. 17.32 Landmarks for aspiration of the hip joint A, the stifle joint B, and the tarsocrural joint C.

Stifle joint

The stifle joint is the joint most often and most easily aspirated. The patient is in lateral recumbency with the stifle joint held flexed at an angle of 90°, which is the best position for observing bulging of the joint as a result of overfilling. The patella, patellar ligament, and tibial tuberosity are the reference points. The needle is inserted halfway between the patella and the tibial tuberosity, either medial or lateral to the patellar ligament (Fig. 17.32b). Then the needle is moved in the caudal direction to the intercondylar space of the femur. The needle must pass through the large amount of fat that separates the patellar ligament from the joint capsule and thus in a large dog it may need to be inserted fully.

Tarsocrural joint

The tarsocrural joint can be punctured from either the dorsal or the plantar surface, as well as medially or laterally. The most simple approach is through the proximal lateroplantar joint sac (Fig. 17.32c). The patient is in lateral recumbency with the joint upward. The distal fibula (lateral malleolus), the distal tibia (lateral), and the calcaneus are the reference points. The space between the lateral malleolus and the distal tibia is palpated while the tarsocrural joint is flexed. The needle is directed dorsomedially and distally, more or less parallel to the calcaneus. In the dorsal approach to the joint, the needle is inserted in the plantar direction between the tibia and the talus, lateral to the extensor tendons.

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18 Nervous system

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The nervous system is a complex measuring and regulating system that receives information via sensory components and then stores and processes this information (integration component). It also generates information that activates effectors via motor components. The nervous system functions as a powerful interactive communication network that influences almost all organ systems and contributes to the regulation of the internal milieu. It enables the organism to maintain itself in the environment.

The intrinsic functions of the nervous system (reception, conduction, transmission of signals) cannot be observed by physical examination, but the end effect of the neuronal activity, the specific motor activity, can be observed quite well. *Spontaneous*

motor activity (behavior, locomotion, posture, eye movements) and *provoked motor activity* (reflexes and reactions) provide an impression of the *function* of the nervous system. Together with the results of other parts of the physical examination, they usually make it possible to localize an observed dysfunction.

The *morphology* of the nervous system can only be examined by diagnostic imaging, but the clinical value of imaging techniques strongly depends upon the quality of both the history and the physical examination, as well as on the interpretation of the findings. An effectively oriented additional examination is not possible when there is no clue to the localization of the lesion. Conversely, the results of diagnostic imaging are difficult to interpret when the history and physical examination have not been carried out carefully. It is then difficult to make a causal connection between the observed morphologic abnormality and the inappropriately defined functional disturbance.

As pointed out in § 2.5, the information provided by the signalment, history, and general impression leads to formulation of the iatrotropic problems (§ 3.1.1). These problems are the basis for deciding upon further physical examination. When this concerns neurological examination, its purpose will be to provide answers to the following questions:

- Is there a functional disturbance of the nervous system?
- Where is this disturbance localized?
- What are the differential diagnoses?

At this stage it is often possible to say something about the prognosis (with and without treatment), and to draw up a diagnostic and/or therapeutic plan.

18.1 History

As the foregoing suggests, the symptoms of neurological disturbances are often characterized by abnormal motor activity (abnormal behavior, seizures, disturbed locomotion). The onset and course of the symptoms should be elucidated (acute or insidious onset, gradually and continuously worsening or with varying intensity, occurring periodically or in attacks).

The most important symptoms resulting from a dysfunction of the nervous system are described below, together with some suggestions for additional questions to further define the problem.

Eating and swallowing problems

Additional questions are asked to try to differentiate between problems in the use of the jaws, teeth, and tongue, as opposed to problems in swallowing. As an example, an animal that makes a mess of eating, lets food fall out of its mouth, salivates excessively while trying to eat and drink, splashes water all over while drinking, etc., can have a disturbance of the motor function of the tongue, the facial muscles, and/or the masticatory muscles.

Swallowing problems (dysphagia) can be shown by the observation that the animal eats with slow swallowing actions (sometimes with the neck extended), coughing hard to clear its throat, and gagging. There can also be abnormal swallowing, sometimes with eructation of swallowed air. Such a clinical picture is consistent with a pharyngeal problem.

Not only abnormalities in the functioning of the muscles that are directly involved in the taking in of food but also abnormalities in the spinal column and/or extremities can hinder food intake. Examples are neck pain, which can cause problems in eating from a pan on the floor, or generalized muscle weakness, which may cause the animal to lie down in order to eat from a pan on the floor.

Altered vocalization (dysphonia)

Owners rarely report spontaneously that the animal's vocalization has changed, but directed questions may reveal a well-defined problem (dysphonia) and consequently lead to appropriate differential diagnoses. Apart from local lesions of the laryngeal muscles or a regional disturbance in innervation, a systemic disease such as myasthenia gravis, polyneuropathy, or polymyositis can hamper the function of the vocal cords.

Disturbed locomotion

Especially when there are less impressive locomotion disorders, additional questions must be asked in order to obtain a picture of the type of disturbance (lameness, paresis, ataxia). This often occurs in the interplay of the general impression and the history, in which the owner explains or shows what the problem is. Something that is difficult to explain in words may be made clear immediately by observing how the dog walks, for example: 'Look, you can see it now. There, that's what I mean!' It may prove useful to ask the owner for a description that allows the veterinarian to see it: 'Please try to give a description so that I can see it through your eyes'.

In order to differentiate between neurogenic, myogenic, and orthopedic disorders of locomotion, the following guidelines can be of help:

- Neurogenic/myogenic causes are in general continuously present, without marked changes in intensity.
- Increasing intensity during exertion and then improvement via rest suggests a neuromuscular problem.
- A locomotion disturbance affecting only one leg is usually of orthopedic origin.

- Definite signs of pain with a locomotion disturbance make a primary neurogenic involvement unlikely.
- Shifting localization of the locomotion disturbance strongly indicates an orthopedic problem.

These guidelines should obviously be used with some care, but in the absence of more objective information, such as your own observations, they may have to serve as the basis for formulating the problem and choosing between an orthopedic and a neurological examination. If the results of the chosen examination then seem to conflict with the guidelines, the problem formulation must be revised.

The differentiation between ataxia and paresis can also be very difficult, especially when the signs are not very prominent and are not continuous. Additional history can give a decisive answer and thereby sharpen the problem formulation. The questions have a strongly searching character:

- In search of signs pointing to ataxia, questions are asked about differences between walking on a smooth surface and walking on a rough surface. Dragging the nails on the floor is a strong indication of disturbed proprioception and thus ataxia. Animals with ataxia very easily lose their footing on a smooth surface and their feet slide out from under them. Other movements, which make demands upon good coordination (rapid turning, jumping up in enthusiastic greeting, trying to quickly recover from stumbling) may not always be fully successful. The animal may thus fall down, or fly straight ahead when trying to turn suddenly, or even make a complete somersault. When shaking itself or shaking its head, the animal must sometimes make one or more corrective steps in order to remain standing. Walking in a straight line is not always possible; the animal has a tendency to drift off the track. As one owner aptly expressed it, the animal had become 'very sensitive to side winds'. Sometimes affected animals seek some support and so walk along leaning against the wall. Symptoms of ataxia do not always have to be manifest during walking; animals with static ataxia wobble or shake the head, or sometimes these movements are more like trembling.
- In search of signs of paresis (muscle weakness), we ask questions to learn about the animal's muscular strength. This may lead the owner to report that the animal has difficulty standing up, can only climb stairs with difficulty or not at all, and is less able to jump (over a hedge, into the car, onto a chair or sofa). When jumping off again, the animal sometimes falls through its front legs and sometimes the rear legs also. Such animals often don't want to walk very far and soon stop to sit or lie down. Cats with muscle weakness (paresis) of the hind legs may try to pull themselves forward or upward with the front legs.

Changed habits or movements

With additional questions we try to classify the signs as *1* seizures, *2* fainting spells, or *3* abnormal behavior. These symptoms usually occur periodically or paroxysmally (in attacks), and therefore quite specific questions are needed to obtain a clear picture in order to define the problem.

1. Epileptic seizures can usually be recognized clearly in the history. Crying and howling are very uncommon during an epileptic seizure and point instead to an episode of pain. Additional questions about the position of the head and about the development of the cramps can make this clear.
2. Fainting spells are characterized by attacks of collapsing or sagging down. In contrast to epileptic seizures, no twitching occurs and no cramps are seen, but a fainting spell can also sometimes progress to a seizure.
   Owners often have difficulty knowing whether or not the animal is unconscious during a seizure or fainting spell. Simply asking 'Was the animal unconscious?' does not always produce an answer that accurately describes the situation, e.g., 'No, certainly not, because he was looking at me while he was twitching'. It is important to ask owners for their observations and not for their interpretation.
3. For the history in patients with problem behavior, such as forms of aggression and anxiety, the reader is referred to Chapter 22. The differentiation between problem behavior and abnormal behavior can often be made on the basis of the following definitions:
   - Problem behavior is the normal behavior for this kind of animal that is, however, a hindrance, damaging, and/or dangerous.
   - Abnormal behavior is behavior that is not related to an objective, is markedly increased or decreased in frequency, or is characterized by abnormal motor activity.

To ask whether the patient behaves normally often results in an answer that has no informative value (see also § 6.1.3). Instead, it is often helpful to sketch in a few words possible situations that can reveal whether there is abnormal behavior, such as compulsive movements (pressing, compulsive walking, circling movements, insufficient recognition of the surroundings and owner, i.e., disorientation), and deterioration of learned behavior (urinating in the house, not responding to rattling of the leash or the food bowl). These behavioral

changes occur very slowly, mostly in elderly dogs, and therefore they may be regarded by the owners as part of aging. Specific questions with examples may bring help: 'Do you sometimes see him just standing there as though he is dreaming? Is it sometimes difficult to make contact with him? Does he wander aimlessly around the room? Does he still show enthusiasm when visitors arrive?' As always, these questions should be geared to the mood and the perception of the owner.

Supplement to the history

When the history does not sufficiently clarify the patient's symptoms and when the patient does not exhibit them during the examination, the owner might be asked to make a video recording of them at home. This may clarify the locomotion disturbance and enable formulation of the problem.

18.2 Neurological examination

18.2.1 Introduction

The completeness of the examination may vary with the problem. In some cases a selected part of the neurological examination will suffice. For example, in a patient with perfect locomotion it is not very useful to examine postural reactions and spinal reflexes. In a patient presented solely because of seizures, the examination can be confined to the head. But such a selection obviously depends on a well-defined problem that is beyond doubt.

The order in which the different parts of the examination are completed is mainly determined by the degree of cooperation of the patient, which usually improves as the examination progresses.

Trying to perform the examination in spite of strong resistance by the patient, or by use of force or coercion, makes both the observations and their interpretation difficult. Gaining the cooperation of the owner and the patient will add much to the diagnostic process.

The necessary instruments consist of (1) a reflex hammer (Taylor type), (2) a strong hemostat (arterial clamp), and (3) a small, bright penlight (§ 4.2). The performance of the neurological examination is described below point by point. The anatomical and physiological background is summarized and a few abnormalities are explained. Interpretation of the results is given only brief attention.

18.2.2 Behavior and the level of consciousness

Behavior

The evaluation of abnormal behavior is not possible if it occurs paroxysmally or consists of subtle changes. In these cases the clinician must depend upon the owner's descriptions.

Sometimes abnormal behavior is observed during the examination itself, e.g., disorientation, compulsive movements (pushing against the wall, walking in circles), or convulsions.

Level of consciousness

Consciousness is being aware of the surroundings and of oneself. The philosophical concept 'oneself' is not applicable to dogs or cats. Being aware of the surroundings can only be determined by a subjective interpretation of the animal's behavior. The following levels of consciousness can be distinguished:

- *Attentive, alert* (responding to the surroundings). If asleep, can be awakened with minimal stimuli. The state of being awake persists for a longer time.
- *Sopor* (depression, somnolence). Can be awakened by light stimuli but in the absence of these stimuli, quickly falls back into the original state.
- *Stupor.* Can only be awakened by strong stimuli.
- *Coma.* Cannot be awakened.

In order to evaluate the reproducibility of the response to a given stimulus, it is necessary to carefully describe the stimulus as well as the response: duration, intensity, and character of the stimuli; nature and duration of the response.

Examples:

1. Stimulus: a few loud hand-claps. Reaction: the dog raises its head, points it ears, and turns its head in the direction from which the sound is coming. This reaction remains for a few seconds and then the dog again 'goes to sleep'.
2. Stimulus: using a hemostat to clamp very strongly on the cuticle at the base of the toenail. Reaction: that leg is quickly flexed. The dog opens its eyes and very briefly raises its head a few centimeters.

In both examples we must describe the level of consciousness as stupor. The examples point out that the difference between levels is rather artificial and that within levels of consciousness there can be large differences in intensity (ordinal scale, § 3.1.2). The second example shows that the manner in which the patient responds must fulfil certain conditions. The flexor reflex is a spinal reflex and provides no information about the cerebral functions! However, the fact that the dog also responds by opening its eyes and raising its head indicates that there is also conscious pain perception (§ 18.2.7).

18.2.3 Locomotion and posture

Locomotion

Normal locomotion can be described as the supple, symmetrical, and well-coordinated movement of the head, trunk, and extremities that results in effective propulsion of the body. Evaluation of locomotion must

be undertaken in a spacious area with a rough floor or ground surface.

Disturbed locomotion can be caused by:

1 reduced *strength*
2 reduced *coordination*
3 *mechanical* interference
4 *involuntary movements or additional movements*

In their pure forms these causes result in characteristic locomotive abnormalities. Often, however, the disturbed locomotion is the result of a combination of causes.

1 Strength. The strength necessary to overcome gravity and to propel and control the movements of the body is provided by the striated muscles. This potential strength can only become operational if the motor nervous system receives the correct integrated information, transmits it, and then transfers it to the muscles.

Paresis and paralysis refer to the decrease and the absence of voluntary force or movement. In animals it is not possible to determine whether the exertion of force or movement is under the influence of 'will'. Thus it is better to speak of meaningful movements. Especially when there is doubt about the presence of severe tetraparesis or tetraparalysis, it is necessary to verify whether meaningful movements are made. This may be very difficult: a dog may make weak pedaling movements, strongly mimicking attempts to crawl forward. When pedaling movements can be provoked by tempting the animal with some food, the movements are purposeful and consequently there is tetraparesis. When these movements occur spontaneously (unrelated to external stimuli) and are more or less continuously present, they are not purposeful and the term tetraparalysis is applied.

A frequent misconception is that the presence of increased muscle tone means that there is paresis rather than complete paralysis. The degree of hyper- or hypotonicity does not play a role in the differentiation between paresis and paralysis. Rather, it is the presence or absence of meaningful use of the two rear limbs that determines whether there is paresis or paralysis.

Depending on the extremities involved, the following terms are used:

monoparesis/paralysis: one limb
hemiparesis/paralysis: one lateral half of the body
paraparesis/paralysis: rear limbs
tetraparesis/paralysis: all limbs

The term 'plegia', as in hemiplegia, is also used in place of paralysis but mainly to indicate the very sudden development of paralysis.

For clinical purposes, the motor nervous system is divided into two systems (Fig. 18.1): the central motor system (CMS) and the peripheral motor system (PMS).

The CMS is a component of the central nervous system. The cell bodies are located in the motor cortex, basal ganglia, and nuclei of the midbrain and medulla. The axons run in the descending motor tracts of the spinal cord. These axons carry the information to the neurons of the peripheral motor system.

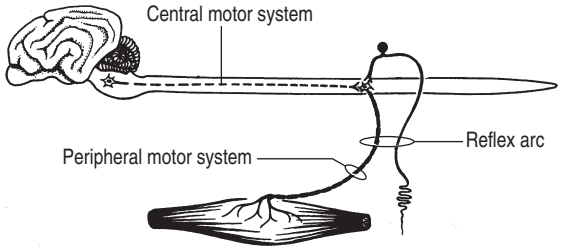


Fig. 18.1 Central motor system (CMS) and peripheral motor system (PMS).

The PMS has its cell bodies in the ventral column of the gray matter in the spinal cord. The axons run in the ventral roots and the spinal nerves with the peripheral nerves to the skeletal muscles. Functional disorders of both systems are associated with reduction in muscle strength.

2 Coordination. The coordination of locomotion is largely a function of the sensory nervous system. The accent lies mainly on the reception and integration of information. The impulses from receptors in the skin, muscles, tendons, and ligaments, as well as visual, vestibular, and olfactory impulses, are integrated into a 'message' for the motor nervous system and eventually for the voluntary muscles. In the integration of information the cerebellum and the vestibular nuclei play a central role. Functional disturbances of the sensors, the peripheral sensory nerves, the ascending tracts in the spinal cord, and the integration centers can cause ataxia or incoordination.

Ataxia or incoordination can be shown by:

- *abnormal position or relation of head, trunk, or limbs*: legs wide apart, unstable, continually making corrective movements, not able to keep the head still, tendency to fall down
- *disturbed locomotion*: staggering, swaying, walking with feet wide apart, stepping on its own toes, stumbling in front and rear legs in different rhythms, falling down when turning or only preventing this by great corrective movements
- *intention ataxia*: tremor of the head occurring and/or worsening during the animal's attempts to position its head in a certain direction; this 'focusing' can be directed toward an auditory, visual, or olfactory stimulus. This form of ataxia is very characteristic of a cerebellar dysfunction.
- *dysmetria*: an abnormality in the fine control of movements, causing them to go in all directions beyond the target
- *hypermetria*: continual overshooting of the goal of the movement in one direction, in the sagittal plane

3 Mechanical defects. In these locomotion problems there is an underlying functional disorder of the supporting system (muscles, tendons, ligaments, joints, skeleton). Also, the pain which occurs with movement causes a mechanical limitation of movement!

All of these are better described as lamenesses (§ 17.3.2). The difference between a mechanical and a neurological cause of a locomotion disturbance cannot always be determined from the locomotion itself. Moreover, combinations are not unusual. To differentiate it is necessary to examine both the locomotive system and the nervous system.

4 Involuntary movements. These movement disorders are mainly important in human neurology. There they indicate a functional disturbance of the extrapyramidal system. Various terms and names of these 'dyskinesias' are in use, not always with equally clear meaning. Some of these also appear, according to the fashion of the moment, in the veterinary literature. Although some of these abnormal movements in the dog and cat seem to outwardly resemble those of extrapyramidal disorders in man, they seldom have an extrapyramidal cause.

The following are a few of the most commonly used terms in veterinary neurology.

Tremor: rhythmic trembling of antagonistic muscle groups

Tic: nonrhythmic contractions of certain muscle groups, especially the facial muscles

Myoclonia: strong rhythmic contractions of a muscle or a muscle group

Posture

Inspection. Normal posture is characterized by symmetrical and equal bearing of weight by all limbs, together with symmetrical positioning of the head, neck, trunk, and tail as appropriate for the breed. All visually observable abnormalities in posture must be further described in terms of location, direction, and time:

- back curved dorsally (kyphosis)
- back curved ventrally (lordosis)
- back curved laterally, left or right (scoliosis)
- head tilted, to left or right
- head bent down (periodically, paroxysmally)
- tail hanging down, instead of in the usual raised position
- etcetera!

Palpation and percussion. Palpation of the head, spinal column, and limbs is, unfortunately, an often neglected part of the neurological examination, although it is simple to perform and, if it reveals abnormalities, it can make an important contribution to the diagnosis.

Head: see § 18.2.4 and § 17.6.

Spinal column: see also § 17.6. Superficial palpation is performed by standing beside the animal and beginning directly caudal to the head. With the entire palmar surface of the hands, contact with the body surface is maintained while letting the spinal column pass under the hands. Attention is given to its form and to any signs of pain.

Deep palpation proceeds in the same direction, not in a smooth continuous motion but by letting the hands skip from place to place, pinching and pressing deeply. The various palpable parts of the skeleton must be examined in turn: the wings of the atlas and the other vertebral processes in the neck (particularly of C6) and the thoracic and lumbar parts of the spinal column. The spinal processes and the spaces between these processes are palpated deeply; they can also be tapped with the reflex hammer. Attention is given to signs of pain, muscular tension, and crepitation.

Limbs (see also Chapter 17). Palpation of the limbs also proceeds in two phases, superficial and deep, and from proximal to distal. Superficial and deep palpation are carried out with the animal standing. The examiner stands in front of the animal to palpate the front legs from proximal to distal, especially taking note of changes in form and consistency of the muscles (hypertrophy, atrophy). Sometimes temperature changes are noted. By deep palpation of the muscles an impression can be obtained of their consistency and sensitivity (signs of pain). The rear legs are examined by standing behind the animal and palpating from proximal to distal, symmetrically.

If there is doubt about the findings it is advisable to repeat the examination with the animal lying on its side (before testing the spinal reflexes).

Passive movements (see also § 17.6). In this examination the clinician moves the parts of the body of the passive patient. The passive movement of the head, neck, and vertebral column is performed routinely in the orthopedic examination but in the neurological examination only in selected cases, namely, if there is suspicion of a spinal problem. During passive movements of the vertebral column attention is given to moveability, pain, and crepitation.

It should be realized that:

1. Observations are only reliable when repeatable.
2. Passive movements should be carried out carefully and are contraindicated if there is suspicion of instability, luxation, or a fracture.
3. Careful performance of palpation and percussion usually makes passive movements unnecessary.

Passive movement of the head and neck. The head can be moved ventrally and dorsally in relation to the cervical vertebrae. The head can also be rotated in

relation to the neck. While performing these movements, one should try to fix the vertebrae caudal to C2.

For passive movement of the cervical vertebrae relative to the trunk, the head and the first two cervical vertebrae are fixed. The neck can then be moved in both vertical and horizontal directions.

Passive movement of the back. The examiner stands behind the animal and uses both hands to grasp the hind legs proximal to the stifle joints. In the standing animal the lumbar and lumbosacral segments of the vertebral column can then be moved dorsally and ventrally. In large dogs this is performed more easily in lateral recumbency. In the standing animal the caudal part of the vertebral column can also be bent laterally and turned around its axis. For a more detailed description of the passive movements of the vertebral column, see § 17.6.

Muscle tonus. The resistance that is revealed by passive movement of the limbs can give an impression of the tonus of the skeletal muscles involved. This examination must be performed both while the animal is standing and while it is lying down. With the animal standing, each foot is grasped individually and moved in the direction of the trunk. If this results in passive bending and no active flexing, a continual slight resistance will be felt due to muscle tonus. After the foot is released from this position, its 'fall' will be slightly slowed. When the animal is lying on its side, only the upper two limbs are examined.

The degree to which muscle tonus can vary can be described as follows:

- normotony: normal tonus
- atony: no tonus
- hypotonia: reduced tonus
- hypertonia: increased tonus (spastic, rigid)
- clasp-knife phenomenon: sudden change from hypertonia to hypotonia

The variation in muscle tonus in healthy dogs is so great that only very clear symmetrical abnormalities or asymmetry can be described as pathologic changes. The clinical significance of abnormalities in muscle tonus is vague and therefore very small.

This is not true for the *Schiff-Sherrington phenomenon*, a combination of hypertonia of the front legs and posterior paralysis. The presence of the Schiff-Sherrington phenomenon indicates a lesion in the spinal cord caudal to the second thoracic vertebra (T2) and almost always cranial to the third lumbar spinal segment (most often at the level of the third lumbar vertebra, L3).

In the gray matter of the spinal cord from L2 to L6 there are integration cells which use information from the proprioceptive organs of the rear limbs to bring about—via the ascending tracts in the spinal cord—a retarding effect on the peripheral motor system of the front legs. The effect is mainly on muscles whose function is to resist gravity, in other words, the extensors. The loss of this inhibiting influence (as in a spinal cord lesion) thus leads to hypertonia of the extensors of the front legs (hyperextension) and paralysis of the hind legs.

18.2.4 Head

This examination consists of inspection, palpation, testing of the cerebral reflexes, and examination of vision, hearing, and the sense of smell.

Inspection

We can think of the head as being built up of the skull, chewing muscles, facial muscles, ears, eyes, skin, lower jaw, and upper jaw. Careful inspection, while standing directly in front of the patient with its head resting on your hand, can reveal abnormalities in *position, form*, and *movement*.

The inspection of the head 'in toto' and of its component parts will be discussed, with some anatomical information. The abnormalities will be discussed in terms of position, form, and movement, and occasionally a cause will be mentioned. Inspection and palpation are discussed separately, although they sometimes overlap.

Head 'in toto'

Position. Various abnormal positions of the head in relation to the neck and/or trunk can be distinguished. The direction, the degree of abnormality, and the progress of the abnormality with time must be described:

- tilted on the longitudinal axis: right or left, 30°, 90°, etc.
- extended: continuous or episodic
- flexed
- turned laterally: left or right in a horizontal plane

Shape. The shape of the head is mainly determined by the skull and the chewing muscles. Abnormalities can be classified as:

- symmetrical changes (congenital hydrocephalus, edema, bilateral atrophy of chewing muscles)
- asymmetrical changes (neoplasia, hematoma, fracture, unilateral atrophy of the chewing muscles)

Mobility. Reduced mobility is often associated with one of the abnormal positions. Disturbed or just increased mobility is seen in ataxia of the head or in myoclonias of the neck muscles.

Ears

Form. See Chapter 20.

Position. This is determined by the cartilage of the pinna and the tonus of the auricular musculature (n. facialis, VII). A unilaterally drooping ear can be the result of atony of the dorsal auricular muscles due to, for example, paralysis of n. facialis.

Chewing muscles

Anatomy. Involved are:
- m. temporalis, m. masseter
- n. mandibularis (n. trigeminus, V)

Form. Either hypertrophy or atrophy can occur on one or both sides.

Motility. Rhythmic or nonrhythmic contractions of the chewing muscles can occur episodically. These myoclonia can be seen at the onset as well as during an epileptic seizure, but also unrelated to a seizure. The muscle contractions can be associated with movements of the lower jaw.

Position. Sagging of the lower jaw can be the result of paralysis of the chewing muscles. Palpation and passive movement of the lower jaw can give information about this.

Facial muscles

Anatomy. The superficial muscles of the head, lips, cheeks (muscles of expression), ears, and eyelids are innervated by n. facialis. The exception is m. levator palpebrae superioris, which is innervated by n. oculomotorius, III.

Position. Changes in muscle tone cause positional changes and a change in the facial expression. If these changes occur bilaterally, they are difficult to recognize. The owner can sometimes say something about this, if asked specifically about it.

Hypertonia can occur in tetanus, causing wrinkling of the skin between the ears and a so-called 'sardonic grin' in which the corners of the mouth are retracted caudally, the eyelids are slit-shaped, and the expression is rigid.[1]

Hypotonia can be symmetrical or asymmetrical. The head acquires a flat, sad, expressionless appearance.

Motility. Myoclonia can also develop in the facial muscles.

Eyes, eyelids, and palpebral fissures

Anatomy. Involved are:
- m. orbicularis oculi; closing of the eyelids, n. facialis
- m. levator palpebrae superioris; raising upper eyelid, n. oculomotorius
- smooth muscle fiber, present in the m. levator and in the nictitating membrane (sympathetic innervation)

Form. See Chapter 19.

Position of the eye. The position of the eye depends on the tonus of the muscles of the eye and retrobulbar structures. Strabismus is an abnormal position of the eye and it can be present continuously, independent of the position of the head, or only during certain positions or after changes in position. Strabismus can occur in one or both eyes. The direction in which the position is abnormal can also vary.

Mobility. Nystagmus is a usually rhythmic movement of one or both eyes. Different types of nystagmus can be distinguished by:
- speed of the oscillating movements
  - In pendular nystagmus the movements in both directions are at the same speed.
  - Phasic nystagmus consists of a slow movement in one direction followed by a rapid return movement in the opposite direction. Since the rapid phase is easiest to evaluate, it determines the naming of the direction of the nystagmus.
- direction: horizontal, vertical, rotating
- time of occurrence
  - Spontaneous nystagmus is present continuously.
  - Positional nystagmus occurs only when the head is in certain fixed positions.
  - Positional-change nystagmus occurs directly after changes in the position of the head and then gradually disappears.
  - Photokinetic nystagmus is physiological and occurs when the eyes follow rapidly passing objects.

Atactic eye movements are a special form of nystagmus. They vary nonrhythmically in speed and direction.

The movements of the eye are easiest to evaluate by lifting the upper eyelid to visualize the white sclera.

Pupils

Anatomy. Involved are:
- mm. sphincter pupillae; parasympathetic (III), narrowing
- mm. dilator pupillae; sympathetic, widening

Form. (see Chapter 19).

Position:
- miosis = narrowing of the pupil without widening in darkness
- mydriasis = dilation of the pupil, with or without an intact pupil reflex
- Horner's syndrome = combination of unilateral miosis, protrusion of the nictitating membrane, and ptosis (drooping of the upper eyelid), as the result of loss of sympathetic innervation
- anisocoria = unequal size of the pupils

Mobility. The pupillary reflex is described with cerebral reflexes (see Chapter 19).

Lower jaw

Anatomy. Involved are:
- chewing muscles: m. masseter, m. temporalis, m. pterigoideus, m. digastricus
- n. mandibularis (n. trigeminus, V).

Position. Sagging lower jaw in paresis or paralysis of the n. mandibularis.

Mobility. Clonic contractions of the chewing muscles can cause rhythmic movement of the lower jaw. Limited or painful movement of the lower jaw can result from spasm of the chewing muscles due to tetanus, myositis of the chewing muscles, retrobulbar abscess, and abnormalities in the mandibular joints (luxation, fracture, arthrosis).

Palpation of the head

This consists of superficial and deep palpation of the bones and soft tissues of the head, such as the nuchal crest, sagittal crest, zygomatic arch, frontal bone, bridge of the nose, upper jaw, lower jaw, edge of the orbit, and the muscles that cover the skull.

During this part of the examination the mouth must also be opened to determine whether opening is possible, whether there is appropriate muscle resistance (tonus), and whether there is pain, abnormal mobility, or crepitation. The tongue can be examined and the swallowing reflex can be tested (see *Cerebral reflexes*).

Tongue

Anatomy. Involved is the n. hypoglossus, XII.

Form. Hypertrophy of the tongue occurs in some muscular diseases. Atrophy of the tongue is difficult to recognize if it is bilateral. Atrophy of the muscles causes wrinkling of the mucosa.

Position. Unilateral atrophy causes displacement of the tongue to the abnormal side when at rest and to the contralateral side when the tongue is extended. A decrease or loss of tonus in the retractor muscles results in the tongue hanging out of the mouth.

Mobility. The spontaneous movements can best be evaluated by examining the function of the tongue for which it is intended: intake of food and fluid. It is difficult to grasp the tongue in healthy dogs but it is easier when there is paresis. In the latter case, traction on the tongue results in little retraction.

Cerebral reflexes

The integration centers for the cerebral reflexes lie in the brain and chiefly in the brainstem. The various reflexes are discussed here with a short description of the reflex arc or pathway. Some reflexes can be suppressed by the cerebral cortex (e.g., threat reflex).

Pupillary reflex. *Technique.* After the eyelids have been closed for a short time, a strong light stimulus will cause narrowing of the pupil. This occurs in the eye into which the light shines as well as in the eye that is still being held closed (direct and consensual pupillary reflexes, respectively). The reflex should be tested from right to left and from left to right. The degree and speed of pupillary contraction is dependent on many factors. Only the presence or absence of the reflex is important in the neurological examination. Asymmetry of the reactions is certainly abnormal. Even the slightest narrowing of the pupil is enough to say that the reflex is present. When there is doubt, the conditions of the test should be optimized: darker surroundings and a stronger light source (see § 19.4.11).

Anatomy. Retina → n. opticus → tractus opticus → pretectum → nucleus Edinger-Westphal (parasympathetic) → the parasympathetic fibers pass with the n. oculomotorius (III) to the periorbital area where switching from pre- to postganglionic fibers occurs in the ciliary ganglion. The nn. ciliaris innervate the mm. sphincter pupillae.

Eyelid reflex. *Technique.* Tapping the skin of the head (sensory innervation by the trigeminal nerve) results in a temporary closure (blinking) of the eyelids of both eyes. To prevent a threat reflex from occurring, the finger or instrument used to tap the head must be kept out of the field of vision, by tapping above the orbit, at the back of the nose, on the upper lip, or around the nostrils. The medial canthus is the most sensitive, but it is just here that tapping can elicit a threat reflex by approaching the corner of the eye. Hence the medial canthus is only used in animals in a coma or under anesthesia.

Anatomy. Afferent: n. trigeminus (V); efferent: n. facialis (VII).

Menace reflex. *Technique.* An abrupt movement of the forefinger toward the eye should be followed immediately by blinking of the eyelids. Air movement that can stimulate the cornea and thereby evoke the corneal reflex must be avoided. Thus a sufficient distance from the cornea must be maintained.

Anatomy. Retina → n. opticus (II) → chiasma opticum → rostral part of the brainstem (pretectum, tectum, quadrigeminal bodies) → nucleus n. facialis → n. facialis → m. orbicularis oculi.

Explanation. This reflex can be influenced by the cerebral cortex and hence the absence of the reflex is not necessarily pathological, but if the patient is quiet, relaxed, and not distracted, then the absence of the reflex must be considered abnormal.

Swallowing and coughing reflexes. *Technique.* Firmly but carefully compressing the pharynx between the thumb and fingers usually causes swallowing. Stimulation of the coughing reflex is usually possible by palpating the trachea and/or larynx (see also § 9.2.3). It is not always possible to stimulate the coughing reflex in healthy dogs. The stimulation of the swallowing reflex is always possible, certainly by touching the back of the tongue.

Anatomy. Afferent and efferent: n. vagus (X) and n. glossopharyngeus (IX).

Vision

There are various methods to test vision.

1. *History.* Specific questions about actions that above all require visual ability can give useful information: meeting or catching an object thrown toward the animal, running into objects in unfamiliar surroundings (in the light or dark), etc.
2. *Visual placing reaction.* This reaction is absent in severe visual disturbances and also when the efferent part of the reflex arc is not functioning.
3. *Obstacle test.* Evaluation of the behavior of the dog when an obstacle such as a stick is placed in its way is a dependable means of detecting severe visual disturbances.
4. *Falling cotton test.* A fluff of cotton falling within the visual field of the patient causes the head and eye to move simultaneously with the slowly falling cotton. The vision of each eye can be tested in this way without the usually difficult use of a blindfold. This method is especially suitable for detecting a unilateral visual disturbance.

Note! The results of the menace reflex and the pupillary reflex are not decisive with regard to the presence or absence of blindness. The optical cortex is not involved in these reflexes. Thus both reflexes can be present in cortical blindness and they can be absent if there is a peripheral motor defect of the facial nerve and/or the oculomotor nerve, while vision is intact.

Hearing (vestibulocochlear nerve, VIII)

The absence of any response to a strong sound stimulus (a whistle) in the presence of an undisturbed level of consciousness strongly indicates a severe loss of hearing. Abnormal reactions to sound stimuli are difficult to interpret (see Chapter 20).

The sense of smell (olfactory nerve, I)

Observation of the behavior and specific questions in the history give an impression of the ability to smell. Anosmia (loss of this ability) can be determined with aromatic substances. Compounds with a strong stimulatory effect on the olfactory nerves also stimulate the sensory nerves of the n. trigeminus.

18.2.5 Postural reactions

Introduction

Postural reactions or correction reactions are stimulated by placing the body or parts of the body in abnormal postures. A large part of the nervous system is brought into action by the development of the reactions to the abnormal posture, which is why these reactions are of clinical importance. The absence of these reactions or their asymmetrical presence is, if confirmed by repetition of testing, pathological. The bilateral presence of slow responses can be pathological!

A frequent mistake in this examination is the inadequate stressing or loading of the limb being examined.

Knuckling-over reflex (Fig. 18.2)

Technique. While the animal is standing, a foot is lifted and then placed down again but with its dorsal surface contacting the table or floor. A rapid correction to the original position is a normal reaction. Although there are great individual differences, the speed of the correction should be the same on the left and the right sides and for the front and rear feet. The pressure on each foot should be equal, because the speed of the reaction is partly dependent upon the degree of loading.

Anatomy. The proprioceptive receptors in muscles, tendons, and ligaments, and possibly also the exteroceptive receptors in the skin, detect the information concerning the position of the limbs. This information is transmitted via the afferent nerves, the dorsal roots, and the spinal ganglion, to the ascending tracts in the spinal cord. In the medulla oblongata the information is transferred to various nuclei and tracts. Part goes to the thalamus and cortex, but the cerebellum, being most important in proprioceptive integration, receives the most. After processing, the information is transferred to important motor nuclei in the brainstem. Via the descending spinal tracts (central motor system), signals are transferred to the motor cell bodies in the ventral column of the gray matter (peripheral motor system). Via the motor axons in the neuromuscular synapse, the muscle is then activated.

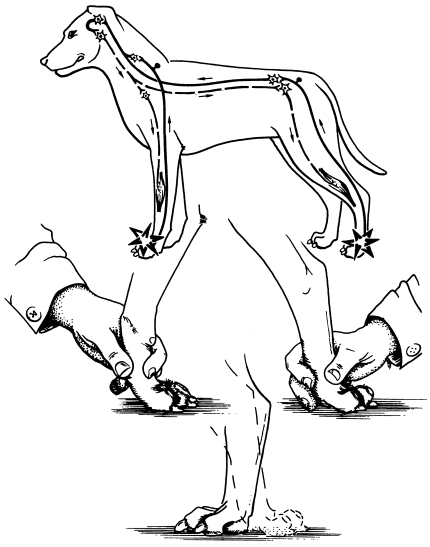


Fig. 18.2 Knuckling-over reflex in the dog. Technique and the nerves involved.

Note: If the results of knuckling-over are inconclusive and/or insufficiently repeatable, hopping and, if necessary, tactile placing can also be tested. If the results of knuckling-over are unequivocal, the testing of hopping and tactile placing adds no useful information.

Testing knuckling-over in cats is troublesome because they often resist having their feet touched. It is easier to test their proprioception by hopping.

Hopping (Fig. 18.3)

Technique. The animal must be supported in a horizontal position in such a way that one limb touches the surface of the table and at the same time bears a large part of the body weight. The displacement of the center of gravity of the patient laterally causes a hopping movement. This can be tested in all limbs independently.

Anatomy. The tracts along which this reaction pass are the same as for the knuckling-over reflex.

Explanation. The absence of this reaction in one or more limbs must always be considered abnormal. Each asymmetry is also certainly abnormal. Especially in large dogs, the test is difficult to perform and requires not only the patient's cooperation but also the examiner's skill. In general, the test is easily performed in cats.

The hopping test cannot be performed if the patient is too heavy to lift. The 'paper-slide test' can be used instead. With the dog standing on the floor (not on the table), a sheet of paper or a newspaper is placed under one foot so that the dog is standing on it. Then the paper is slowly moved laterally. If proprioception is adequate, the dog will lift the foot and return it to its original position. The distance of correction depends on the size of the dog and the weight borne on the leg, but it also varies among healthy dogs of equal size. Clear asymmetry in the response can be interpreted objectively.

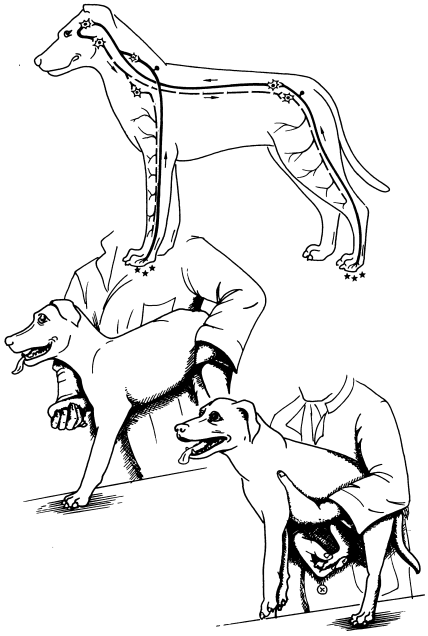


Fig. 18.3 Hopping test in the dog. Technique and the nerves involved.

Placing reactions (Fig. 18.4)

Tactile placing. *Technique.* The patient is held in the horizontal position, with one hand covering its eyes, and is moved so that the dorsal side of the front feet touches the object. This should cause slight bending of the front legs and then forward placement of them at a slant. Tactile placement of the rear feet is less reliable. This reaction is tested with both legs simultaneously or one by one.

Anatomy. As for the knuckling-over: peripheral afferent nerves, dorsal roots, ascending tracts, cerebellum, central motor and peripheral motor systems.

Optical placing. Technique. This is done in the same way but without shielding the eyes. Under normal conditions the front limbs are stretched out toward the edge of the table even before contact is made.

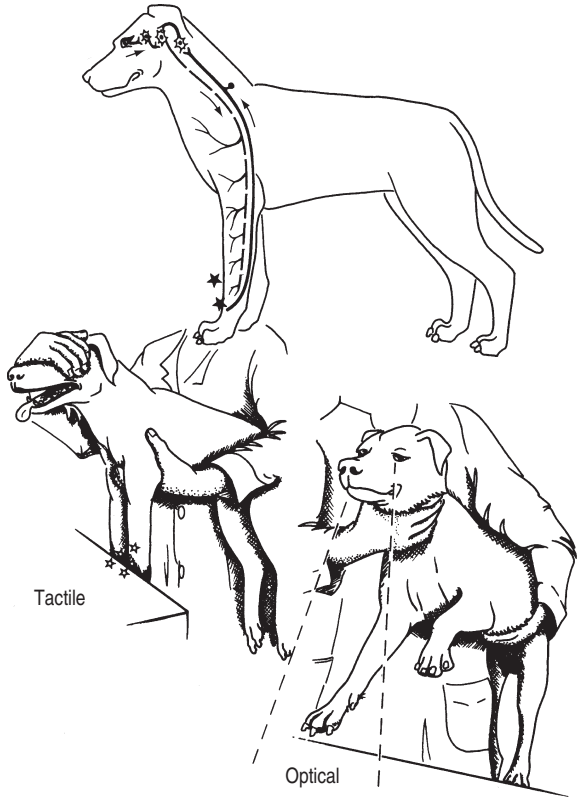


Fig. 18.4 Tactile and optical placing reactions in a dog. Technique and nerves involved.

Anatomy. The afferent part of the reflex is formed in this case by the optic tract and after integration in the visual cortex, commands are transmitted to the motor nuclei, possibly with participation of the cerebellum. If this reaction is present, it may also be concluded that vision is not severely disturbed.

Explanation. The two reactions are not always easy to test, not only because the patient may be difficult to handle but also because these reactions are sometimes difficult to arouse. Probably the reaction can be suppressed by the cerebral cortex. This means that absence of the reaction is not necessarily abnormal. Since the optical reaction appears to be less under the influence of the cortex, it is more reliable than the tactile placing reaction.

The patient's weight and lack of cooperation are limiting factors. Cats usually strongly resist having their eyes shielded.

18.2.6 Spinal reflexes

Introduction

Spinal reflexes are reflexes for which the integration center is located in the gray matter of the spinal cord. The presence of these reflexes is *only* dependent on the functional integrity of the components of the reflex arc: (1) receptor, (2) afferent neurons, (3) switching integration cells, (4) efferent motor neurons, and (5) effector. The manner in which the reflex is tested will be described, together with essential anatomical information.

All spinal reflexes are in principle examined in the upper legs while the animal is lying on its side, and then the animal is turned over to allow the other side to be examined. Very large dogs may resist being placed on the examination table, but the examination can usually be performed quite easily while the animal is lying on its side on the floor. Some dogs of dwarf breeds do not easily allow examination in lateral recumbency. In such cases the front leg reflexes can be tested with the dog in a sitting position (with a leg not bearing weight).

Cats are a separate problem. Most will resist lying on the side. Holding the cat up under the axillae in a vertical position facing the examiner is sometimes effective.

Patellar ligament reflex (Fig. 18.5)

Technique. A light percussion on the patellar ligament with the leg slightly lifted and the knee joint slightly bent causes extension of the knee.

Anatomy. Involved are:

- m. quadriceps
- n. femoralis; spinal segments L3–L5 (L6)

Flexor reflex (Fig. 18.6)

Technique. Rapidly increased pressure on the cuticle of the nail (or adjacent skin or skin between the toes) causes flexing of all joints of the leg. The pressure is applied with the fingers or with a hemostat, but just touching the bottom of the foot is often enough to evoke the reflex. If so, pinching the toe or using a hemostat is an unnecessary torment. However, avoiding the use of this maximal stimulation when in doubt about the absence of the flexor reflex is a mistake!

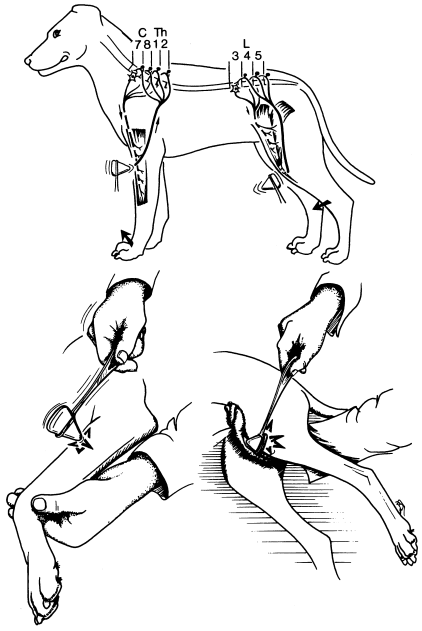


Fig. 18.5 Patellar ligament reflex and reflex of the m. extensor carpi radialis in the dog. Technique and reflex arc.

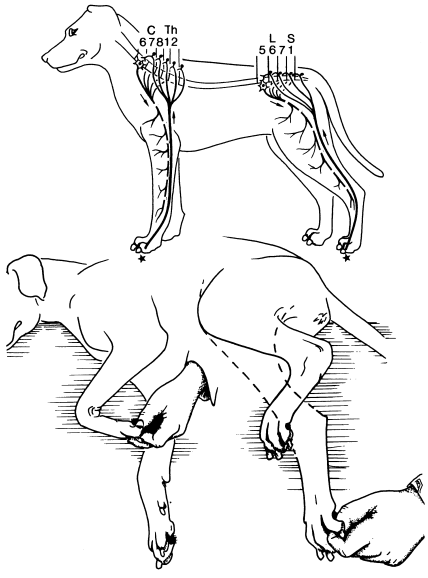


Fig. 18.6 Flexor reflex of the front and rear legs in the dog. Technique and reflex arc.

Anatomy. Involved are:
- front leg: sensory and motor: brachial plexus; C6–T1 (T2); all flexors
- rear leg: sensory and motor: n. ischiadicus, L5–S1; all flexors

Caution: the presence of the flexor reflex does not allow any conclusions with regard to the conscious (cortical) perception of the applied stimulus.

Reflex of the m. extensor carpi radialis (Fig. 18.5)

Technique. This muscle is easily palpated among the other extensors on the craniolateral side of the radius directly distal to the elbow. Percussion of the belly of the muscle with the leg slightly lifted up and the joints slightly flexed results in extension of the foot.

Anatomy. Involved are:
- m. extensor carpi radialis
- n radialis; C7, C8, T1 (T2)

Anal/Perineal reflex

Technique. Stimulation of the area of the anus and perineum results in contraction of the m. sphincter ani and flexion of the tail. The stimulus can be applied by percussion of the perineum with the reflex hammer.

Anatomy. Involved are:
- m. sphincter ani and flexors of the tail
- n. pudendus; S1, S2, S3

Pathological reflexes

Arousing the following reactions requires no special manipulation; they can occur during testing of the spinal reflexes. They are not observed in healthy animals in lateral recumbency. Their presence indicates a functional disorder in the spinal cord.

Crossed extensor reflex. Technique. This reflex is elicited in the same way as the flexor reflex. In addition to flexion of the leg being examined, there is simultaneous extension of the contralateral leg.

Anatomy. Involved are:
- extensors of the contralateral leg
- brachial plexus or lumbosacral plexus

Explanation. If this reaction occurs while the dog or cat is not resisting, it must be considered abnormal. This reflex is also present in a healthy animal in standing position, which makes it possible to lift up one leg without the contralateral leg collapsing. In a healthy animal that is lying down, this reflex is absent because of labyrinthine, optical, and sensory impulses which have a damping effect on spinal switching neurons.

Mass response. Technique. This concerns an abnormality of the flexor reflex in the rear leg. The picture can vary: there can be flexion of a rear leg of long duration, sometimes combined with alternating extension and flexion or bizarre contractions, which can spread to the contralateral leg, tail, and anus. There can also be a series of rhythmic contractions (cloni) in both limbs.

Explanation. The presence of such mass reactions to a local stimulus indicates a severe functional disturbance in the spinal cord cranial to the lumbosacral plexus.

Postreflex clonus. This is simply the repeated occurrence of a normal reflex response even when only one stimulus has been administered.

Evaluation of the spinal reflexes

During the tests of the spinal reflexes, an evaluation is made of the quality of the reflex as well as of its presence or absence. For the qualitative characteristics the following ordinal scale is used:

– absent	0
– present	1
– increased	2
– pathological reflex	3

The reliability of the observations depends on the experience of the clinician and the degree of cooperation of the patient. Reliability can be increased if the examination is performed by more than one person and/or by repeating the examination at another time and/or under different conditions.

18.2.7 Pain perception

Introduction

Receptors can be divided into four groups on the basis of their properties:
- special senses: vision, hearing, smell, balance
- exteroceptive receptors: pressure, touch, pain, temperature
- interoceptive receptors: blood pressure, central temperature
- proprioceptive receptors: stretching of muscles, tendons, and ligaments

Several of these sensory functions are tested during the neurological examination. In this section we consider pain perception and superficial skin sensitivity.

Anatomy

The exteroceptive receptors are located in the skin and subcutis or in deep structures, and are sensitive to mechanical stimuli, among other things. Stimulation of these mechanoreceptors causes a nerve action potential. The information is transferred via the afferent neurons and the dorsal root to the interneurons in the dorsal column of the spinal cord. From here two paths are followed.

1 *Spinal reflex pathway.* This passes to the motor neurons in the ventral gray column of the same segment and a few adjacent segments. There is no crossing over. The reaction is expressed by the peripheral motor system (e.g., contraction of the muscular ring of the anus, bending of a leg).
2 *Cortical pathways.* These pass to the ascending tracts and via the thalamus to the cortex. At the spinal level, crossing over occurs regularly! Conscious apprehension of the stimulus thus occurs in the thalamus or the somatic cortex.

We recall from anatomy that two types of reaction can occur following a mechanical stimulus to the skin:

1 Some reactions occur with participation of the conscious centers (cortex, thalamus). These cortical reactions include crying, whining, lifting the head, looking at an object, biting, dilation of the pupils, etc.
2 Other reactions occur without participation of the cerebrum. These are reflexes or local/segmental reactions: flexor reflex, cutaneous muscle contraction.

The reactions can quite naturally occur in sequence, so that the reflex activity occurs first and then the cortical perception can be seen.

Examination of pain perception (Fig. 18.7)

Provided that it is strong enough, each mechanical stimulus can arouse a cortical reaction. In the dog we can test superficial and deep pain perception.

Deep pain perception. For this purpose not only the superficial but also the deep receptors under the skin are stimulated.

Technique. With the fingers or with a hemostat, an abrupt pressure is applied to the rim of a nail, a toe, or a fold of skin. In the healthy dog and cat, this always causes a strong cortical reaction. Testing of deep pain sensation is, however, only necessary in case of severe paresis or paralysis.

Superficial pain perception. Only the skin receptors are stimulated.

Technique. The skin is pricked with a pencil, ballpoint, or similar object (but not sharp, such as an injection needle).

It has long been known that it is not always possible to arouse a cortical reaction in the healthy dog in this manner. It is also not always possible with a sharp needle. However, local, segmental reflexes are stimulated!

Note: Testing of conscious pain perception by superficial pricking of the skin is not always dependable. Sometimes it is the sensory innervation of the skin that is tested in this manner.



Fig. 18.7 Examination of pain perception in the dog, showing method and reflex arc.

18.3 Notation

There is a form on the DVD for recording the history and physical examination of the nervous system. On this form a few abbreviations are used. For example, to record a drooping and thickened left ear, the following will be filled in:

☒ ears L/R$^{p\ v}$

18.4 Further examination

Apart from blood examinations, the following more specific examinations may be necessary:

- ophthalmological examination (funduscopy)
- cytological, bacteriological, and biochemical examination of cerebrospinal fluid
- diagnostic imaging (radiography, ultrasonography, CT, MRI)
- electrophysiological examination (electromyography [EMG], evoked potentials [EP]).
- tissue biopsy for histological examination (muscle, nerve)

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19 Eyes

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Animals with eye problems are usually presented quite specifically for these problems and without many other problems. It is often apparent that an eye problem is involved as soon as the history is being taken. In the signalment, special attention is given to the breed because many eye diseases are known to have a breed predisposition or to be hereditary. Several ophthalmic abnormalities are related to the brachycephalic skull type.

19.1 History

If the iatrotropic problem appears to be ophthalmologic, the history, following the general history, is directed to this problem. Is it a problem of the right eye (oculus dexter, OD) or of the left eye (oculus sinister, OS), or has it been from the beginning bilateral (ODS)? It is important that there be no misunderstanding about the meaning of 'left' and 'right'.

19.1.1 Symptoms

Rubbing or scraping along the eye, frequent blinking, and holding the eyelids tightly closed (blepharospasm) are the result of reflexes and reactions that can arise from stimulation of the eyelids, conjunctiva, and anterior segment of the globe (from the cornea to and including the ciliary body). Pain in the ciliary body can also result in the avoidance of light (photophobia). The flow of tears (epiphora) can also be a noticeable sign. The causes of this are excessive production of tears due to the stimuli just mentioned, or reduced passage of tears through the tear drainage system, or a combination of the two. If there is inflammation, with or without infection, exudate can also flow out of the conjunctival sac. If such an exudate is noted, its type (mucoid or purulent) and amount should be determined.

A reduced ability to see (reduced vision) can lead to a fairly large variety of changes in behavior, such as a loss of orientation, lifting the feet too high ('walking like a rooster'), uncertainty, anxiety, and (as a result) sometimes aggression. In addition, actually walking into or bumping obstacles is a striking sign. The conditions

under which these signs occur, such as in a well-lighted or shaded area, on familiar or unfamiliar terrain, must be taken into account in the evaluation.

In some cases the occurrence of changes such as signs of pain during specific forms of behavior, such as yawning, chewing, barking, or when biting food are important in diagnosis, in view of the anatomic relation between the orbits and the mandibles (see § 19.4.1).

The owner may report that the affected eye is 'too spherical'. It is, however, naturally more or less spherical in shape. In the history and especially in the examination that follows, one must differentiate between an eye that is too far rostral (exophthalmos), one that is enlarged (buphthalmos), and one in which there is a change in color of the cornea or lens. When the eye gives the impression of being 'too small', it is possible that it is indeed too small (microphthalmus), but it could also simply be positioned deeper in the orbit (enophthalmus). This differentiation is of great importance for the diagnosis, prognosis, and therapy.

19.1.2 Living conditions

Especially in connection with trauma, it is important to know whether a dog is used for hunting or is a guide dog or is in training as a watchdog or guard dog. A disturbance in vision will in principle make an animal with a specific vision-dependent task unsuited for that work. For a dog or cat kept as a household pet, bilateral blindness is usually less of a handicap. The house in which the animal is kept plays an important role: walking up or down stairs (to an apartment, or upstairs in a house) is an additional problem for a dog that is blind; a roomy area in which to walk, without many differences in level, such as a lawn without a pond, makes life easier for the dog. The composition of the family is also important. Small children moving about without supervision can presumably be a menace to a blind dog. If either a child or an adult suddenly comes within the 'individual space' of the animal, aggression born out of anxiety can be the result.

If visual disorders are associated with problems in perception involving the other senses (smell, hearing) or with a decreased sense of direction, then the functioning of the animal also as a 'household pet' can give rise to problems.

19.1.3 Past history

It is important to learn whether the same problem has occurred previously in the same or the contralateral eye. In view of the fact that a considerable number of eye disorders have a clearly inheritable character or are familial in occurrence, it is useful to inquire whether similar problems have occurred in the immediate family of the patient. For further examination, a pedigree analysis or genetic investigation can be performed.

19.2 Location and conditions for the examination

19.2.1 Light

For general inspection of the structures surrounding the eye, comparing left and right, and evaluating the color of the conjunctiva, sclera (yellow under neon light), and iris, either diffuse daylight or artificial light is satisfactory. The examination should preferably be carried out in an area in which no direct sunlight falls.

Focal light

Sunlight is too strong, contains UV radiation (very damaging to the retina), and can cause problems during use of a loupe because of the concentration of infrared radiation. Two useful forms of light are an easily-positioned spotlight and a lamp mounted in a holder on the examiner's forehead ('miner's lamp'). A halogen lamp with smoothly adjustable light intensity is optimal. An ordinary flashlight has the disadvantage that it leaves only one hand free for other purposes and the amount of light it provides is less adequate.

Darkness

It must be possible to darken the room used for eye examinations. This is necessary for the use of a slit lamp or an ophthalmoscope. It must also be possible to evaluate the patient's vision in semidarkness, but pupillary reflexes can only be evaluated in a completely darkened room.

19.2.2 Position of the patient during the examination

Dog

The examiner sits on a stool at the head of the examination table. The dog is placed on the table and the person who restrains the dog stands at its left side. By a command and by pressing down on the lumbar area, the dog is brought into a sitting position. With the right arm reaching over the dog, the right hand is used to extend the dog's right front leg, and the left hand is used to extend its left front leg so that the dog is in a 'sphinx position'. The front feet are allowed to hang over the edge of the table (up to the carpus). Then the left hand is used to hold the dog's muzzle from below, with the left elbow placed on the table for support. The right hand is placed on the dog's right shoulder with as little traction as possible on the skin, to avoid affecting the position and closure of the eyelids. If the dog sags down in the front or rear legs into a lateral position, the examination is made

difficult because of the asymmetry, deeper position of the eyes, protrusion of the nictitating membrane, difficulty in examining with an ophthalmoscope, etc. Dogs that are difficult to restrain and/or are aggressive should be muzzled (§ 24.2.2). Sedation generally causes enophthalmus and protrusion of the nictitating membrane and thus makes the examination difficult.

Pekingese, Shih Tzu (and other short-nosed breeds)

Insofar as possible, it is the owner who must restrain an animal of these breeds, because of the risk of luxation of the globe. The dog should be placed close to the edge of the examination table. It should be restrained by the owner's making a ring with both hands around its neck in a way that does not hinder its respiration too much and with the least possible caudal traction on the skin.

Cat

The cat is restrained in a sphinx position in the same way as the dog, with extra attention to both the front and rear feet. If sedation is necessary, medetomedine interferes very little with the diagnostic ophthalmic examination.

19.3 Instruments and aids (see also § 4.2)

Penlight

This is a focal light source that provides a small beam of light. It is used to examine the most anterior parts of the globe and to test the pupillary reflexes.

Slit lamp

This gives a slit-shaped beam of light, 0.5–1 mm wide and 5–15 mm high. With this beam optical slices are made through the eye. Densities are illuminated in the beam (Tyndall effect, § 4.1.1) and the outlines of the different anatomical structures of the anterior segment of the eye can be seen.

Blue filter

Cobalt blue light can be useful for intensifying the fluorescence of minimal corneal defects, after these have been stained with fluorescein (§ 19.4.9).

Ophthalmoscope (direct)

This is a light source with a lens system. The fundus can be inspected with the 0 or −1D lens. Other lenses can be selected to inspect parts that are less deep: between 0 and +8D for the vitreous, +8D for the posterior lens capsule, +8 to +12D for the lens contents, +12D for the anterior lens capsule, +12 to +20D for the anterior chamber, and +20D for the cornea. The examiner should perform ophthalmoscopy without wearing glasses, for the ophthalmoscope can be adjusted to compensate for them.

A direct ophthalmoscope should also contain a slit lamp, a keratoscope for evaluating the corneal curvature, and a cobalt blue filter, so that a separate slit lamp is unnecessary. Most ophthalmoscopes can also be converted for use as an otoscope and a vaginoscope.

Fixation forceps

Von Graefe's forceps are necessary for inspection of the conjunctiva, including the nictitating membrane.

Schirmer tear test (STT)

Tear production is measured with the STT by use of sterile strips of filter paper that are standardized and calibrated.

Culture tubes

A sterile dry cotton swab, supplied in a culture tube, is used to collect material for microbiological culture. If there is likely to be a long interval between collection and inoculation of the culture media, as may occur in practice, it is better to use a 'moist' swab in transport medium. For special diagnostic procedures, such as the polymerase chain reaction (PCR) for herpes virus, the laboratory should be consulted in advance about the method of sample collection and the media to be used.

Eye spatula

This is used to collect exudate for microbiological examination or superficial epithelial cells for cytological examination.[1]

Cytobrush

Material for cytological or microbiological examination can also be collected efficiently with a small brush developed for this purpose.[2]

Eye curette

A curette with a diameter of about 3 mm is used to collect material for microbiological or cytological examination as well as for freshening a corneal ulcer or curetting a chalazion.

Fluorescein

Fluorescein-impregnated paper strips[3] are used to stain corneal defects and fluorescein drops are used to check the patency of the tear drainage system.

Mydriatic (short-acting)

Tropicamide (0.5%) produces brief widening of the pupil (mydriasis) of short duration, via which good

inspection of the retropupillary area is made possible.[4] In pups younger than 4 months, atropine (1%) can be used as the mydriatic.

Local anesthetic

Lidocaine (4%) and tetracaine (0.5%) are drugs that, after a brief discomfort, induce a short period of anesthesia of the conjunctiva and the cornea, enabling local inspection or minor procedures such as tonometry or removal of a foreign body. They may only be used for diagnostic purposes. Their repeated 'therapeutic' use retards the healing of epithelial defects in the cornea and they can increase the pain (neuritis dolorosa) by overstimulation.

19.4 Examination of the eye and adnexa

As noted in § 4.1.1, the examination of the eyes[5-8] is carried out largely by inspection, which in principle proceeds 'from outside to inside', with the exception of the 'lacrimal apparatus' and the globe as a whole. For the eye and adnexa, the location in three dimensions is indicated by use of (1) anterior (rostral) and posterior (aboral/caudal), (2) nasal (medial) and temporal (lateral), and (3) dorsal (superior) and ventral (inferior). The radial locations of structures in or on the cornea, anterior chamber, iris, and lens are indicated by means of the hours of the clock. For the required stability, the ophthalmic examination is performed with the animal in the sitting position.

19.4.1 Head and skull

Position in space

During inspection it is of great importance to observe the animal quietly and to restrain it as little as possible and only if absolutely necessary. The eyelids, the skin around the eye, the lips, cheeks, and ears should hang or stand symmetrically and have adequate tonus (see also Chapter 18).

In visual disturbances, as well as neurological or oral abnormalities, the head may be held in an abnormal—usually too low—position. Severe pain, associated with tight closure of the eyelids (blepharospasm) can also lead to an abnormal position of the head. The patient usually moves carefully and insecurely and lifts its feet too high (like a rooster).

Mandibular lymph nodes

These are the most important of the palpable regional lymph nodes related to the eyes. In cases in which the problems appear to be limited exclusively to the eye, these nodes are still included in the examination (see Chapter 8).

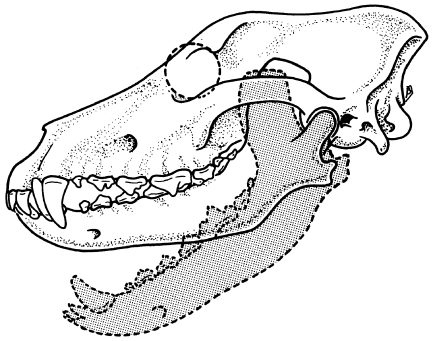


Fig. 19.1 The retrobulbar structures. When the mouth is opened, the coronoid process is moved toward the eye.

Chewing muscles and opening of the mouth

The chewing muscles provide important support for the globe ventrally and caudally. They form part of the soft floor of the orbit. When the muscles are swollen the globe is pressed forward (exophthalmos), and when they are atrophied it is instead deeply-set (enophthalmus). The coronoid process of the mandible is just behind the eye (Fig. 19.1). In the ophthalmic examination the mouth is opened as described in § 11.2.1. If there is a space-occupying process (hemorrhage, inflammation, abscess, neoplasia) between the globe and the coronoid process, limited movement and/or pain may be observed when the mouth is opened. The area around the eye, the musculature, the skin, and the temporomandibular joint are inspected and palpated for swelling, atrophy, hard or soft areas, pain, temperature differences, and asymmetry. The tonsils and the maxillary mucosa caudal to the second molar (dog), the soft floor of the orbit, are inspected and palpated.

Bony parts of the orbits, sinuses, and nasal cavity

In the dog, the rostral part of the bony orbit is formed by the zygomatic bone, lacrimal bone, maxillary bone, sphenoid bone, palate bone, and frontal bone.[9] On the medial (nasal) side the orbit is formed by the frontal bone. This continues laterally (temporally) as the zygomatic process and connects to the frontal process of the zygomatic bone by a bridge of connective tissue. The bony parts are inspected and palpated for symmetry.

Rostral and dorsomedial to the orbit lie the maxillary sinus, the nasal cavity, and the frontal sinus, respectively. Disorders here can have consequences for the orbits and their contents. The examination of these spaces is described in Chapter 9.

19.4.2 Surroundings of the eye

Soft parts of the orbit around the globe

Swelling can occur just within the bony parts of the orbit due to space-occupying processes around and/or behind

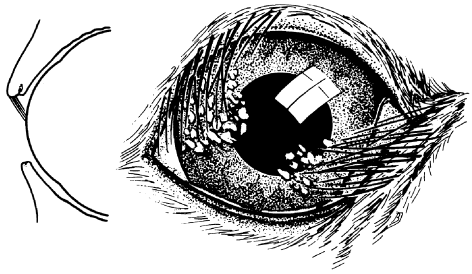


Fig. 19.2 Trichiasis. Hairs in a normal location which cause irritation of the conjunctiva and/or cornea because of their abnormal placement, e.g., hairs on the nasal fold or on the lateral part of the upper eyelid.



Fig. 19.3 Tear stripe caused by overflow of tears (epiphora) under the medial canthus, due to hindrance to drainage and/or overproduction. The adhesion line is also visible (for explanation, see Fig. 19.4).

the globe. Swelling may occur within the bony parts of the orbit due to trauma, inflammation, or neoplasia. This area is inspected and both the bony edge of the orbit and the soft tissue lying just within the edge are palpated.

Trichiasis: folds of skin on the nose and head

Trichiasis is the term used to describe hairs which, although in a normal location around a body opening such as the eye, cause irritation because of their abnormal placement or direction of growth (Fig. 19.2). Thus the long, fairly stiff hairs on the folds of skin on the nose can irritate the eye. The extremely brachycephalic animals in particular suffer from this.

Sometimes it is especially the long hairs on the lateral part of the upper eyelid, combined with entropion of the lid margin (see § 19.4.5), which irritate the ventral conjunctiva and the cornea because of their abnormal placement. These parts of the skin are inspected with as little influence as possible being exerted on the position of the skin of the head by the manner in which the animal is restrained. There is trichiasis if the hairs are wet and after eversion of the edge of the upper lid they still come back into contact with the cornea or the conjunctival sac. Such hairs often lead to irritation, vessel ingrowth, and pigmentation of the cornea in the area of irritation, or to ulceration or sometimes even perforation. When there is excessive head skin (bloodhound, Shar-Pei) or folds of head skin (chow chow), the hanging folds of skin, often in combination with entropion of the border of the upper eyelid, can severely irritate the globe.

Tear stripe

Overproduction and/or decreased drainage of tears leads to overflow over the skin, usually from the medial canthus. This causes a tear stripe (Fig. 19.3), which is a gradual discoloration of the hair to dark brown. The passage of tears through the drainage apparatus to the nose can be checked with fluorescein (see § 19.4.9).

In dogs with nasal folds of skin there is also frequently inflammation in the persistently moist area of skin between the folds (intertrigo). This area is thus inspected and palpated for the presence of a tear stripe, discoloration, or thickening. Occasionally the opening of a fistula can be found in this area and it almost always arises from inflammation of the root of the 4th premolar and only very seldom from the tear drainage apparatus. Note that the nasolacrimal duct does not pass through the subcutaneous space but through the lacrimal bone (hence from the orbit) to the nasal cavity.

Wet lower eyelid

The opening of the lids causes the tear fluid to be spread into a very thin, uniform, film over the cornea. Between the palpebral conjunctiva and the globe the tear film remains intact because of the capillary action between the two layers. The meibomian glands and glands of Zeis and Moll in the edge of the eyelids secrete sebum which keeps the edges slightly oily. Because of this hydrophobic layer on the edges and the adhesion of the tear film on the cornea and conjunctiva, excess tear fluid does not run over the edge of the lid but is drained medially when the lids close during blinking, which resembles the closure of a zipper, from lateral to medial. Wet lower eyelids occur especially in abnormalities that disturb the function of the lower lid margin, such as distichiasis (see § 19.4.5) and in disturbed eyelid function caused by an abnormal position (entropion, and extreme exophthalmos including luxation of the globe).

Wetness on both the upper and the lower eyelid is almost always the consequence of severe blepharospasm, such as may be caused by entropion or a corneal ulcer. If the spasm is of long duration, there can be brown discoloration, or even alopecia of the eyelids.

19.4.3 Tear film and tear production

The order in which this examination proceeds does not completely follow the obvious order of the anatomical

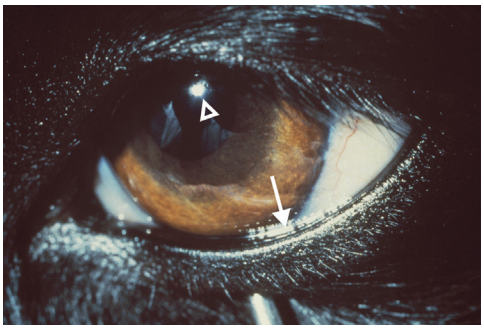


Fig. 19.4 Inspection of the tear film. There should be a sharply outlined reflection image (△) that is only distorted by the curvature of the cornea (curved mirror), and an adhesion line between the eyelid or third eyelid and the cornea or conjunctiva (arrow; also see Fig. 19.3).

structures of the eye. First the tear film and tear production are checked, before they can be influenced by other procedures. When the tear film is normal (Fig. 19.4), an intact, reflecting, and clear fluid line is visible between the free border of the lid margin and the cornea and/or the edge of the nictitating membrane and the cornea. There is also a normal reflected image on the tear film over the cornea. On the normal tear film over the spherical surface of a normally shaped cornea, the image of the window or a lamp will be reflected perfectly.

Fluorescent lighting and glistening, reflecting, or shadow-producing objects including hairs can also cause false reflections in the tear film which are sometimes incorrectly interpreted as corneal defects or even lens luxation! If inspection reveals little or no reflection or if there is only a dull rather than a glossy image, the tear film may be interrupted, not intact, or even absent.

If there is the least doubt concerning the integrity of the tear film, or if mucus or mucopurulent discharge is present, the tear production is measured by means of the Schirmer tear test (STT). Each package contains two standardized strips of filter paper containing a blue dye; they are sterile and usually calibrated (Fig. 19.5). At the place where their edges are notched, the strips are bent at an angle of about 135° while still in the package. The package is opened at the opposite end and a strip is grasped there with dry forceps. The strip should not be touched with the fingers, for this breaks sterility and affects the speed with which the paper takes up fluid. The lower eyelid is everted slightly with the fingers of the other hand. The rounded tip of the strip is placed in the ventral conjunctival sac at about one-third the distance from the lateral canthus (with the bent end pointing downward) and the lower eyelid and test strip are released. After 1 minute (*not* 5 minutes, as in humans), the strips are removed and read immediately. The length of the part that is moist (and colored blue) above the notch is a measure of the tear production.

An intermediate value could be found if there is inadequate stability or continuity of the tear film. This can lead to rapid breakup of the tear film, via which small areas of the cornea dry out a little. The consequence is earlier death of the superficial epithelial cells. These intact but not vital cells can be shown by means of rose bengal staining (see § 19.4.9).[10]

Because an eye that is too dry can develop serious problems, it is the lower limit, 9 mm for the dog and 6 mm for the cat, that is of importance. Only in the

Box 19.1 Reference values[10-13]

dog	13-25 mm; in keratoconjunctivitis sicca (KCS) ≤ 9 mm
cat	10-20 mm; in keratoconjunctivitis sicca ≤ 6 mm
intermediate values	suspect
rabbit	5.3 ± 2.9 (SD) in 1 minute

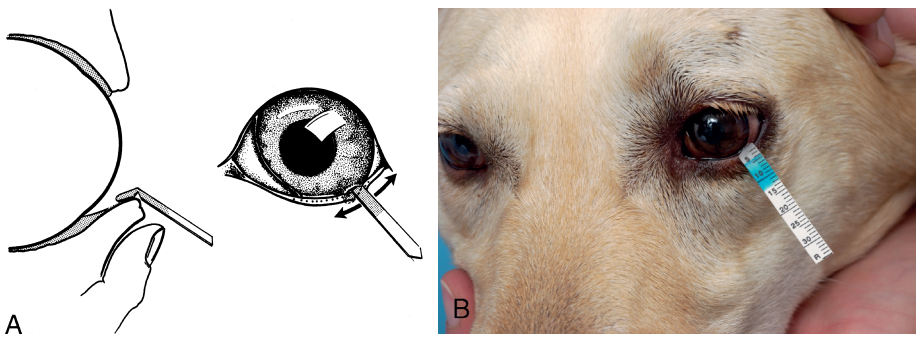


Fig. 19.5 The Schirmer tear test. The rounded end of the strip is inserted to the level of the notch in the side of the strip, at an angle of about 135°. The eyelid is slightly everted by a finger. The test strip is inserted in the conjunctival sac at about one-third of the distance from the lateral canthus and after 1 minute it is removed and read. The calibration and the blue dye facilitate the reading.

case of *very clear* overproduction can the STT be omitted. When there is mucopurulent discharge, even if the eye glistens and reflects the mucus or pus, the STT is *always* done. For further evaluation of the reflection image, see § 19.4.9.

19.4.4 Ocular discharge

When there is mucopurulent discharge (with a normal STT) or other signs characteristic of an infection, material is collected for culture. Only after this has been done is the discharge rinsed away with sterile, hand-warm 0.9% NaCl solution.

Dry cotton swab

With the eyelids held apart with two fingers of one hand, the swab is held in the other hand and used to approach the eye from the lateral side to obtain material from the conjunctival sac in the medial canthus (Fig. 19.6a). Thus the sample is obtained between the palpebral conjunctiva and the third eyelid. Care should be taken that neither the sterile cotton swab nor its stick nor the sterile part of the top are contaminated by hair or by one's own fingers. The swab should be used to inoculate culture media before it dries out.

Moist cotton swab

Since transport to the laboratory may take some time, it is better to use a culture tube containing a cotton swab in bouillon or a transport medium. This does not dry out and thus more often results in a positive culture. It is, however, less suitable for demonstrating fungi.

After these examinations any ocular discharge that is present can be removed by rinsing the cornea and conjunctival sac with lukewarm 0.9% NaCl solution.

Performance (Fig. 19.6b). The back of one hand holds an absorbing paper tissue against the nose of the patient while the thumb and index finger of the same hand spread the eyelids.

19.4.5 Eyelids (palpebrae) (Fig. 19.7)

Function

The closure of the lid should be regular and smooth, so that a good tear film continues to be maintained. In birds it is primarily the nictitating membrane that has this function. Lid closure should be evaluated by means of the eyelid reflex, preferably without touching the head. This reflex can also be stimulated by tapping the skin in the medial canthus. The animal's inability to

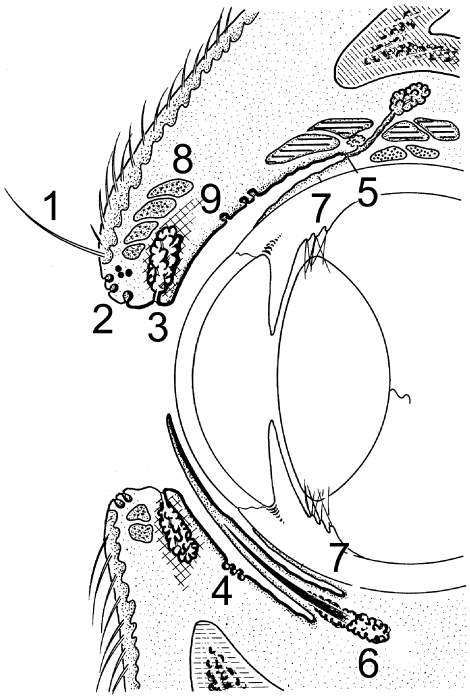


Fig. 19.7 Cross-section of the eyelids and the conjunctival sac. 1 eyelash-like hairs on the lateral part of the upper eyelid, 2 glands of Zeis and Moll, 3 meibomian glands (sebaceous), 4 goblet cells, 5 fornix, 6 superficial gland of the nictitating membrane, 7 scleral or bulbar conjunctiva, 8 m. orbicularis oculi, 9 goblet cells.

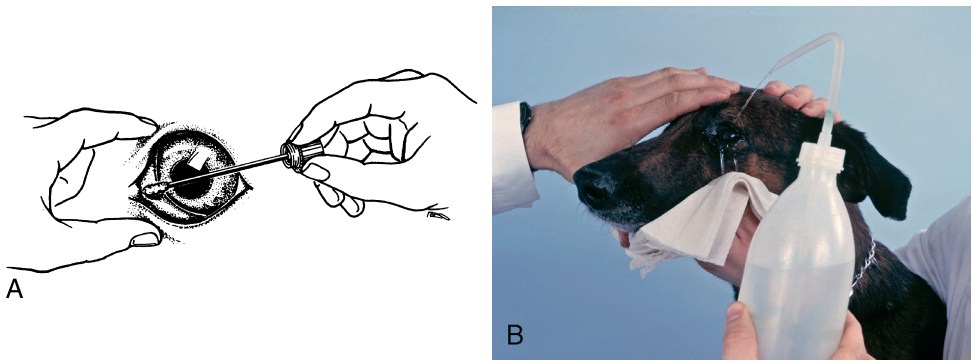


Fig. 19.6 A Material is collected for microbiological culture from the conjunctival sac in the medial canthus. B The eye is rinsed from the lateral side with lukewarm 0.9% NaCl solution. The tip of the bottle should not make contact with the patient.

completely close the eyelids (e.g., due to disturbed innervation or exophthalmos) is called lagophthalmos. The patient's inability to fully open the upper eyelid, due to disturbed innervation or swelling or neoplasia, is called ptosis.

Palpebral fissure

The palpebral fissure should be related to the size of the globe. With a normal fissure length the cornea is completely 'enclosed' when the eyelids are open, leaving the sclera hardly visible, in contrast to humans. The examiner compares the length of the fissure of the two eyes. In dogs the length of the palpebral fissure when stretched varies from 27.8 (± 2.7) to 32.1 (± 4.7) mm.[15] In some breeds the fissure is much too wide, so that a diamond-shaped opening and the combination of entropion and ectropion may develop. In dogs with an oversized fissure the length is usually more than 40 mm. Finally, 'the eye', that is to say, the palpebral fissure, should also be kept open without difficulty. With even slight irritation of the conjunctiva or the rostral segment of the globe, the eyelids are more or less closed. When the pain is more severe, the eye is kept tightly closed (blepharospasm), especially when the pain originates from the cornea, the iris, or the ciliary muscle. This gives the impression of a short palpebral fissure. Congenital shortening of the palpebral fissure is encountered occasionally, often in association with entropion of the upper eyelid.

Outer surface of the eyelid

The outer surface of the eyelids is inspected and then palpated for wounds, swelling, alopecia, or wetness. Wet eyelids and trichiasis were discussed in § 19.4.2.

The margin of the eyelid

The free rim of the lid margin on the outside is usually pigmented, smooth, glossy, hairless, and dry. It is 2–3 mm wide on the lower lid and about 1 mm wide on the upper lid. The haired part of the outer surface ends in a narrow edge that is seen to be perpendicular to the cornea. In the middle of this margin lies a barely visible groove in which the openings of the meibomian glands are visible as small spots. Dogs and cats do not have a row of eye lashes, but they do have eyelash-like hairs beginning 1–2 mm away from the free rim of the upper lid margin, mainly laterally. The presence of hairs on the free rim of the lid margin is referred to as distichiasis (Fig. 19.8). The edge must be examined very carefully to detect them, preferably with magnifying glasses and a spotlight or with the slit lamp microscope. Initially only mucus accumulated around the hair may be seen as a small irregularity on the free rim of the lid margin. When this is wiped away the hair can be seen. During inspection and palpation of the edge of the eyelid, one should also note whether there are congenital defects such as palpebral aplasia (or coloboma), and acquired defects or swellings due to trauma, inflammation (chalazion/hordeolum), and/or neoplasia.

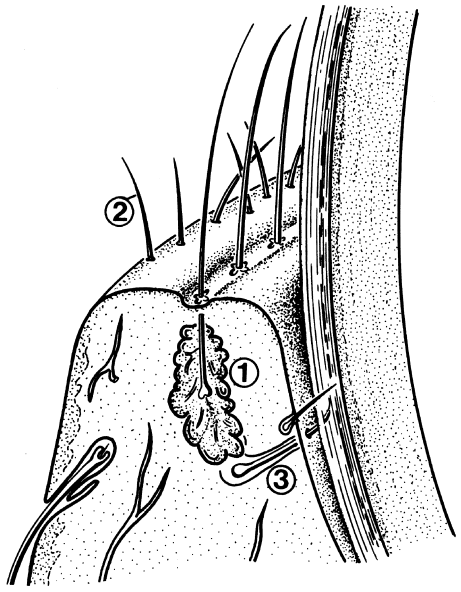


Fig. 19.8 Distichiasis: Hairs on the free rim of the margin of the eyelid. 1 hair follicles in a meibomian gland, 2 in the glands of Zeis and Moll and elsewhere in the free rim of the eyelid, 3 ectopic cilia emerging in the conjunctival sac.

Position of the eyelid

The edge of the eyelid should fit smoothly against the curvature of the globe (Fig. 19.9). There can be entropion or inversion of the margin of the lid, which is primary (congenital or acquired) or secondary (too wide palpebral fissure, enophthalmos after trauma), or there can be ectropion or eversion of the margin of the lid.

Entropion or ectropion can be complete, which is to say that the entire eyelid edge is involved. It can also be angular (only the lateral canthus) and it can be partial (e.g., medial) (Fig. 19.10). The severity is expressed as low, medium, or high grade (Fig. 19.9). If there is no entropion but the eyelid is wet, or if the animal is of a predisposed breed (e.g., bouvier and chow chow), then the entropion test is performed.

Entropion test (Fig. 19.11)

A fold of skin is picked up, about 1.5 mm ventral to the lateral canthus. Then the hairy outside of the lid is placed against the cornea. During this test the dog should be held in a way that does not stretch the skin of the head. If there is no entropion tendency, no

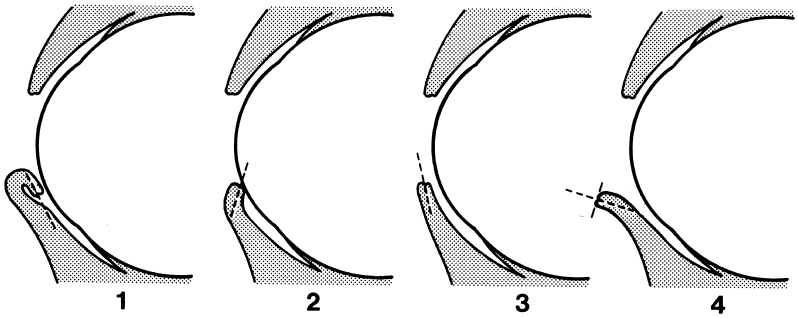


Fig. 19.9 Positions of the edge of the eyelid. 1 high-grade entropion, 2 low-grade entropion, 3 normal position, 4 ectropion.

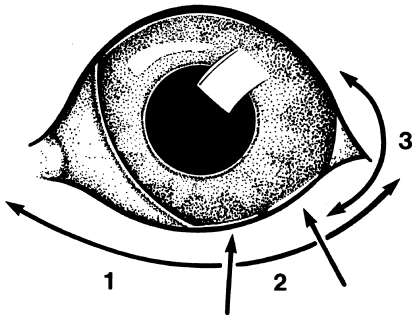


Fig. 19.10 Possible locations of eyelid abnormalities in entropion: 1 complete lower eyelid, 2 partial lower eyelid, 3 angular in the lateral canthus.



Fig. 19.11 Entropion test. At about 1.5 cm ventrolateral to the lower eyelid a fold of skin is lifted and the eyelid is entropionized.

entropion will occur or the entropion that is artificially formed will be blinked away immediately when the fold of skin is released. If there is instead habitual entropion, the patient will be unable to blink the entropion away or can do so only with great difficulty.

19.4.6 Conjunctiva and nictitating membrane

The conjunctiva is a thin, transparent membrane attached to the inner side of the free rim of the lid margin, covering the inside of the lid and returning to the limbus at the fornix. The conjunctival part, which covers the inner side of the eyelids, is called the palpebral conjunctiva. From the turn at the fornix the conjunctiva covers the clearly visible sclera and is referred to as scleral conjunctiva. In the medial canthus there is a large, folded extension of the conjunctiva, the nictitating membrane (plica semilunaris conjunctivae; third eyelid).

The most important function of the conjunctiva is that of a supple, smooth, moist barrier which closes off the space between the eyelids and the globe and orbit, while still allowing movement of the globe. The conjunctiva also plays an important role in local immune defense. It is rich in lymphatic tissue and contains numerous goblet cells, which produce mucus.

The ducts of the lacrimal glands and accessory lacrimal glands open into the dorsal fornix. The conjunctiva is attached to the underlying tissue by elastic fibers.

The conjunctiva is transparent and its apparent color is actually the color of the underlying tissue (see also § 8.3.5). The scleral conjunctival vascular system has anastomoses with the vascular system of the globe. Inflammation (uveitis) or increased pressure (glaucoma) in the bulb almost always involves the conjunctival vessels as well, causing redness of the conjunctiva.

Dorsally and ventrally in the mucosa of the medial canthus of dogs and cats, about 5–8 mm from the angle and about 1 mm inside the edge of the eyelid, are the lacrimal puncta, the openings of the tear drainage system. In rabbits there is only one lacrimal punctum. From the lacrimal puncta one can follow the canaliculi for a few millimeters under the thin mucosa. The lacrimal sac in the medial canthus by the entrance of the nasolacrimal duct into the lacrimal canal is, however, not visible. (see § 19.4.9 for checking passage through the drainage system).

The nictitating membrane contains a flat T-shaped cartilage which gives it support and curvature. At the base is the superior gland of the nictitating membrane, which is responsible for about 30% of the mucoserous

fraction of the tear production. The ocular mucosa of the nictitating membrane in particular contains considerable lymphoid tissue.

Inspection and palpation

The examination of the conjunctiva consists of inspection and palpation and, if necessary, taking a smear or scraping or a biopsy. Before inspection the conjunctiva is anesthetized with a few drops of a local anesthetic. If there is doubt about the sensitivity of the cornea, it should be examined before the anesthetic is applied (§ 19.4.9).

Whenever drops of a local anesthetic or medication are applied, the patient should be looking directly upward. The dropper should never come in contact with the cornea, the eyelids, or hairs of the patient (keep 5 to 10 cm above the eye). If the dropper becomes contaminated, the contaminant will be sucked inside when the dropper is released!

The eyelid is ectropionized with Von Graefe's fixation forceps (Fig. 19.12). The conjunctival limb of the forceps is inserted between the globe and palpebral conjunctiva, in a plane tangential to the globe and parallel to the edge of the eyelid, in such a way that the corners of the jaws of the forceps do not damage the cornea. The eyelid is held with one jaw of the forceps on the palpebral conjunctiva and the other on the skin, 1–2 mm from the edge of the eyelid. The jaws of the forceps thus come to lie perpendicular to the edge of the eyelid. Often some sebaceous secretion is thus squeezed from the meibomian glands.

Note: hand contact with the head must be maintained without interruption! The opposite end of the forceps (arrow in Fig. 19.12) must remain free of the palm of the hand. In case of resistance and/or unexpected movements, the hand with the forceps will follow the movements of the head and the cornea will not be damaged. With fairly firm closure of the forceps the eyelid is ectropionized and rolled up, so that the conjunctiva is made visible and at the same time tensed. If the forceps are not held firmly closed, the eyelid slips out of the jaws and there is a risk that the teeth will thereby damage the edge of the eyelid.

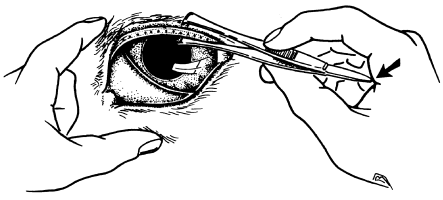


Fig. 19.12 Inspection of the edge of the eyelid and the palpebral conjunctiva. The upper eyelid is ectropionized with the aid of Von Graefe's fixation forceps. The opposite end of the forceps must remain sufficiently free from the palm of the hand (arrow).

The conjunctiva is evaluated for color, smoothness (feel with the tip of the finger if necessary), moistness, swelling (e.g., due to edema = chemosis), lesions/defects, follicles, vascular injection, foreign bodies, and inflammatory exudate. Any pigmented spots are also noted. If these have a diameter of about 1 mm and are located 1–5 mm inside the margin of the lid, they sometimes contain ectopic cilia (see Fig. 19.8). Without use of magnification (loupe or microscope), the hairs are difficult to recognize. A neoplasm (adenoma, melanoma,) can also be markedly pigmented. The medial canthus is examined to see that the lacrimal puncta are present and of adequate size.

Nictitating membrane (plica semilunaris conjunctivae, third eyelid)

In dogs and cats the nictitating membrane is located nasoventrally, in the rabbit nasally, and in birds dorsally. In most birds the third eyelid is transparent.

Before beginning the inspection, one should compare the two eyes to see whether the nictitating membrane is adequately positioned in the medial canthus. A nictitating membrane that is visible far laterally is described as protruding. Among the causes of this are local abnormalities of the nictitating membrane as well as enophthalmos. In case of doubt one can raise the dog's nose, for this causes a protrusion to increase. In addition, processes located behind the globe can press the third eyelid forward (retrobulbar abscess, tumor).

The nictitating membrane (Fig. 19.13) is inspected—after local anesthesia—by bringing the forceps in from the lateral side to its edge. (Remember to maintain contact with the hand on the animal's head!) Light pressure on the cornea causes a slight enophthalmos, so that the nictitating membrane shoots up over one jaw of the forceps by itself. Then the nictitating membrane is fixed and pulled laterally so that the palpebral mucosa can be evaluated. Then it is moved medially and the ocular side is inspected.

In addition to the aspects mentioned for the palpebral conjunctiva, attention is given to the cartilage visible through the conjunctiva (Fig. 19.14, (1)), the often present lymph follicle field (2) in the ocular mucosa, and swelling of the lacrimal gland (3) at the base of

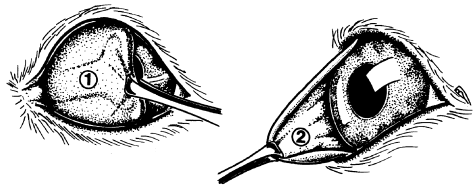


Fig. 19.13 Inspection of the palpebral (1) and the bulbar (2) side of the nictitating membrane.

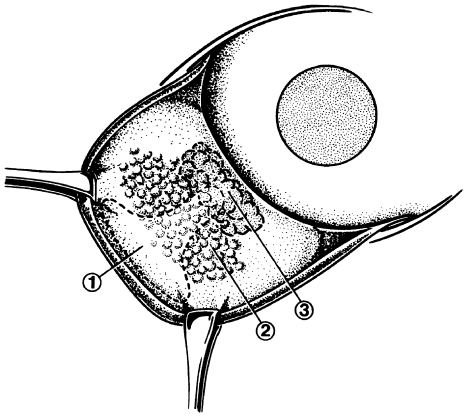


Fig. 19.14 The bulbar side of the nictitating membrane. 1 cartilage, 2 field of lymphoid follicles, 3 superficial glands of the nictitating membrane.

the nictitating membrane. Foreign bodies sometimes remain lodged behind the nictitating membrane.

Scleral conjunctiva

The scleral conjunctiva is evaluated while the eyelids are spread apart with the fingers. The white sclera must be clearly visible through the transparent conjunctiva. This very loose scleral conjunctiva can contain a few thin vessels, especially in young animals. The conjunctival vessels lie more perpendicular to the limbus and are brilliant red. The scleral vessels usually lie more or less parallel to the limbus and are usually purple. Excessive vascular activity (vascular injection), redness, soft swelling, and bleeding (between the conjunctiva and the sclera) are usually quite easily recognized against the white background of the sclera. When there is doubt whether these abnormalities are conjunctival or scleral, the conjunctiva can be anesthetized and then lifted or moved a little with the fixation forceps to make this differentiation. Also, a drop of 0.1% epinephrine can be applied. Usually the conjunctival vessels react with a rapid vasoconstriction and are then less clearly visible. The scleral vessels initially remain practically unchanged.

19.4.7 Globe (bulbus oculi)

The globe as a whole should be evaluated separately.

Position

In looking at the patient, take note of the line of vision (the imaginary visual axis) and the interplay of the two eyes. The eyes fix upon a certain point. One can then try to attract the attention of the animal (by snapping the fingers or having the owner call the dog), so that the coordination of the eyes can be checked.

Strabismus (squinting) is often encountered in Siamese cats and occasionally in the dog. Nystagmus is the term used for involuntary trembling, repeatedly vertical or horizontal or rotary eye movements (see § 18.2.4).

Enophthalmos

The retractor bulbi muscle is very strong in domestic mammals and can retract the globe as much as 10 to 15 mm. This also results in protrusion of the nictitating membrane. When there is pain or irritation of the eye, there is almost always not only blepharospasm but also enophthalmos (deeply set eye). Also when there is hypersensitivity to light (photophobia), blepharospasm and enophthalmos can occur. The examination must then be directed especially to these aspects. Enophthalmos can be caused by insufficient retrobulbar support due to cachexia, old age, loss of retrobulbar fat, atrophy of chewing muscles, or retraction of the eye by the retractor bulbi muscle.

Exophthalmos

This refers to rostral displacement of the globe. Several breeds have a more or less 'physiologic' exophthalmos: the Pekingese, Shih Tzu, Boston terrier, and French bulldog. Pathologic exophthalmos is usually caused by space-occupying processes behind the globe. There is also a certain pseudo-exophthalmos when there is an enlarged globe (see under size). Because the exophthalmos in itself does not usually give an indication of its cause, further examination is required. In this regard it is important to begin with the anatomical structures behind the eye (see § 19.4.2) and to consider the possible pathological changes there.

Retrobulbar pressure (retropulsion)

If either exophthalmos or enophthalmos is indicated in the history or found during the examination, it is important to evaluate the pressure within the eye by palpation. For this purpose one lays the tips of the forefingers on the upper eyelids, closes the eyelids, and presses both globes carefully into the orbits (Fig. 19.15). The counter pressure in the two orbits must be equal and it should be possible to press the eyes (in dolichocephalic breeds), easily and without pain, to about 10–15 mm deep in the orbits. This manipulation can then be repeated while the owner holds the animal's mouth open. The retrobulbar area can be examined further by ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI) (§ 19.6).

Size

The two globes should be equal in size and appropriate to the size of the animal's head. A wide palpebral fissure or



Fig. 19.15 Measurement of the retrobulbar pressure. With both forefingers on the upper eyelids, the globes are pressed into the orbits.

enophthalmos does not necessarily mean that the globe is too small, although this may be the first impression.

Unilateral microphthalmos (congenitally small globe), phthisis bulbi (acquired small globe), and buphthalmos (acquired enlargement of the globe) are usually recognized easily. It is more difficult if the cornea of one eye is opaque white, for this usually makes the eye seem larger. To confirm the size, one can measure the horizontal diameter along the limbus with sliding calipers. The horizontal corneal diameter is 16.7 ± 1 mm in dogs and 17.9 ± 0.8 mm in cats.[15] If there is an identical abnormality in size in both eyes, one must estimate whether the globes are of abnormal size and not appropriate for the size of the head. One must then look for associated signs to support the impression about the size of the globes. Ultrasonography provides an objective measure of globe size.

Intraocular pressure/tension

The aqueous fluid is formed by diffusion via the ciliary body and by active secretion by the superficial epithelium of the ciliary processes. It flows via the posterior chamber (between the lens and the iris), through the pupil, to the anterior chamber. It is drained through the pectinate ligament in the drainage angle and from there partly by means of pinocytosis and via very fine canals to the scleral venous plexus. Another part flows out via the ciliary cleft. From there the greater part passes via the vortex system. A small part passes via anastomoses to the conjunctival vascular network. The aqueous fluid maintains the tension of the eye at an average pressure of about 16–25 mm Hg in dogs.[17] This intraocular pressure together with the rigidity of the cornea is called the tension. The least reliable but still most readily available method for the practitioner to measure the tension is by palpation. Reliable veterinary tonometers use applanation of the cornea with anesthesia, or the rebound effect on the cornea, without the need for a topical anesthetic. However, they are costly for general practice.

Bilateral measurement of tension by palpation

The tips of the two index fingers are laid, slightly curved, on the closed upper eyelids of the two eyes (Fig. 19.16a). If the curvature of the globe can be felt, slight pressure can be applied with both fingers at the same time and thus the tension of both eyes can be compared. When correctly performed, the globe is not pressed into the orbital, and there is no protrusion of the nictitating membrane. For further comparison, one can then immediately palpate the tension of the eyes of another dog.

Unilateral measurement of tension by palpation

The tips of both index fingers are placed on the upper eyelid of one globe. One fingertip palpates while the other carefully varies the pressure (Fig. 19.16b). Both methods give rough, subjective estimates. Breed predispositions and secondary signs of glaucoma such as complete diffuse corneal edema and mydriasis are then also of extra importance for the diagnosis.

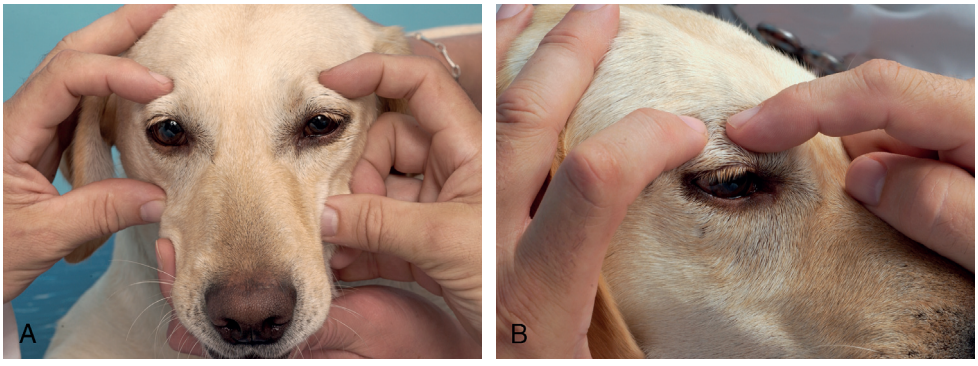


Fig. 19.16 Estimating tension by bilateral palpation. A With the tips of both forefingers on the upper eyelids, the globes are lightly pressed inward from the lateral side, against the hard orbital floor. B Unilateral method of manual estimation of tension. One finger is used to palpate while the other varies the pressure.

19.4.8 Sclera

After the examination of the area around the eye, the orbits, adnexa, and the globe as a whole, the components of the globe itself are examined.

The sclera together with the cornea forms the stiff outer wall of the globe. The sclera consists of white, lamellar, slightly elastic fibrous tissue. The thickness varies, being 1 mm near the ciliary body, 0.3 mm at the equator, and about 0.8 mm at the emergence of the optic nerve. In contrast to the avascular cornea, the sclera contains both a lymphatic and a blood vascular system. Parts of the scleral venous plexus can be seen as a slightly bluish ring about 2 mm posterior to the limbus. From this plexus, anastomosing vessels join the conjunctival vascular system. Small accumulations of pigment can be seen in the superficial layers of the sclera, especially in older animals.

Color

During inspection, note is taken of the color of the sclera, which is normally practically white. Pigments circulating in the body can discolor it, most often making it yellow (see § 8.3.5).

Vascular injection

If the sclera is thin, the vascular system shines through with a bluish color (this is normal in pups and kittens). When the eye is inflamed or there is glaucoma, there can be increased vascular activity (vascular injection, redness) and edema in the limbal area. This is often found in combination with conjunctival vascular injection. If there is doubt whether the vascular injection is conjunctival or scleral, the conjunctiva can be lifted up or moved slightly over the sclera (see § 19.4.6) or the conjunctival vessels can be identified with the aid of a drop of 0.1% epinephrine.

Thickening

Local inflammation of the sclera or episclera can result in pinkish-red thickened areas. These can be palpated with a fingertip to evaluate their firmness. Neoplasms usually arising from the uvea (mostly melanomas) or limbus (nevus) can cause darkly pigmented areas on the sclera.

19.4.9 Cornea

The cornea is the avascular, transparent window in the globe that allows light to pass through to the retina. The thickness, which is mainly determined by the stroma, varies from 0.45 to 0.65 mm.[9] From the outer surface (covered by the tear film) to the inner surface, the cornea consists of the following layers:

1 epithelium (7–15 cells thick)
2 stroma (in very regularly-oriented collagen fibers)
3 Descemet's membrane (fibrous, elastic layer)
4 endothelium

Nerve fibers from the trigeminal nerve (n.V) branch extensively under the corneal surface, resulting in great corneal sensitivity. The transparency of the cornea is the result of the absence of keratinization, its uniform lamellar structure, and the relatively dehydrated condition of the stroma. The endothelium has the most important (Na^+ pump) function in this regard. Damage to the endothelium or elevation of the pressure in the anterior chamber thus leads immediately to fluid retention in the cornea (edema). This may cause its thickness to increase five fold. Epithelial damage also leads immediately to edema, but to a much smaller degree and limited to a small area. The edema leads to irregular swelling of the cornea with gray-blue-white discoloration and an irregular surface (islet pattern). A normal cornea has an intact tear film and has a smooth, spherical surface that is reflective, transparent, and very sensitive.

Further examination should take place in a dimly-lit or darkened room!

Reflectivity

By means of its smooth surface, normally curved shape, and appropriate tear film, the cornea acts as a curved mirror. Although the reflected image of a window, outside light, or a lamp is distorted by the curvature, the object is completely and distinctly reflected (see Fig. 19.4).

If inspection with or without a lamp reveals little or no reflection, the tear film may not be intact (see § 19.4.3) and/or the corneal surface may be irregular. A reflected image that is irregular but reasonably sharply outlined is almost always an indication of irregularity of the surface of the cornea, such as due to edema, possibly associated with defects. The tops of the greatest elevations reflect well (mountain peaks in the sun). This gives rise to a distorted image or one that is shattered. Pigment or granulation tissue can also cause a poorly outlined or scattered reflection image.

Curvature (sphericality)

The curvature of the cornea can be tested with the keratoscope. The keratoscope is a disk with concentric black and white rings which when lighted are projected onto the cornea. Most direct ophthalmoscopes are provided with a keratoscope with a line pattern. These rings or line patterns should be uniform and concentric when reflected by the cornea. If the cornea has an irregular protrusion or depression or is conical (keratoconus), the reflected image will be distorted (like elevation contours).

Transparency

The entire cornea should be completely transparent, but in pups of about 12–40 days it is still slightly hazy. With the naked eye, or better yet with a loupe or a slit lamp microscope, it is possible to detect focal edema, scars (white, like the sclera), dystrophic precipitates (white, like sugar crystals or glass fibers), blood vessels, granulation tissue, pigment, or foreign bodies. In many corneal diseases, the cornea becomes locally vascularized. Superficial blood vessels are usually branched and continue into the conjunctiva. Deep vessels have a greater resemblance to broom straws (branching late) and disappear under the sclera. In order to localize abnormalities in the depth of the cornea, use is made of the slit lamp, preferably in combination with a binocular loupe or microscope.

If there is so much corneal edema that inspection of the deeper parts is impossible because of the cloudiness, drops of hypertonic (5–10%) NaCl solution can be applied in order to reduce the edema temporarily.

Note: Descemet's membrane remains clear when there is corneal edema. If a clear pit is found in a field of corneal edema, it is most probably a deep defect that extends to Descemet's membrane! It should be checked with fluorescein (see below). The margin of the defect (stroma) will stain, the 'floor' of the defect (Descemet's membrane) will not.

Slit lamp (microscope)

With the aid of a narrow beam of light (Fig. 19.17), its length and width being adjusted to the size of the part to be examined, a thin slice is made through the eye so that even optically dense parts or areas can be illuminated (Tyndall effect; § 4.1.1).[17]

In addition, convex and concave surfaces in the cornea and the anterior and posterior lens capsules produce reflections. By moving the lamp up and down and from side to side, by rotating it and by varying the angle (15–45° with respect to the eye of the examiner), the eye is examined for abnormalities. The first line is formed by the reflection on and the scattering in the cross-section of the cornea. This is followed by the cross-section of the anterior chamber, which forms a darker band, in which there is almost no light scattering. Then the light bundle reaches the surface of the iris and the anterior lens capsule, which is observed as a convex line (curving out toward the examiner). The lens is then 'transected', its optical density being similar to that of the cornea. In animals over 6 years of age there is a physiological sclerosis of the nucleus of the lens, leading to a less transparent cross-section in the slit lamp picture. The posterior lens capsule produces a concave line and then the light beam fans out in the vitreous. The retina is usually not visible with the slit lamp. If it is visible, either the lens is absent or dislocated (lens luxation) or the retina is displaced anteriorly (retinal detachment).

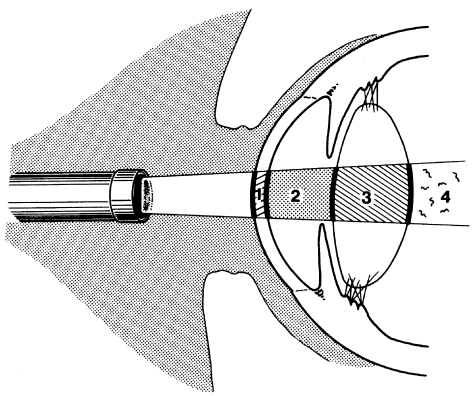


Fig. 19.17 The narrow light beam of the slit lamp penetrates the anterior segment of the eye. 1 cornea, 2 anterior chamber, 3 lens, 4 vitreous.

Sensitivity

The sensitivity of the cornea can be tested with a moistened and twisted pluck of cotton. This should be done before a local anesthetic is applied (see § 19.4.6). When the cornea is touched the eyelids should close immediately (corneal reflex). This reflex can also be stimulated by blowing on the cornea, but the cornea should not be touched with the fingertip.

Diagnostic staining

The use of staining materials can be helpful for the detection of defects in the cornea and for examination of the tear drainage system. If there are indications of central corneal defects (edema, irregular reflection image), staining should be delayed until after the examination of the deeper parts of the eye. Otherwise the persistence of the stain can temporarily prevent good examination of the deeper parts.

Sodium fluorescein

The orange-colored sodium fluorescein becomes yellow-green fluorescent when diluted and it adheres quite well in corneal defects, thereby improving visualization. The patency of the tear drainage system can also be examined with fluorescein. For examination of corneal defects, it is preferable to use paper strips impregnated with this stain; the strip is placed in the ventral conjunctival sac for about 1 second. Excess stain can be rinsed away if necessary.

Fluorescein solution is especially useful for examining the tear drainage system, but much more dye is applied than with the paper strip. If the fluorescein solution becomes contaminated, pathogenic bacteria such as *Pseudomonas spp.* may grow in it.[17-19] Thus it is customary to use commercially available mini-packages.

Passage through the tear drainage system (Fig. 19.18)

When there is hindrance to tear drainage, which can be manifested by a tear stripe (see § 19.4.2), the passage of the fluorescein from the conjunctival sac to the nose is checked. For this purpose the impregnated strip is left in the conjunctival sac a little longer than for corneal staining and a few drops of 0.9% NaCl solution can also be applied. It is also possible to use a fluorescein solution (see above). With the nose in a low position the stain should reach the ipsilateral nostril within maximally one minute. When its appearance in the nostril is in doubt, it can be checked with a cobalt blue light, which makes the fluorescence easier to see. If there is rapid passage of the stain in spite of epiphora, then it can be concluded that there is overproduction of tears caused, for example, by irritation. An abnormally high tear production will have been noticed earlier in the eye examination in the Schirmer tear test. Very slow passage or no passage at all can be the result of an abnormality in the tear drainage system, with or without overproduction of tears.

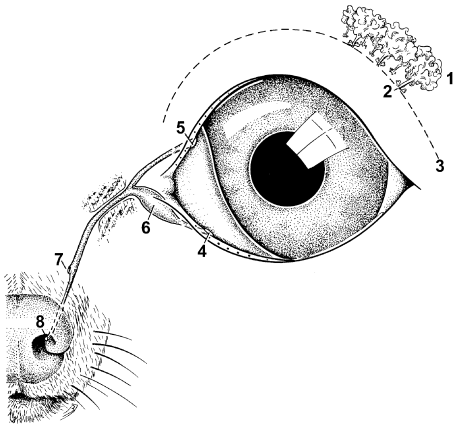


Fig. 19.18 The tear apparatus. 1 tear gland, 2 accessory tear glands, 3 fornix, 4 inferior lacrimal punctum, 5 superior lacrimal punctum, 6 lacrimal sac, 7 nasolacrimal duct, 8 orifice in the nasal opening.

Corneal defects (Fig. 19.19)

Fluorescein cannot penetrate in or through intact corneal or conjunctival epithelium. When there is an epithelial or deeper defect, the stain can penetrate and attach in and between the damaged epithelium and/or stroma. In case of doubt, one can make use of cobalt blue light and a loupe or slit lamp microscope. If a fluorescein-positive defect is present, its location, size, edge, and depth are considered. A smooth and regular edge together with vascular injection toward the defect indicate a good tendency to heal. In contrast, edges that are irregular or undermined (the fluorescein creeps under the edge) and the absence of vascular injection are signs of indolence. Scrapings of these edges can be made for further examination (microbiology, cytology) (see § 19.2). Edges that are swollen and yellowish-gray are usually an indication of a very aggressive liquefaction of the corneal tissue by lysing bacterial products.

In addition to the appearance of the edges, the deeper parts of the defect are also examined. In deep defects, epithelium and stroma are well stained by fluorescein but Descemet's membrane is not. Very deep defects

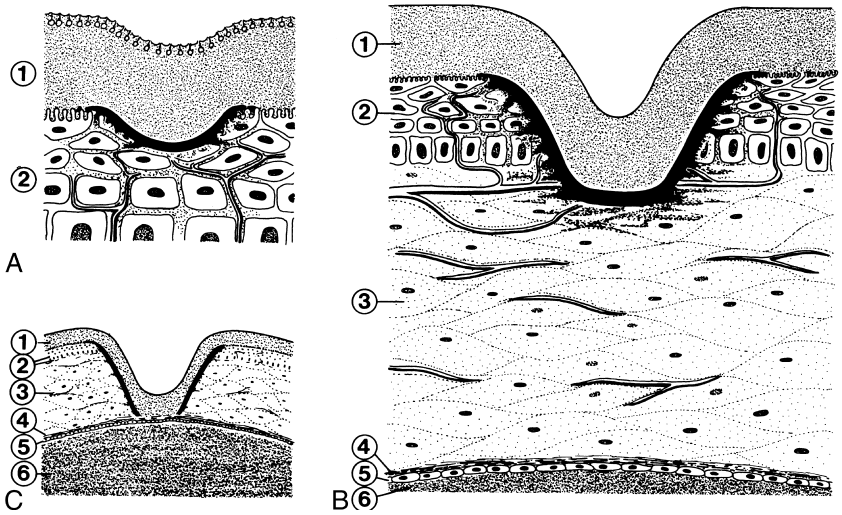


Fig. 19.19 Corneal defects in cross-section, stained with fluorescein (black in the figure). A superficial epithelial defect, B defect extending into the stroma, C defect extending to Descemet's membrane, which itself does not take up the stain. 1 tear film, 2 epithelium, 3 stroma, 4 Descemet's membrane, 5 endothelium, 6 aqueous.

thus consist of a crater with a fluorescent wall and a thin, crystal-clear center. In such a case one must take great care because of the risk of corneal perforation. Damaged granulation tissue on the cornea also stains with fluorescein and should not be confused with a corneal defect.

The fluorescence disappears after a few hours. As soon as a corneal defect is covered by flattening epithelial cells, it becomes fluorescein-negative, even if the cornea is not yet of normal thickness.

Rose bengal (not routine)

Rose bengal* (dichlorotetraiodofluorescein) 1% penetrates through intact, but not vital, epithelial cells of the cornea and conjunctiva, and attaches to cells no longer covered with mucin, giving them a purplish-red color.[20] Positive staining of the cornea with rose bengal indicates a qualitatively and/or quantitatively inadequate tear film. The stain is irritating to the eye, so a local anesthetic should be applied in advance, and when defects are present the staining is very persistent. Hence this diagnostic staining is used only when dubious STT values lead to suspicion of keratoconjunctivitis sicca or there is too rapid disruption of the tear film without epithelial defects (fluorescein-negative). The number of purplish-red flecks, which can only be counted carefully with the aid of a slit lamp microscope, is a measure of the loss of cells and consequently of the severity of the disturbance of the tear film. In cats dendritic corneal defects, such as can be caused by herpes virus infection, may also be stained by rose bengal.

19.4.10 Anterior chamber

The anterior chamber is examined with the aid of the slit lamp or a small, focal light source. The anterior chamber is evaluated for shape, depth, and clarity.

Shape and depth

The anterior border is formed by the endothelium of the cornea. In the light beam of the slit lamp special attention is given to the posterior border of the section through the cornea (first refraction line). Small precipitates can be attached to the endothelium, causing an irregular, bumpy inner border. The iris and, at the level of the pupil, the lens form the caudal border of the anterior chamber. The iris, lying against the lens, should follow its curvature. Thickening of the iris causes this regular curvature to be distorted and the slit lamp shows a bumpy or a larger step to the lens than is normal. With loss of support from the lens, due to its detachment, absence, or flattening, the iris lies in a flat plane, so that the anterior chamber is deeper and the light line over the surface of the iris (the caudal border of the anterior chamber) is straight.

The angle of the anterior chamber is formed by the anterior face of the base of the iris and the inner side of the cornea at the limbus. The chamber angle should form a roomy entry to the drainage system for the aqueous fluid (see § 19.4.7). In the ophthalmologic literature an unambiguous distinction is not always made between the concept of chamber angle and that of drainage or filtration angle. If the chamber angle is narrowed, the beam of the slit lamp on the iris will lie closer to or in contact with the corneal endothelium.

The pectinate ligaments of the drainage can only be inspected with the aid of a special contact lens (gonioscopy).[21]

Clarity

The fluid in the anterior chamber should be crystal clear. In healthy animals the anterior chamber is therefore optically 'empty'. In principle, any cloudiness in the anterior chamber is abnormal. Examples are given below.

As a result of trauma, a uveal vessel can rupture and hemorrhage can occur in the anterior chamber (*hyphema*). In the light beam of the slit lamp, one finds the anterior chamber more or less filled with blood. If the bleeding has already stopped, the sedimentation of the erythrocytes will result in a horizontal line in the anterior chamber.

Hypopion is the presence of pus in the anterior chamber. In general it is the product of inflammation in the uvea (anterior uveitis).[22]

After inflammation or trauma, adhesions (synechiae) can develop. *Anterior synechiae* are those formed between the cornea and the iris, and *posterior synechiae* are those between the iris and the lens. As part of the syndrome of persistent papillary membrane, thread-like structures may be observed in the anterior chamber (see § 19.4.12: embryonic remnants). Small, fixed or drifting, usually pigmented cysts (*iris cysts*) are occasionally observed in the anterior chamber. Very thin, white clouds of *vitreous* hanging over the edge of the pupil are an indication of the beginning of a lens luxation (see § 19.4.14). Neoplasms can more or less fill the anterior chamber.

19.4.11 Pupil

Shape and position

The central opening in the iris is called the pupil. The shape of this opening is determined by the course of the fibers of the sphincter muscle of the pupil. Many species have a round pupil. The cat has a vertically slit-form pupil. The shape of the pupil is particularly recognizable during complete *miosis* (narrowing of the pupil).

* Lissamine green can be used in place of rose bengal.

In *mydriasis* (widening of the pupil), the pupil is usually round or practically round. *Anisocoria* refers to a difference in the size of the two pupils. Adhesions between the edge of the pupil and the lens or the cornea can cause changes in the shape of the pupil (dyscoria).

Reflexes

The pupillary reflex apparatus regulates the size of the pupil opening and thus the amount of light that falls upon the retina. The accommodation system of the lens is influenced at the same time. The sphincter muscle of the pupil is the strongest muscle and is innervated by the parasympathetic fibers in the oculomotor nerve. The dilator muscle of the pupil is innervated by sympathetic fibers.

Direct pupillary reflex (DPR). In a completely darkened room a strong but not too large light source is held before the eye. A penlight can be used for this purpose. The light is held about 5 cm in front of the eye on the imaginary visual axis, so that the light beam shines on the central point (central area) of the retina. The eye should be allowed at least 15 seconds to adapt to the dark and then suddenly the light is turned on. The exposed pupil should narrow rapidly and remain small (miosis).

Consensual or indirect pupillary reflex (CPR). In this test one observes the pupil of the eye that is not illuminated. The room should be darkened slightly less than for evaluating the direct reflex. When the light is shone in one eye, usually a prompt miosis occurs in the opposite eye. The CPR is named after the eye in which the light is shone.

When light shines on the retina, the narrowing of the pupil should occur within a few seconds and should be optimal after 5–6 seconds. After the light is turned off, mydriasis returns slowly (minimum of 15 seconds). Miosis can occur slowly in response to light because of the animal's anxiety or because of a pathological change. The test should therefore be repeated a few times.

Pupillary rigidity, which is the complete absence of a reaction to light, is almost without exception the result of a pathological condition. If there is an abnormal pupillary reaction and a mydriatic has not been used, the principal conclusions which can be drawn are:

1. DPR and CPR normally present: normal
2. DPR and CPR present bilaterally but slow: anxiety or retinal abnormality without complete loss of function
3. normal pupil size, DPR and CPR absent: possible adhesions between the lens and iris, or iris atrophy
4. bilateral mydriasis, DPR and CPR absent: bilateral motor disturbance, possibly combined with afferent disturbance, which cannot be localized further
5. anisocoria with slight mydriasis on right side and normal pupil on left, DPR and CPR delayed on right side and normal on left: abnormalities in the afferent system on the right, from the retina to the optic chiasm
6. anisocoria with mydriasis on right side and normal pupil on left, DPR absent on right side and normal on left, CPR absent: defect in parasympathetic innervation on the right side (via the oculomotor nerve)
7. anisocoria with mydriasis on right side and normal pupil on left, DPR and CPR absent on right side but DPR normal and CPR absent on left: optic nerve and ciliary ganglion nonfunctional on the right side, usually caused by a retrobulbar lesion

19.4.12 Iris

The iris is a part of the uvea. Posteriorly the iris merges with the ciliary body, without a definite border. The ciliary body merges, via the ora ciliaris retinae, with the choroid and the pigment epithelium of the retina.

The iris consists of connective tissue, muscle fibers of the sphincter and the dilator muscles, and a great number of blood vessels and nerve fibers, and it is usually strongly pigmented. In most species of animals there is a well-developed arterial ring in the base of the iris. This can often be seen as a small, slightly meandering, elevated ring.

Color

In most species of animals the iris is deep brown to golden yellow (but blue in the Siamese cat). The pigmentation is usually most pronounced at the edge of the pupil. Pigment epithelium extending from the retina covers the posterior surface of the iris. The absence of pigment from the anterior part and the stroma of the iris gives a blue appearance as a result of the pigment epithelium on its posterior surface. If there is no pigment in either the iris or the pigment epithelium (albino), the iris appears red because of its vascular network. Abnormalities in iris pigmentation are often associated with similar abnormalities in the choroid. Sometimes pigment is absent in only one eye, so the irises are of different colors (*heterochromia iridis*). This can be seen, for example, in 'blue merle' dogs.

A reddish or gray coloring of the iris indicates hyperemia and/or exudative inflammation. These are signs of iritis or uveitis. The development of darkly pigmented focal elevations is an indication of the beginning of a neoplasm.

Surface

The normal iris has a slightly irregular surface as a result of the vascular network that lies just under the surface.

During inspection with the slit lamp, the light beam falling on the iris causes a curved line, more or less parallel to the lens curvature. One looks for focal, often more deeply pigmented nodules (melanoma). An unusually smooth, slightly tense surface, the result of diffuse swelling, is also abnormal; it can be due to inflammation or neoplastic growth in the entire iris.

Thickness

When the light from the slit lamp shines on the iris and the anterior lens capsule, one can easily evaluate the thickness of the iris, right at the transition.

If the iris is thickened, the light beam will make a more definite step from the iris to the anterior capsule. In this case the curvature of the iris can also be obviously abnormal (see also § 19.4.10).

Defects

When inspected with a focal light source or the slit lamp, the edge of the iris should be reasonably smooth and regular. The pupil should have a shape appropriate to the species.

Defects in the edge of the iris (through which one can see the lens) are usually congenital (colobomas) (Fig. 19.20); the shape of the pupil is only slightly changed. One can also encounter mesh-like defects (atrophy); the iris can be almost transparent focally or even absent over large areas (aniridia).

Embryonic remnants

During embryonic development the 'pupil' of the primitive iris tissue is covered by a vascular membrane, the pupillary membrane (see Fig. 19.24). This membrane connected to the anterior side of the iris at the level of the so-called collarette (epipupillary, thus not at the pupil margin), begins to regress about two weeks before birth, and generally has completely disappeared by two to four weeks after birth. Occasionally, remnants of this membrane remain as congenital defects (Fig. 19.21).



Fig. 19.20 Interrupted contour of the pupil due to congenital defects in closure of the edge of the iris/pupil (colobomas).

A 'thread' on the surface of the iris or crossing the pupil to another part of the iris, or attached to the lens or the cornea, is called a *persistent pupillary membrane* (PPM). Larger parts of the membrane persisting in the center, with a few threads passing to the iris, sometimes resemble a spider's web in the anterior chamber. They can also remain attached to the corneal endothelium and cause scars there. Threads from the surface of the iris or the edge of the pupil can also be acquired (uveitis).

Resting position

Because the iris is normally supported and pushed slightly forward by the lens, it should follow the same curvature as the lens. If the lens is absent, too flat, or luxated, the iris loses its support and lies in a flat plane. In addition, the iris and especially its pupillary margin will no longer follow the eye movements but begin to flutter (*iridodonesis*). In inspecting the eye for iridodonesis, the examiner must hold his own head still. The patient must also be held as still as possible and for this purpose the person holding the animal should rest his elbow(s) on the table). With a spot light or slit lamp, the edge of the iris in particular is observed carefully until the patient makes a spontaneous movement of the eye. Directly after the eye movement one can see the iridodonesis develop. When inspection with the slit lamp reveals a straight or slightly posteriorly curving light beam on the iris, it is very likely that support for the iris by the lens is inadequate or completely missing. In this case one must give special attention to the presence of iridodonesis and the location and shape of the lens, as well as to the presence of small amounts of vitreous in the anterior chamber.

A circular adhesion of the iris to the lens (e.g., after iritis) can obstruct the flow of aqueous fluid through the pupil. As a result, the iris can bulge anteriorly (iris bombé; see Fig. 19.27a). The line of light reflection by the slit lamp on the iris thus lies almost directly behind the cornea, the anterior chamber angle has almost disappeared, and centrally the iris turns directly posterior to the anterior capsule of the lens. This abnormality is often associated with an overall increase in pressure in the eye (glaucoma), via which diffuse clouding (edema) of the cornea develops. This hinders the slit lamp examination of the ophthalmic structures behind the cornea considerably.

Transillumination

When cloudiness of the cornea hinders inspection of the anterior chamber and especially the iris and pupil, transillumination may be effective. A small, strong light source such as a penlight is shone into the eye from below or the light is placed directly against the sclera 5–10 mm posterior to the limbus. In this way light shines on the tapetum lucidum. If one then

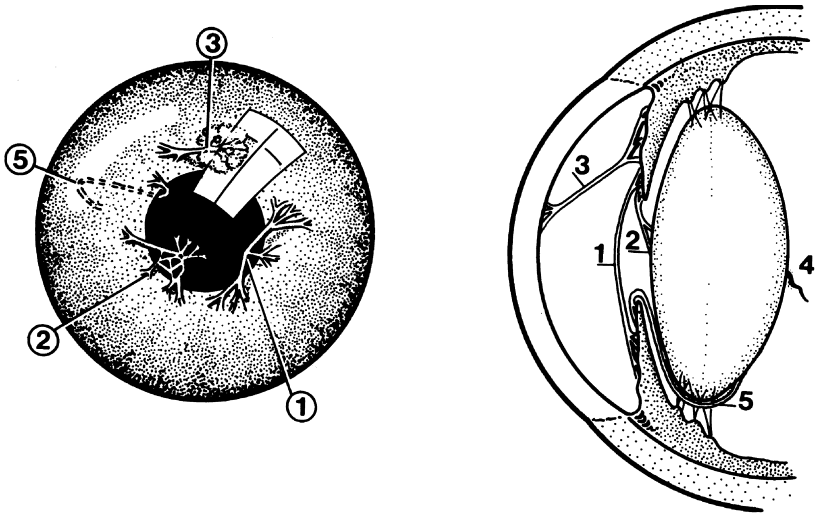


Fig. 19.21 Remnants of the 'hyaloid' system, the tunica vasculosa lentis and the pupillary membrane: 1 persistent pupillary membrane, crossing the pupil, 2 extending from the iris to the anterior capsule of the lens, 3 between the iris and the corneal endothelium, 4 remnant of the hyaloid artery (only visible when a slit lamp microscope is used), 5 remnant of the anterior tunica vasculosa lentis anterior.

looks into the eye from the front, one can use the reflected light to evaluate the contour and sharpness of the pupillary margin.

19.4.13 Posterior chamber

The posterior chamber of the eye is formed by the space bordered by the lens, the ciliary body, and the iris. This space cannot normally be inspected. The presence of a cyst or neoplasm arising from the ciliary body results in space between the iris and the lens, so that inspection with the slit lamp is possible.

19.4.14 Lens

The lens is a biconvex structure (Fig. 19.22) and in dogs the distance between the anterior and posterior poles is 6–7 mm. Anteriorly there is a fairly thick capsule, beneath which there are one or two layers of epithelial cells. Just past the equator is the transition to the posterior capsule of the lens, which is much thinner and under which there is no epithelium. The interior of the lens consists of fibers which are arranged like the layers of an onion, arising in the equatorial area and surrounding the older lens nuclei. The central nuclei of the lens undergo condensation with age and they also undergo dehydration. In older animals (from about six years of age) this can result in a physiologic haziness of the center of the lens (nuclear sclerosis).

The lens fibers lie grouped in such a way that the connection points where their ends meet (Fig. 19.23) form a Y in the anterior part of the lens and an

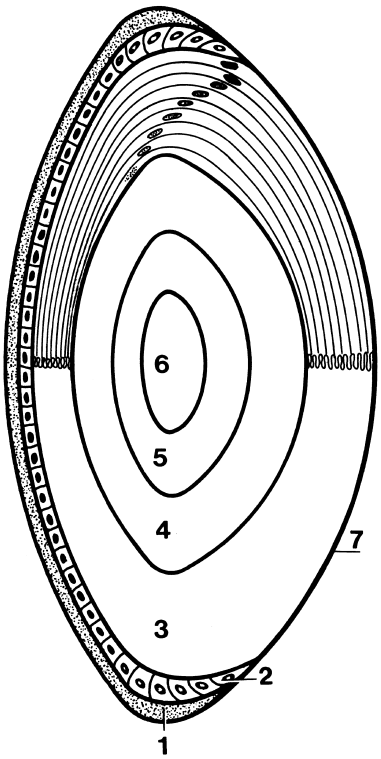


Fig. 19.22 Cross-section of the lens. 1 thick anterior capsule, 2 epithelium, 3 cortex (youngest fibers), 4 juvenile nucleus, 5 fetal nucleus, 6 embryonal nucleus, 7 posterior capsule.

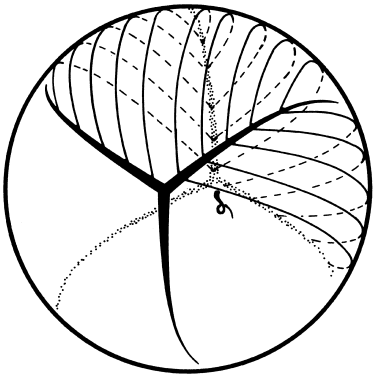


Fig. 19.23 The course of the lens fibers in the anterior and posterior parts of the lens. The junction of the fibers forms the connection lines, in the shape of a Y anteriorly and an inverted Y posteriorly.

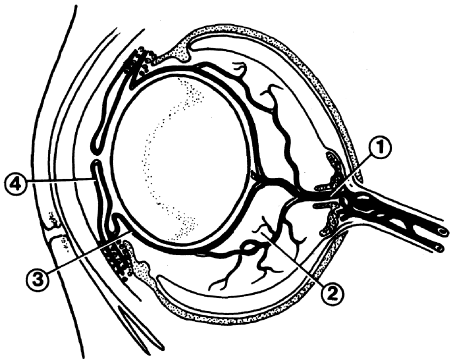


Fig. 19.24 The embryonal 'hyaloid' vascular system around the lens, at its maximum development. 1 arteria hyaloidea, 2 tunica vasculosa lentis (TVL) posterior, 3 TVL anterior, 4 membrana pupillaris.

inverted Y in the posterior part. Especially in pups and kittens, these lines are easily seen with the slit lamp microscope. Turbidity of the lens fibers (cataract) often begins at these division lines, so that they can also be distinguished with the naked eye in the light of the slit lamp.

The lens hangs on very fine threads, the zonular fibers, which form the suspensory apparatus of the lens, the ciliary zonules or Zinn's zonules. The fibers are attached to the lens at its equator and they are suspended peripherally between the ciliary processes of the ciliary body.

The lens contains no blood vessels or nerves and thus inflammation within it is extremely rare (only in congenital, traumatic, or neoplastic abnormalities). During the embryonal phase (Fig. 19.24) the hyaloid artery (arteria hyaloidea, AH) grows anteriorly out of the optic papilla. At the lens it divides to form a surrounding vascular network, the tunica vasculosa lentis (TVL). After passing the equator the vessels join to form the vascular ring in the future base of the iris, where the pupillary membrane (PM) also arises. This AH-TVL-PM system begins to regress shortly before birth. A remnant of the hyaloid artery is visible postnatally as a white microscopic spiral string hanging from the posterior capsule slightly under the posterior pole (see Fig. 19.21).

The inspection of the lens is performed initially with a focal light source and subsequently with the slit lamp (Figs 19.25 and 19.17).

Note: Vision is tested directly after this initial inspection (see § 19.4.16), but before it can be influenced by the administration of a mydriatic. In animals that already have mydriasis, for example as a result of loss of retinal function, the examination of the lens, vitreous, and fundus can be carried out directly. If there is a more or less normal pupillary reaction, the definitive examination of the lens and

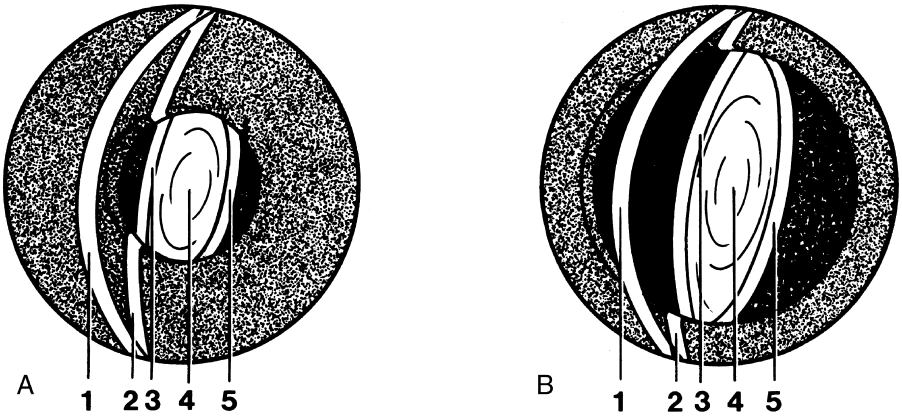


Fig. 19.25 Slit lamp image of the anterior segment of the eye: A in miosis, B in mydriasis. 1 reflection on cross-section through the cornea, 2 light beam on the surface of the iris, 3 light beam on the anterior lens capsule, 4 cross-section through the lens, 5 light beam on the posterior lens capsule.

deeper parts of the eye is carried out after administration of a short-working mydriatic (older animals: 0.5% tropicamide; animals up to about 12 weeks: 1% atropine).[4]

Caution: if glaucoma has been diagnosed or is suspected because of increased intraocular pressure (increased tension), or there is an increased risk of glaucoma, as with lens luxation, the use of a mydriatic is contraindicated! Also do not forget that animals, especially cats, can react to the bitter mydriatic after it passes through the nasolacrimal duct to the nasopharynx and reaches the taste papillae, by excessive salivation, swallowing, and/or foaming at the mouth.

Clarity

Macroscopically the lens is completely transparent, having approximately the same density, in the slit lamp light, as the cornea. Every abnormal increase in density of the lens or its capsule shown by the light beam of the slit lamp is called cataract.

The location of cataracts within the lens is described using the terms polar, capsular, subcapsular, cortical, anterior, posterior, and nuclear. Cataracts at the periphery of the lens are described as equatorial (Fig. 19.26).

Size and shape

When there is enlargement of the lens due to swelling, the only change usually seen in the slit lamp beam is a slight shallowness of the anterior chamber. If the lens is too small in diameter, full mydriasis allows the ciliary processes of the ciliary body to be seen within the pupil. The lens can also be too flat or have an irregularly folded surface, or instead bulge out in a conical shape. If the lens is too flat, the iris lies in a flat plane. If the anterior surface of the lens is irregular, the iris tends to take on this irregularity also. The slit lamp line on the iris and the anterior capsule will thus be either too straight or wavy (Fig. 19.28a). Conical changes are usually posterior and the slit lamp line on the posterior capsule, which is found to be unusually deep, bends away or has an abnormal curvature.

Lentidonesis

If some of the zonular fibers are missing or defective (Fig. 19.27), the lens will be partly loosened and vitreous can 'leak' over the edge of the pupil into the anterior chamber. This will be visible as very thin, white, cloudy material in the anterior chamber. When the eye moves, the lens can, because of its inertia, lag behind and vibrate (lentidonesis). Just as in inspection for iridodonesis, the head of the patient must be held very still and the examiner must wait for a spontaneous movement of the eye.

Location

If most or all of the zonular fibers are broken, the lens can be displaced. When only part of the fibers are broken there is subluxation. The iris thus loses part of its support, iridodonesis develops, and an aphakic crescent develops between the pupil and the contour of the lens (Fig. 19.28c).

In complete anterior luxation of the lens (Fig. 19.28d), the slit lamp cross-section of the lens is found to lie directly against the corneal endothelium. In total posterior luxation, the slit lamp light beam shows in the worst cases that behind the pupil there is no lens at all or only a small part of the lens. To magnify the view of the lens and its surroundings, use can be made of the ophthalmoscope (+8 to +12).

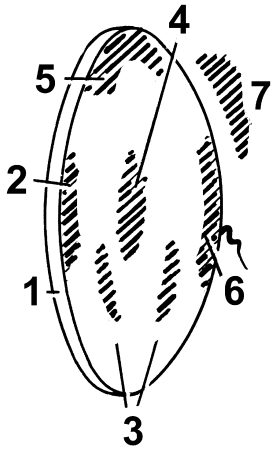


Fig. 19.26 Locations of lens densities (cataract). 1 capsular, 2 subcapsular, anterior polar, 3 cortical, 4 nuclear, 5 equatorial, 6 subcapsular cortical, posterior polar, 7 retrolental.

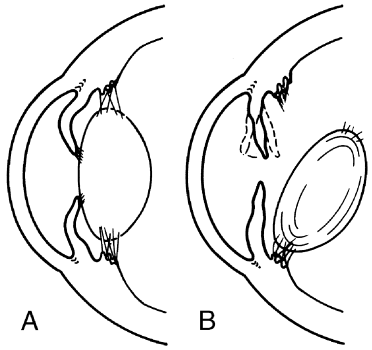


Fig. 19.27 A The edge of the pupil is adhered to the anterior lens capsule. The iris is pushed anteriorly by the continuing production of aqueous: iris bombé. B Some of the zonular fibers are ruptured. The lens is luxated posteriorly. The iris and the lens thus lose their support and fixation, respectively, and they both make trembling movements: iridodonesis and lentidonesis, respectively.

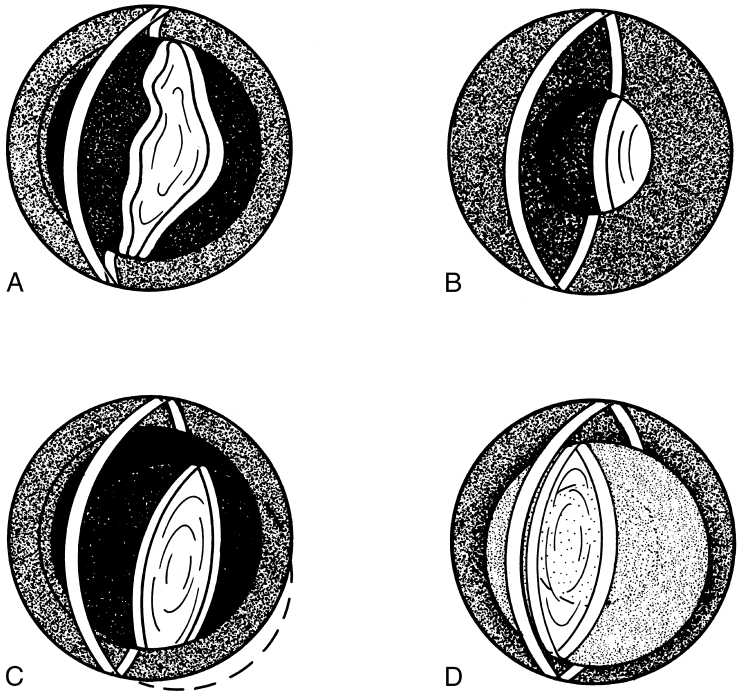


Fig. 19.28 Slit lamp images. A An image in mydriasis of a lens that is too flat and irregular on the anterior surface and is conical posteriorly. B Posterior luxation of the lens, in miosis. C Posterior luxation of the lens, in mydriasis. A dark moon is visible between the equator of the lens and the pupil contour. D Anterior luxation of the lens (into the anterior chamber). The cross-section of the lens is now visible directly behind the cornea.

19.4.15 Vitreous

The vitreous is a gelatinous mass which may have many compartments. There is still little known about this structure. This part of the eye also contains no blood vessels or nerves. A white string extending from the posterior capsule of the lens in the direction of the retina can be a persistent hyaloid artery. Densities (Fig. 19.29), such as those due to degenerative processes, may be seen as small white flakes which float in the vitreous (asteroid hyalosis). In a liquefied vitreous they can also have the tendency to swirl downward (synchysis scintillans). In the examination with the slit lamp, with full mydriasis, these crystalline spots can be illuminated in the light beam behind the posterior capsule of the lens. Larger flakes or streaks of blood in the light beam indicate processes arising from the choroid or retina. Streaks of blood behind the lens, with or without vessels, can be congenital abnormalities or an indication of retinal detachment. If there is more solid material, with thicker vessels, neoplasia must be considered. When abnormalities are found in the vitreous, they can be examined further with the ophthalmoscope (lenses +1 to +8).

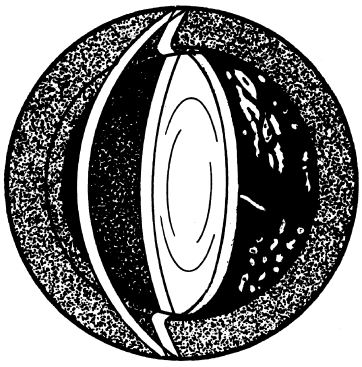


Fig. 19.29 Slit lamp image of densities in the vitreous, during mydriasis. The white string behind the capsule at the posterior pole of the lens is a persistent hyaloid artery. Streaks or flakes (asteroid hyalosis or synchysis scintillans) light up in the vitreum.

19.4.16 Fundus (retina and choroid)

The fundus is understood to mean the most posterior inner layers of the globe that are visible with the ophthalmoscope (Fig. 19.30). The innermost layer is formed by the retina. This is a transparent membrane through which the underlying choroid is visible. Only when there are abnormalities such as exudation, retinal hemorrhage, retinitis, or retinal detachment, can the retina itself be evaluated. The central area (in humans called macula) is the part in which, during miosis, the most important image recording occurs. The

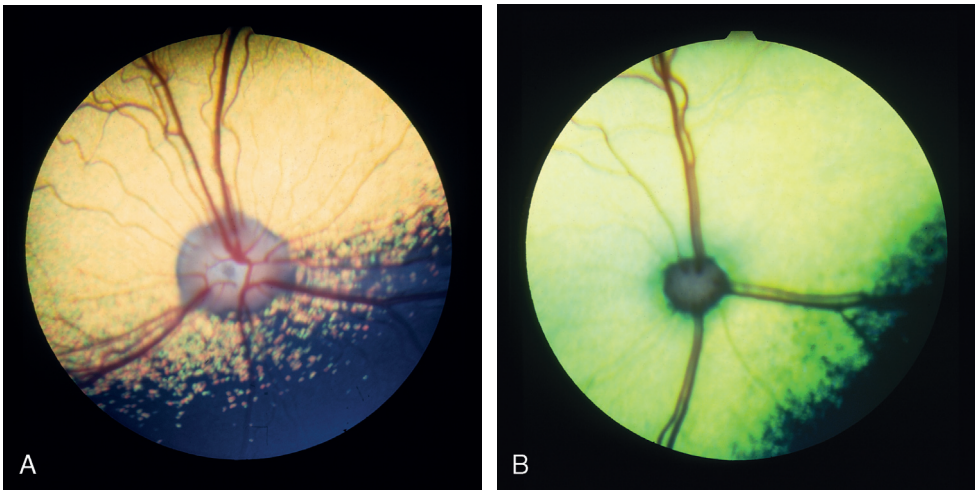


Fig. 19.30 Fundus image (by direct ophthalmoscopy only small areas can be examined) of the right eye of a dog (A) and the right eye of a cat (B). Dark vessels: retinal venules, open vessels: retinal arterioles, light area: tapetum lucidum, dark speckled area: tapetum nigrum.

central area contains a greater concentration of cones. Toward the periphery the concentration of rods rises quickly, especially in species of animals that hunt in the dark. The nerve fibers of the retina come together in the optic papilla (optic disc), from which they proceed as the optic nerve (n. II) via the optic chiasm to the brain. The papilla is the only part of the nervous system that can be inspected noninvasively.

In most species of animals the greatest concentration of retinal blood vessels passes to and around the central area. The retinal arterioles are in general thinner and brighter than the venules, which are somewhat darker red. In the dog the arterioles rise up over the edge of the papilla; the venules can partially join in a ring nearer the center of the papilla. In the cat the vessels disappear directly at the edge of the papilla into the tissue. These retinal vessels are the only part of the vascular system that can be inspected in this way.

The choroid lies posterior to the retina. Its inner layer is strongly pigmented in most species/breeds of animals. The term tapetum nigrum is used for the pigmented choroid. A more or less hemispherical area dorsal to the papilla, varying in color from blue to orange-yellow or green, is called the tapetum lucidum. This area contains crystalline structures which scatter the light so that a great variety of colors is produced. Before these structures are developed (pups/kittens younger than about seven weeks), this part of the fundus is dark purplish-blue. In English and American literature tapetal area or fundus is often used for T. lucidum and nontapetal area or fundus for the T. nigrum.

In some dogs with a very strongly pigmented (also chocolate colored) skin, the tapetum lucidum is only slightly developed or even absent. In some animals with little pigment, much white skin, or a blue merle color pattern, portions of the tapetum nigrum and/or lucidum can be absent and hence the vessels of the choroid are visible. These vessels should radiate more or less regularly to and from the papilla. Because of the very great variation in the appearance of the fundus between and within animal species, inexperienced examiners find the fundus difficult to evaluate and can usually only confirm gross abnormalities. When there is doubt it is better to refer the patient to someone who has specific expertise in this subject.

Examination of vision

The examination of the vision of animals is difficult and not very reliable. The owner's mention in the history that the patient bumps into objects in the light and/or in the dark is usually reliable information. If vision is to be evaluated, it must in any case be done before the size of the pupil is influenced (e.g., it can be done directly after the pupillary reflex has been tested), but it can also be done after mydriasis has been induced (e.g., in patients with central clouding of the cornea, anterior chamber, lens, or vitreous).

Vision is tested in full light and in a shaded area, allowing the use of both eyes and with one eye shielded. It is preferable for the animal to be able to walk freely during this examination.

Obstacle test

In a room or hallway with a few obstacles, such as a horizontal pole at some distance from the ground, white paper, a ladder, etc., the animal is released and then called by the owner. Preferably the animal should

be called toward the exit. One observes the behavior of the animal. Careful walking, holding the head low, sniffing excessively, being easily startled, lifting the feet too high like a rooster, bumping into the objects, etc. all indicate visual disturbance or blindness. In case of doubt the test can be repeated after the obstacles have been moved or taken away.

Optical placing reaction

Small animals can be picked up in such a way that the front legs can be moved freely. When the animal is brought near a table, it should place its feet upon the table (optical placing reaction). If it does not do so until the feet have contacted the edge of the table, its vision is poor (but it has a good tactile placing reaction) (also see § 18.2.5).

Falling object test

Let an object such as a small fluff of cotton fall in front of the animal. This should not cause any perceptible movement of the air. If the animal follows the object with one or both eyes, the vision of the eye(s) is presumably normal. Failure of the eyes to follow the falling object is an indication, but not a confirmation, of poor vision.

Falling off test

The vision of pups, kittens, or cats can be tested by placing the patient on a table without restraining it. Cushions are placed on the floor surrounding the table. If the patient walks around and falls right off the table, one may conclude that the vision is poor or absent. If the patient will hardly move or not move at all, the test is inconclusive.

Menace reaction

The menace reaction can be provoked by waving an extended finger in the direction of the eye. This test is not very reliable. The tactile hairs around the eye and the cornea itself are extremely sensitive to air movements, which are very quickly produced by the moving hand, thus stimulating the eyelid reflex (see § 19.4.5 and § 18.2.4). The complete absence of a response is an indication for a vision problem, but no more than that, for some animals react very phlegmatically and some are frozen by fear in a foreign environment or in the presence of a veterinarian.

Ophthalmoscopy

Ophthalmoscopy is performed by use of a light beam and a system of lenses. It can be direct or indirect. Because the nonspecialized veterinarian usually only has access to a direct ophthalmoscope, only this system will be described here. With the ophthalmoscope, a fundus area of only about 10 mm diameter can be examined. It is possible to examine the eye during miosis, but the examination is much more difficult than in mydriasis and so a short-acting mydriatic is applied about 15–20 min before the examination (see § 19.3)[3]. In very young animals mydriasis is produced by applying 1% atropine, ½–3 hours before the examination.

Ophthalmoscopy should always be performed in a darkened room. If possible, the patient should be positioned so that it looks directly at the examiner. Dogs and cats should preferably be held in a sphinx position, or alternatively in standing position. The animal is then restrained in such a way that the head and neck are at an angle of about 90°.

Ophthalmoscope

Begin direct ophthalmoscopy with a lens of −1, corrected if necessary for the examiner's eye.

The ophthalmoscopic examination

The light beam of the ophthalmoscope is placed in the visual axis of the patient (Fig. 19.31). The ophthalmoscope is then brought to about 5 cm from the eye. Then the examiner's eye is brought to about 1 cm from the opening in the ophthalmoscope. Use the right eye to examine the patient's right eye and the left eye for the patient's left eye. Using the opposite eye has the disadvantage of bringing the examiner 'nose to nose' with the patient, with the risk of the patient sneezing in your eye or biting your nose. If one begins carefully to examine in the visual axis, one usually directly obtains a view of the central area or the papilla. Only after inspection of this area is the periphery inspected, by slight turning of the ophthalmoscope.

Inspection

Papilla. The color, shape, outline, and elevation of the papilla are noted; a small central depression is normal. A healthy color is pinkish white. The outline should be sharp. The shape varies from round to slightly triangular or oval, depending on the species and the degree of myelination.

Vessels. If the retinal vessels are present, attention is given to their thickness, the regularity of the vessel wall, and the filling, the degree of tortuosity and color. The complete absence of vessels in the normal location is either congenital, acquired complete atrophy or due to complete detachment of the choroid, the retina being suspended in the vitreous. Very thin vessels in the normal location can be an indication of degeneration.

Tapetum lucidum. A normal tapetum lucidum, with a normal retina overlying it, makes a moderately reflective, glossy, very finely granular and nicely colored picture. If there has been retinal degeneration, less light is absorbed through the retina, so that the

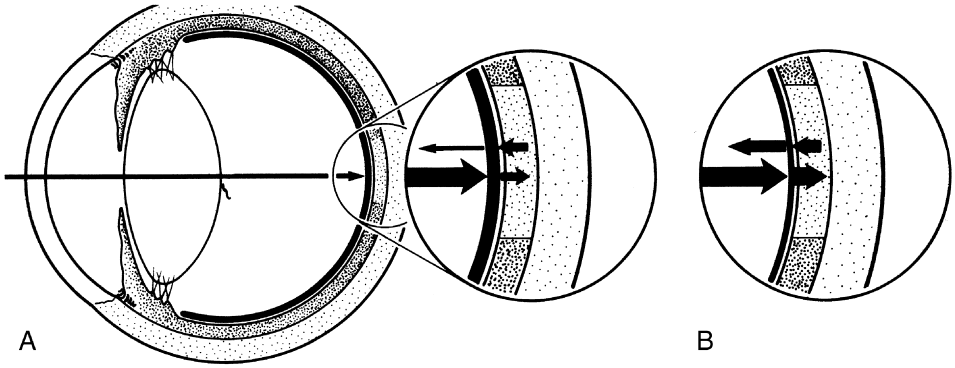


Fig. 19.31 The path of the light during ophthalmoscopic examination of the eye, in the visual axis. In circle A the light passes through a normal functioning retina (black); the entering light is partly absorbed by photoreceptors of the retina. The rest is reflected through the tapetum lucidum. Circle B: when there is loss of function of the photoreceptors (e.g., degeneration), very little light is absorbed; almost all light is now passing through and is being reflected by the tapetum lucidum (hyperreflection).

affected area is strongly illuminated, as though a lamp were shining from behind it (hyperreflection). The examination should also detect any hemorrhages, exudates, accumulation of pigment or neoplasia.

Tapetum nigrum. Abnormalities in this very strongly pigmented area are very difficult for an inexperienced examiner to recognize.

19.5 Notation

The DVD contains a form for systematic recording of the findings of the history and examination. Several of the abnormalities can be drawn in.

19.6 Further examination

Ultrasonography is very useful for further examination of the contents of the globe and the orbit.[23] In companion animals an ultrasonographic probe of 7.5–15 MHz is needed. Ultrasonographic guidance facilitates accurate fine-needle aspiration biopsy of orbital processes.

Radiographic examination is carried out for the detection of radiopaque foreign bodies and changes in bony structures. Both the making and the interpretation of radiographs in this area require considerable experience.[24,25]

The contents of the globe, the adnexa, and the skull can be examined by computerized tomography (CT) and magnetic resonance imaging (MRI).[26] In recent years there has been increasing use of microbiological culture techniques and the polymerase chain reaction (PCR) for identification of pathogenic organisms. Cytological examination of fine-needle aspiration biopsies is also used more often. Blood examination can sometimes be helpful in characterizing inflammatory processes.

The most important ophthalmologic techniques for further examination are:

- impression smear (Cytobrush) or biopsy[2,27,28]
- alcian blue staining[14]
- tonometry/tonography[16]
- binocular slit lamp biomicroscopy[17]
- aspiration from the anterior chamber and other diagnostic aspirations[21]
- endothelial microscopy (specular microscopy)
- gonioscopy (chamber angle inspection)[21]
- indirect ophthalmoscopy[29]
- fundus contact lens examination
- electroretinography (ERG; examination of the retinal activity)
- visual evoked potentials (VEP; examination of brain activity, stimulated by light)
- fluorescence angiography[30,31]

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20 Ears

A.J. Venker-van Haagen

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The examination of the ear consists of examining the pinna, the ear canal, the tympanic membrane, the middle ear, and the inner ear or labyrinth. Whether there is a problem with one or both ears, the history usually localizes it directly. Sometimes abnormalities of the ears are part of a generalized disorder, such as a skin disease, or are the cause of generalized symptoms. Pruritus, pain, changes in the shape of the ears, and increased secretion and odor are usually clearly described by the owner.

Both ears should always be examined, even if the history seems to indicate a unilateral problem, because a severe disorder in one ear can disguise a less severe but still important disorder in the other ear. Whenever possible, the examination is begun on the side of the 'good' ear, in order to avoid carrying contamination from the 'bad' ear over to the 'good' ear.

In disorders of the labyrinth the resulting vestibular dysfunction is so striking that coexisting deafness or reduced hearing are seldom mentioned in the history. Poor hearing or deafness are usually only noticed if the hearing of both ears is disturbed.

20.1 History

If the general history and/or general impression indicate an ear problem, questions are directed to the past history. We ask whether there have been similar problems in the past, in the same ear, in the opposite ear, or in both ears. Have the problems developed suddenly (a foreign body in the ear canal can cause intense itching), or are they gradually worsening, or are they recurring? What has the owner already done to try to relieve the problem? In cases of chronic recurrent otitis externa, the latter question is aimed specifically at discovering whether the owner has cleaned the ears frequently. This method of 'treatment' can make the otitis externa persist and even become more severe. If a parasitic disease is suspected, questions should be asked about contacts with other animals, of the same species as well as other species.

20.1.1 Symptoms

Owners are often first confronted with the presence of an ear problem in the animal because of the symptoms of pruritus and pain: rubbing the ear, scratching at it, shaking the head. The head may be held in a different position, usually with the problem side turned downward. The pinna can also have a different *position* than is characteristic for the breed and although this can simply be due to a structural defect in this individual, it can also be an artifact (ear trimming)* or be due to an inflammation or tumor of the pinna, or filling with blood (othematoma) or pus.

The hair covering the pinna on the convex side is a continuation of the coat on the head, sometimes with an increase in the length of the hairs on the edge of the pinna. The concave side is thinly haired. Long hairs can be matted by food, blood, or exudate.

* prohibited by law in several countries

Skin changes are often caused by self-mutilation (scratching, rubbing) and especially in the acute phase they are characterized by interruptions of the epithelium. Chronic skin changes are usually located on the concave side of the pinna and can be in the form of scaling, hyperpigmentation, and proliferation, the latter particularly at the base of the ear.

Thickening of the pinna can result from chronic changes, but can also develop very acutely as a result of hemorrhage (othematoma), in which case the owner may have noted the fluctuating character of the thickening.

The *temperature* of the pinna varies with the circulation of blood, which can be increased in inflammation. Sometimes the owner reports that the pinnas feel warm.

Cerumen is secreted at the base of the pinna and in the ear canal. Cerumen is a product of sebaceous and ceruminous glands, yellow-brown and waxy. The odor can be described as slightly aromatic. Normally a small amount of cerumen is seen in the ear canal as well as at the base of the pinna on the concave side. If the skin becomes inflamed, the production of cerumen can increase and its composition can change. As a result of an increase and a change in the bacterial flora, the appearance and the odor of the cerumen can change. In severe inflammation, pus and blood can be mixed with it. Many owners can describe the odor as well as the appearance of the cerumen.

20.2 Examination of the ear

When indicated—for example, by signs of a disturbance of equilibrium—the examination is not limited to examination of the ear, but is extended to include a general examination and/or a neurological examination.

20.2.1 External ear

The shape of the external ear is determined by the cartilaginous structures and to a small extent by bone. The pinna, the vertical part of the ear canal, and half of the horizontal ear canal are formed by the auricular cartilage. The second part of the horizontal ear canal is formed by the annular cartilage and the bony external acoustic meatus, which is part of the temporal bone of the skull. The attachment between the two cartilages and also between the cartilage and bone is formed by connective tissue. This structure of the external ear allows it to move freely in relation to the skull. The directions of the movements are determined by the actions of muscles attached to the cartilaginous structures. The innervation of the muscles is provided by the facial nerve (VII) and the trigeminal nerve (V). Under normal conditions a lively asymmetrical activity of the ears is observed. The function of this movement is to obtain optimal reception of sound, but ear movements also have a function in facial expression and, to a small extent, in defense. It is also thought that the movements of the jaws during eating have a function in the transport of cerumen.

The pinna and the inner side of the external ear canal are covered by skin. On the convex side of the pinna the hair is dense and full, on the concave side it is thin. The ear canal in most animals has little or no hair, but in poodles, schnauzers, and rough-coated terriers, the entrance to the ear canal in particular can be quite heavily haired, which can lead to chronic ear problems. The vascular supply to the pinna can easily be seen on the convex side. The concave side is mainly supplied by vessels that penetrate through the cartilage.

Pinna

The pinnas are inspected for symmetry (although especially in dogs asymmetry can be normal) and for uniformity and any abnormalities of the skin and hair covering.

The pinnas are palpated to discover temperature differences and structural changes. Temperature differences can occur as a result of reduced circulation (cool in shock, cold if necrotic) or inflammation (warmer). When the pinna is thickened by an othematoma its temperature is normal but when there is an accumulation of pus (cat, after fighting), the pinna is warmer than normal. Structural changes can be due to tumors, but more often they are due to ossification of the cartilages after trauma.

Ear canal

Inspection of the entrance of the ear canal provides important findings if there are indications of inflammation of the ear canal. First, the width of the entrance is examined, for normally it should be possible to look into the first part of the vertical part of the ear canal. A small amount of hair can obstruct the view without being considered abnormal. The entrance can be narrowed by swelling of the skin or proliferation of the skin. Excessive hair can occlude the entrance. In severe infections, erosions can also be seen in the epithelium of the ear canal. Excessive production of cerumen can be visible in the entrance. Pathological secretions, such as an excessively sebaceous cerumen, or cerumen mixed with pus or blood, can already be visible here. In cases in which excessive abnormal secretion is already visible at the entrance, an abnormal and excessively strong odor will also be noted.

The vertical part of the ear canal can be examined by *palpation*. It should be possible to palpate this simple funnel-shaped part of the ear canal without causing pain. It should therefore be possible to slightly compress the cartilaginous structure. During this examination and passive movement of this part of the ear canal, there should be no sensation of fluid movements, which can indicate an excessive amount of fluid secretion. The

compressibility can be reduced by proliferation in the ear canal and by ossification of the cartilage. When there is severe proliferation in the canal, the circumference is also increased.

Inspection of the further course of the ear canal is only possible with the help of special illumination techniques and special instruments. An otoscope is used for this purpose in dogs and cats. This instrument consists of an ear speculum with exchangeable cones, a small light source, and a magnifying lens (also see § 4.1.1). The otoscope provides good illumination, especially by use of fiberglass bundles. The same otoscope can be used to examine the ear canal and the tympanic membrane in a small cat as well as in a very large dog, by means of various sizes of cones.

The technique of otoscopic examination is the same in the dog and cat. The animal is held in a sitting position or resting on its elbows and sternum on the examination table and fixed in position by an expert assistant (also see § 24.1.3). The animal's head is held looking straight ahead. If possible, the mouth should not be tightly closed with a cloth band or muzzle (§ 24.1.3) during this examination, particularly with something tied behind the ears, for this usually presses the ear canal shut or fixes it tightly against the head.

When the animal is held securely, either sitting or lying on its sternum, the left hand (if the examiner is right-handed) is used to grasp the pinna securely and pull it firmly out laterally and ventrally. The effect of this is that the vertical and horizontal parts of the ear canal together form a straight horizontal tunnel. Now the otoscope, held in the right hand, is inserted carefully into the ear canal. The entire canal and the tympanic membrane can be seen by keeping the ear canal stretched and slowly moving it, dorsally, rostrally, ventrally, and caudally, while looking, following with the otoscope (Fig. 20.1).

Sometimes the examination of the ear canal is hindered by excessive hair in the entrance. The hair can be plucked out with the help of a round-topped Péan forceps. With a short jerk bunches of hair can be plucked out. This is not noticeably painful for the animal and scarcely results in hyperemia of the skin of the ear canal. The examination can also be hindered by excessive secretion or by excessive scaling. In this case the ear canal must be flushed before good otoscopic examination can be carried out. If microscopic examination for parasites or bacteriologic examination of secretion is indicated, material for this purpose must be collected before the flushing.

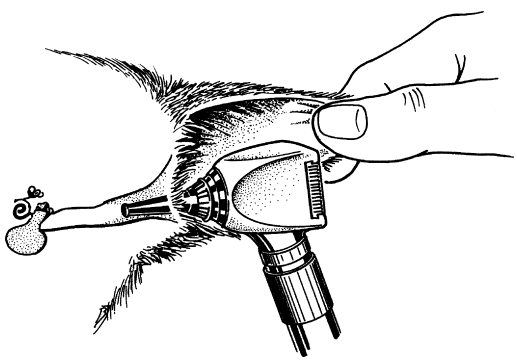


Fig. 20.1 Use of an otoscope in the cat.

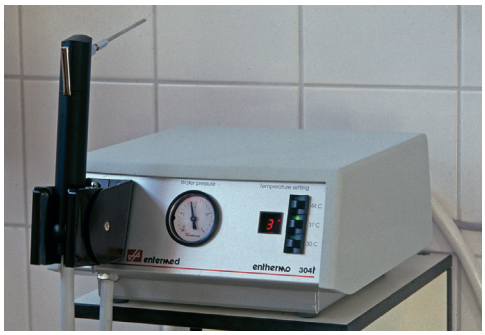


Fig. 20.2 Ear flushing apparatus with handgrip and cannula.

Water or 0.9% NaCl solution can be used to flush the ear. The fluid must have a temperature of 35–39°C in order to prevent dizziness and even a shock reaction. The stream of water must be thin and strong in order to wash out the long and narrow ear canal. An apparatus developed for ear flushing in man is excellent for this.

The apparatus is connected to the water supply pipe. The water is heated to 37°C and the pressure is indicated by the meter (Fig. 20.2). The blunt cannula is easily exchanged and can be sterilized. A stream of water is sprayed into the ear canal through the cannula, with a force that is regulated by an easily-controlled lever on the handle. Every ear can be flushed in this manner, even if it is not known whether the tympanic membrane is intact, with one exception: if after a recent trauma there is blood present in the ear canal (skull trauma, risk of meningitis!) the ear may *not* be flushed.

After the flushing, the ear canal is dried. This is accomplished most effectively by letting the animal shake its head. Then the otoscopic examination continues.

The ear canal can be too narrow because of inflammation (swelling or proliferation) of the lining skin. Epithelial lesions may be seen and tumors can also occur. Foreign bodies and bunches of hair (usually loose and coming from outside the ear canal) must not escape attention.

20.2.2 Tympanic membrane

If the ear canal is wide enough, the tympanic membrane can be inspected. The tympanic membrane is a light transparent membrane. It is round, but it appears oval

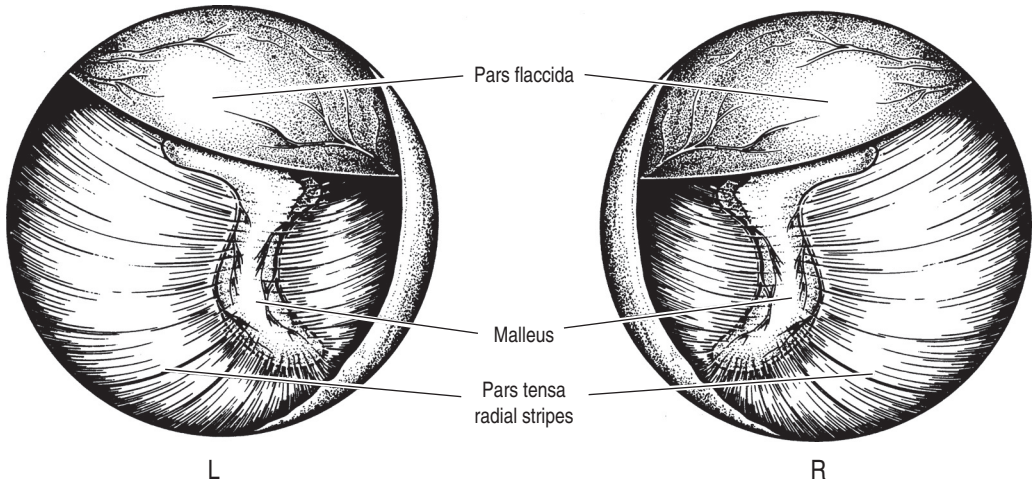


Fig. 20.3 Drawing of the right and left tympanic membranes with names of anatomical structures.

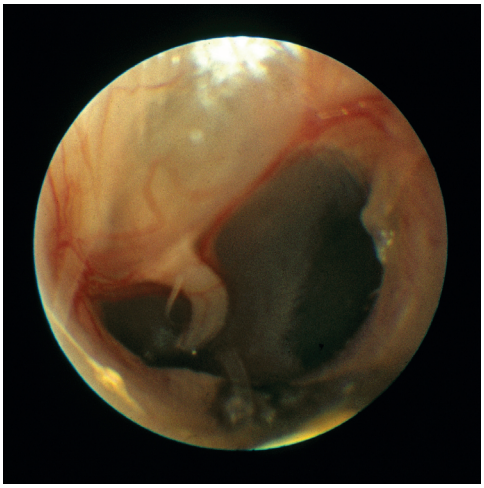


Fig. 20.4 Otoscopic view of the left tympanic membrane of a dog. The handle of the malleus (manubrium mallei) is largely embedded in the tympanic membrane and is visible as a curved white structure.

because it is not situated perpendicular to the long axis of the ear canal, but lies further inside ventrally and rostrally than it does dorsally and caudally. The tightly stretched part, the pars tensa, has a grayish-blue color, within which the handle of the malleus (manubrium mallei) is outlined in white. Dorsally lies the pars flaccida, which is pinkish-red and elastic. Along the manubrium mallei there are small vessels and the structure of the pars tensa has radial stripes. The manubrium mallei is slightly bent and the ventral end points rostrally (Figs 20.3 and 20.4).

Color changes can occur in the course of otitis externa or an inflammation of the middle ear. In chronic otitis externa the tympanic membrane can become white or less transparent. The tympanic membrane can in this case be markedly thickened. If there is a middle ear inflammation the tympanic membrane is red and the other structures are seen less clearly. In the cat a polyp can push from the middle ear against the tympanic membrane, causing it to bulge outward. Eventually the polyp can grow through the tympanic membrane into the external ear canal.

Excessive pressure in the middle ear causes the pars flaccida to bulge outward, giving it the appearance of a 'pink blister' in front of the tympanic membrane. A perforation of the tympanic membrane is usually seen as a dark area. If the tympanic membrane is severely torn, it is possible to see into the middle ear.

20.2.3 Middle ear

The middle ear can be inspected only if the tympanic membrane is destroyed. Healthy mucosa in the middle ear is whitish-yellow. If there is inflammation, the color is red. For further examination of the structures of the ear within the skull, diagnostic imaging is necessary.

20.2.4 Hearing

Examination of hearing is usually not carried further than observing the animal while a whistle is blown, hands are clapped, or a door is slammed shut. These sounds must be produced without the animal being able to see the motions. If the dog or cat does not respond to any of these stimuli, then severe bilateral hearing loss is very likely. Hearing in each ear can be examined separately by means of brainstem evoked response audiometry (BERA).[4] This electrophysiological technique involves recording the brainstem response to stimulation of the ear with tone bursts at several frequencies.

20.3 Notation

A form for recording the observations is shown on the DVD.

20.4 Further examination

The possibilities include:
- examination for parasites
- bacteriological examination
- inspection under anesthesia
- diagnostic imaging (radiography, CT, MRI)
- brainstem evoked response audiometry (BERA)

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21 Endocrine glands

A. Rijnberk and H.S. Kooistra

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The endocrine glands are involved in regulating the function of almost all organ systems. Hence functional disturbances of endocrine glands often have consequences for more than one organ system and thus for the functioning of the animal as a whole.

Because only the enlarged thyroid gland and the testes are accessible for physical examination, the examination of the endocrine glands rests mainly upon signs of functional disturbances of other organ systems. The history and physical examination are used to obtain a picture of the full development of the patient, with special attention to the period in which the iatrotropic problem developed. In addition, several aspects of the organ systems are pursued systematically.

Many relevant findings may already have been obtained in the history, general impression, and general examination. This chapter is mainly intended as a further focusing of the examination in cases in which the problem formulation points in the direction of an endocrine disorder. Overlapping with other chapters is thus unavoidable. Many examples are used to illustrate the descriptions of signs and abnormalities.

Objective information should if possible be collected with the help of measurements based on an interval scale. These data will become even more valuable as measurements, such as body weight, are made during follow-up. Previous photographs can be of great help in obtaining insight into the nature and the rapidity of changes in the patient's appearance.

In this way the history and physical examination often reveal a pattern that makes it possible to recognize an endocrine disorder. In many cases the diagnosis of an endocrine disorder depends on recognition of a pattern. In other cases a diagnosis is only obtained by a thorough analysis of one or more of the formulated problems, such as was presented systematically in Chapter 3. Hence the results of the examination described below can lead to the formulation of a problem representing a disease (e.g., the clinical picture of hyperthyroidism), or it can lead to a problem formulation that goes no further than a clinical sign (e.g., polyuria).

21.1 History

Disorders of endocrine organs often lead to disturbances of other organ systems and the signs arising from these disturbances form the iatrotropic problems. Some of these, such as polydipsia and polyuria, are often the reason that the animal is brought to the veterinarian. The following discussion of signs does not, however, proceed in the order of their frequency of occurrence. First an attempt is made to give a general picture of the patient and this is followed by a few specific questions about the functioning of the organ systems.

Appearance

Both weight loss and obesity are usually mentioned spontaneously by the owner. Other changes in appearance, such as increased abdominal size or a change in the appearance of the face, are often mentioned only in response to specific questioning. However, the owner's impression of such changes may be equivocal. Old photographs sometimes resolve the uncertainty.

Behavior

Apathy and lethargy are two of the classical signs of hypofunction of the thyroid. The picture can be characterized as sleepiness and little or no interest in playing or going for a walk. This is often associated with signs that the animal feels cold, such as a preference for lying in warm places. Apathy and lethargy are also part of the general illness in hypoadrenocorticism. In contrast, in hyperfunction of some endocrine glands, such as hyperthyroidism and hyperadrenocorticism, a preference for cool places is evident. The excessive production of heat can even result in excessive panting. Especially in cats, hyperthyroidism can result in a somewhat tense, restless behavior.

Endurance

Endocrine disorders with a catabolic character (hyperthyroidism and hypercortisolism) lead quite soon to reduced muscle strength. This affects both the muscles of locomotion and those of respiration, and therefore the animals are quickly tired. There remains an interest in going out for a walk, but the walk becomes progressively shorter. In hyperadrenocorticism obesity plays a part in this and an enlarged and full abdomen can also interfere with the proper functioning of the diaphragm. The impression that the animal becomes tired quickly may be increased by the previously mentioned thermal polypnea.

Appetite

The appetite can increase via a direct influence of the excessive secretion of thyroid or adrenocortical hormone on hypothalamic regulatory centers and as compensation for energy loss via glucosuria. Affected animals can exhibit a very pronounced hungry behavior. Picky eaters can change into animals that devour everything, including such things as potato peelings and refuse along the street. At the least suggestion or signal that there is something to eat, they suddenly appear. Especially in those cases in which there is weight loss in spite of a good or even increased appetite, it is important to obtain an exact history of feeding and food intake, to determine the energy intake.

Some endocrine disorders can have the opposite effect, resulting in a poor appetite, signs of nausea, and even vomiting. This is usually part of a general illness and malaise, occurring in hypoadrenocorticism and ketoacidosis resulting from diabetes mellitus.

Water intake

Especially in the dog, many endocrine diseases are associated with reduced concentration of the urine and consequently with increased water intake. The polyuria and polydipsia are readily noticed by the owner, especially if they begin to interfere with the owner's life, such as having to get up a few times every night to let the dog out. The dog may also begin urinating in the house. The amount (in liters) that the dog drinks is often overestimated by the owner. It may also be found that the dog does not really have polydipsia but drinks more because the owner has changed its food from a moist to a dry type. In such cases, further questioning will reveal that water intake has increased but the amount of urine has not. Slight degrees of polyuria can be detected by asking the owner whether the dog has a greater urgency to urinate when first let out in the morning and whether it then urinates more than previously.

The severity of the polydipsia and the polyuria often remains uncertain when evaluated in this manner. Asking the owner for the animal's water intake in liters usually brings matters no further, unless the owner has already been requested to measure and record water intake for a few days. More definitive evidence is only obtained when the specific gravity of the urine is measured. However, water intake may vary considerably during the day. When it is not immediately clear that the polyuria is related to a specific disorder, such as hypercortisolism, the owner should be instructed to collect urine samples at 2-h intervals for 24 h. If these reveal a marked variation in urine osmolality (or specific gravity) during the day, it is more likely to be due to a marked variation in water intake (e.g., primary polydipsia) than to a hormonally-induced reduction in renal concentrating ability.[1]

Reproductive functions

Either hormone excess, as in hyperadrenocorticism, or deficiency, as in hypothyroidism, can directly or

indirectly influence gonadal functions. If the disorder has existed long enough, the owner of a bitch will have noted that the animal has failed to come into estrus. One is deprived of this evidence in spayed bitches and in those in which estrus is prevented with progestagens. In male animals it is even more difficult, for although a diminished interest in the opposite sex can be expected, it is seldom apparent in the history. This may be partly related to the fact that many male animals have only limited contact with females in estrus or proestrus.

Coat and skin

Endocrine diseases such as hyperadrenocorticism, hypothyroidism, hyperestrogenism (primarily in male dogs with testicular tumors), and growth hormone deficiency eventually result in atrophy of the skin and adnexa. This is manifested in the first place as a slightly dull, dry coat. Sometimes the only change noticed initially by the owner is that the animal sheds less hair or no longer sheds at all. The coat is eventually found to be less full, which the owner notices because the plume of the tail disappears or the hair covering on the caudal surfaces of the thighs becomes thinner. Later the coat may become so thin that the skin is visible and bald areas develop. This alopecia usually occurs first on places where friction causes loss of the loose hairs in the atrophic follicles, such as under the collar, on the caudal aspects of the ischium (upon which the dog sits), in the axillae and flanks, and on the lateral surfaces of the trunk (if the animal often lies on its side).

Locomotion

As already mentioned under Endurance, endocrine disorders of a catabolic nature can lead to reduced muscle strength. This can result in muscle weakness with cervical ventroflexion (such as in feline hyperaldosteronism) or a slight tendency to sag down in the joints of the extremities, but a stiff gait can also occur (such as in hypothyroidism). In disorders associated with hypocalcemia, tetanic muscle cramps can occur. Particularly in cats, diabetic neuropathy may result in a plantigrade posture with the hocks touching the floor during walking. Hypoglycemia is also sometimes manifested by muscle weakness and an uncertain gait, at moments such as following a long period without food (during a morning walk before eating).

Nervous system and vision

The metabolic effects with continuing consequences for the central nervous system were discussed above under the topic of Behavior. Apart from these continuously present signs, endocrine disorders associated with electrolyte disturbances or hypoglycemia can lead to the episodic occurrence of fainting spells with the character of epilepsy.

The apathy already mentioned under the topic of Behavior can also be the result of a large pituitary tumor. This can eventually cause pressure on the optic chiasm and thus lead to disturbed vision. A visual disturbance can also occur rather suddenly as a result of clouding of the lens (cataract) due to the hyperglycemia of diabetes mellitus. This can already have been noted by the owner.

21.1.1 Living conditions

Since the background of this examination is a suspicion of an endocrine/metabolic disorder, it will sometimes be necessary to consider the information obtained in the general history (Chapter 6) in more detail with regard to feeding, food intake, etc.

21.1.2 Past history

Many medications in use in veterinary medicine contain hormones, which can cause a variety of metabolic effects. In addition, their administration has consequences for the functioning of endocrine glands.

The family history is of particular importance if the problem has appeared at a young age, but a few endocrine diseases occurring in adult animals have also been found to be familial.

21.2 Physical examination

Just as in obtaining the history, an attempt is made in the physical examination to first obtain a general picture of the patient. This can be achieved with the general impression, as described in Chapter 7. Then follows the examination of a few relevant parts of organ systems. Some results can be taken from those of the general examination (Chapter 8), if this has already taken place. Finally, the endocrine glands themselves are examined in so far as they are accessible for physical examination.

21.2.1 Respiratory movements

Animals with a large production of heat can have thermal polypnea. They pant repeatedly at room temperature, even when at rest. Respiratory compensation for ketoacidosis in diabetes may lead to deep respiratory movements.

21.2.2 Pulse and ictus cordis

In endocrine disorders both bradycardia (in hypothyroidism and with hyperkalemia in hypoadrenocorticism) and tachycardia (in hyperthyroidism) are encountered. In addition, a small circulating volume in

hypoadrenocorticism and a small stroke volume in hypothyroidism can lead to a weak pulse and a weak or even completely undetectable ictus cordis. In interpreting these findings one must certainly take into account the nutritional condition of the animal.

Although this screening examination is mainly intended to obtain information that can lead to pattern recognition, the findings sometimes also provide a reason for a complete examination of the circulatory system (Chapter 10).

21.2.3 Rectal temperature

Animals with hypermetabolism (hyperthyroidism, hyperadrenocorticism) tend to be hyperthermic while those with hypometabolism (hypothyroidism) tend to be hypothermic. Very ill animals, whether comatose or not, can also have a very low body temperature. As was noted in § 8.3.3, excitement and exertion preceding the measurement must be taken into consideration in the interpretation.

21.2.4 Coat and skin

In the examination of the coat and skin, the changes described by the owner should be considered objectively. Attention is given to the gloss, color, continuity, and density of the coat. Areas of alopecia and of very thin covering with hair are sketched in on the figures on the report form.

The bald areas are usually pigmented and sometimes have a slightly rough surface. The pigmentation causes diffuse darkening of the skin. This should not be confused with the sometimes grayish or soiled appearance of the skin that, upon closer examination, is found to be due to the filling of hair follicles with keratin plugs (Fig. 21.1).

The skin atrophy in hyperadrenocorticism mainly involves the dermis, with the result that the skin is thin and easily wrinkled. This can be noticed when determining the thickness, flexibility, and turgor of the skin. The thin wrinkles can be demonstrated by placing two fingers or two hands slightly apart on the side of the trunk or the thigh and then bringing them together. The elasticity of the skin is also reduced, so that when a fold of skin is lifted and released it stretches out slowly (>1 s).



Fig. 21.1 Abdominal skin of a 9-year-old male mixed-breed dog with hyperadrenocorticism. There are still a few hairs, but most hair follicles contain only plugs of amorphous keratin.



Fig. 21.2 A 5-year-old male mixed-breed dog with hypothyroidism. The dog makes a very calm impression. There are thick folds of skin over the shoulders. The thyroxine deficiency has led to cessation of the physiological shedding of hair. There is no definite alopecia but there appears to be less hair in the groin.

In acromegaly the excess of growth hormone leads to the formation of thick skin folds on the head and neck, but this is accompanied by excessive growth of hair rather than thinning of the coat. In hypothyroidism the skin atrophy is accompanied by accumulation of mucopolysaccharides in the dermis. This results in the combination of a dull, thin coat and skin that forms thick folds (Fig. 21.2), to which the associated growth hormone excess appears to contribute.[2] The anal sacs must certainly be included in the examination of the skin and adnexa, as described in § 11.2.4. An apocrine gland tumor of the anal sacs can lead to a paraneoplastic syndrome.

21.2.5 Abdomen

The abdomen is examined with regard to its form and contents, regardless of whether or not the owner has reported that there has been a change in its size. Superficial palpation (§ 11.2.3) is performed to determine whether the abdomen is well suspended; the ventral line of the abdomen should pass fairly straight from the sternum to the os pubis. In addition to sagging as a result of weakening of the muscles, there can be a rounded increase in circumference with a tense abdominal wall due to abdominal and retroperitoneal accumulation of fat. Both forms occur as manifestations of the centripetal accumulation of fat, such as occurs in hyperadrenocorticism. The circumference is measured in centimeters at its maximum. It should be noted that in dogs with obesity not related to hyperadrenocorticism most of the fat is

not accumulated in the abdomen but spread over the entire trunk, sometimes with very clearly circumscribed accumulations bilaterally in the lumbar area.

The abdomen is palpated to detect any resistance, with special attention to possible enlargement of the liver. If the liver is palpable, its extension caudal to the costal arch is noted in centimeters. This is easily determined if the abdominal wall is not tense.

21.2.6 Male genitalia

The genitalia are examined for evidence of hypogonadism or a testicular tumor and in particular a Sertoli cell tumor that has endocrine activity. Especially when hypogonadism is the result of castration at an early age, the androgen deficiency can result in hypogenitalism (small prepuce and small penis). These changes will be much less evident if the hypogonadism developed at a later age. Secondary hypogonadism in old age is manifested by testicular atrophy. The testes are soft and small, while the epididymis retains an essentially normal configuration. The volume of the testis can be estimated with the aid of a string of ovoid beads made for this purpose. These are of increasing size and each is imprinted with its volume (Fig. 4.5).

Absence of testicles in the scrotum can be the result of castration (which might be unknown to the present owner), or incomplete testicular descent. Undescended testicles may be in the abdomen or in the inguinal canal. Incomplete testicular descent is an important risk factor for the development of testicular tumors.[3]

Testicular tumors are described according to the characteristics given in § 4.1.2. The endocrine-active testicular tumors mainly produce an excess of estrogens and thus lead to signs of feminization, including gynecomastia and a slightly enlarged and sagging prepuce (Fig. 21.3).

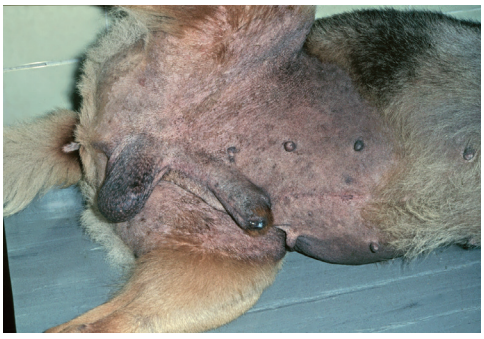


Fig. 21.3 An 8-year-old male German shepherd dog in lateral recumbency. A Sertoli cell tumor in a scrotal testicle is the cause of the hair loss, enlarged nipples, and slightly enlarged prepuce.

21.2.7 Female genitalia

The examination of the female genitalia is limited here to an inspection of the vulva and the caudal part of the vestibule. The vulva is evaluated with regard to form and size, as described in § 13.2.1. By spreading the lips of the vulva, a view can be obtained of the clitoral fold and the body of the clitoris, which can give an indication of exposure to androgen excess.

21.2.8 Skeleton and muscles

Further consideration of the skeleton is chiefly of importance in retarded growth. Disproportionate retardation of the growth in length of the limbs can be a key to the diagnosis. Excessive secretion of growth hormone in adult life causes no growth in length of the limbs, because the growth plates are closed. There is still outgrowth of some endpoints of the body, chiefly of the flat bones. This is clearly seen in the outgrowth of the upper and lower jaws (prognathy), by which the incisor teeth come to be separated from each other.

Endocrine diseases with catabolic effects (hyperthyroidism, hyperadrenocorticism) lead to muscle atrophy, often more clearly seen in the spinal muscles and the thigh muscles. Atrophy of the temporal musculature is sometimes obvious because the occipital protuberance becomes more prominent. Atrophy of the shoulder muscles can result in the front limbs being less closely attached to the trunk. The trunk appears to hang in the shoulder girdle, causing the elbows to be turned slightly outward.

21.2.9 Thyroid glands and parathyroid glands

Apart from the testes, the thyroid glands are the only endocrine glands that may be accessible for physical examination. They lie on either sides of the trachea at the level of the first three to eight tracheal rings. Because of their deep position they are not palpable when of normal size. When enlarged they are usually palpable but because of their loose attachment they are free to gravitate along the trachea. When a mass is detected in this area, the next step is to determine whether it is easily displaced along the trachea, a characteristic of masses arising from thyroid tissue. Then it should be described as discussed in § 4.1.2.

For palpation of the thyroids, the owner is asked to hold the animal's neck slightly extended with the head slightly elevated. The examiner places one hand around the larynx and moves it caudally over the transition from larynx to trachea and then along the trachea down to the thoracic inlet, to determine whether a mass can be detected. In cats thyroid enlargement is

often slight but may be detected by carefully sliding the fingertips alternately along each side of the trachea.

The parathyroid glands are not palpable in healthy animals and even though it is also usually not possible to detect enlarged parathyroids by palpation, when hyperparathyroidism is suspected the neck should be carefully palpated as described above for the thyroid glands.

21.3 Notation

The findings of the history and physical examination are reported on the form on the DVD. The general findings of the physical examination are recorded together with the previously determined general impression (Chapter 7). A summary of the general impression is adequate.

In patients in which a general examination (Chapter 8) has been carried out, the findings can be entered for respiration, pulse, and rectal temperature. These are aspects of the examination that will certainly be included for a new patient but at a follow-up examination can sometimes be omitted.

21.4 Further examination

The diagnosis of an endocrine disorder very often rests upon pattern recognition and the pattern can sometimes be completed by routine laboratory studies. Both hematological and biochemical findings may strengthen certain suspicions.

However strong the suspicion may be, the definitive diagnosis must always rest upon the results of specific functional studies of the gland in question. Hormone measurements, sometimes together with suppression or stimulation tests, provide information about the function of endocrine glands. It is often necessary to also know something about the morphology of the gland. The introduction of diagnostic imaging by ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI) has brought about much progress in the diagnosis of abnormalities of endocrine glands.[4] In addition, cytological examination of aspiration biopsies may provide insight into the nature of morphologic changes (see § 25.2.6).

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22 Behavior

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The management of behavioral problems requires a different approach than is appropriate for the examination for somatic abnormalities. For the latter, the examination consists of the history, general impression, and general examination. In patients presented for behavioral problems, physical examination is performed only if an indication for it is found during the consultation. If the behavioral examination is to be performed by someone who is not a veterinarian, it should be preceded by a veterinarian's attending to the general impression and general examination (Chapters 7 and 8). If these introductory examinations indicate the need for additional physical examination (e.g., the nervous system and/or the eyes), this should also be undertaken before the behavioral examination (see also § 2.5).

In order to make the behavioral treatment less dependent on the owner's perception and description, the consultation includes evaluation of a video recording of the patient. When an appointment is made for an examination concerning a behavioral problem, the owner is requested to document the problem by making a short video recording. Behavioral tests are carried out during the consultation if necessary and these together with the

video recording and the behavior of both the patient and owner during history taking provide information about the problem behavior, the communication signals between the animal and owner, and the characteristics of the bond between them.[1]

Because of the differences in the nature of dogs and cats and the differences in their behavioral problems, the two species are considered separately in this chapter.

22.1 History taking for dogs

Owners of dogs with problem behavior are often much more emotional during the consultation than they are otherwise. In some cases this may be because the problems have existed for a rather long time and the animal's behavior has been a hindering or damaging or even dangerous experience. Without cutting off manifestations of these emotions, the line of the discussion should be maintained. The development of a good discussion technique thus deserves attention. The guidelines summarized in Chapter 6 provide a good basis for this, with the following remarks.

First, questions of an accusatory nature should be avoided with even greater care in a behavioral history than otherwise. Presumably owners come to understand, whether in this discussion or otherwise, that something in the relationship between them and their dog has failed, because for this reason they are seeking help. By leading the discussion with tact one can avoid causing the owner to give answers with a more defensive than informative character.[2]

Second, it is important that when asked 'What is the problem?' the owners are given the chance to tell their story without interruption. This allows them to let off emotional steam, increasing the chance that the subsequent discussion will be informative. This can also be promoted by repeating some of the questions in an altered way to check earlier answers. The protocol for a behavioral history contains such discrete repeat questions, but suggestive questions should be avoided. When an owner describes the behavior of the dog using interpretative terms such as 'aggressive' or 'fearful', he should be asked to spell out this behavior. This allows the examiner to interpret the behavior in connection with other information obtained.

Third, both verbal and nonverbal communication are important. The table and chairs should be so arranged that everyone can look at each other and the veterinarian should assume an interested but relaxed attitude. The owner is given primary attention because it is with the owner that the animal will be discussed.[2]

Fourth, during the consultation the dog is allowed to walk about freely. This provides the examiner with an impression of its behavior (nervous, quiet, free). It stimulates interaction between owner and dog and can reveal the extent to which the dog tries to attract the owner's attention, and how the owner responds. This may reveal something about the owner's role in the development of the problem behavior.

The questions asked of the owner are divided in the usual way:

1. iatrotropic problem
2. present behavior/functioning
3. living conditions
4. past history

22.1.1 Iatrotropic problem

Questions are asked about the following:

- The nature of the problem.
- How long it has been present. The longer a behavioral problem exists, the greater the chance of learned behavior and shaping of the behavior.
- The conditions under which the problem behavior occurs. Questions must be asked especially about the first and the most recent occurrence. Knowing the conditions under which the problem first occurred may provide insight into why it occurred.[3,4] Owners presumably remember best what has occurred most recently and so it is worth asking about this also.
- Any measures, punishment or otherwise, that have been taken to curb the problem. This provides an impression of how the owner gets along with the animal and the effect of these measures. It is important to discover whether such measures, probably unintentionally and/or unconsciously, may have reinforced the problem behavior by giving attention to it.

22.1.2 Present behavior/functioning

The questions are concerned with:

- obedience
- aggression
- anxiety
- other behavior

Obedience

The owner is asked how the animal responds to commands (whether practiced daily or not), such as 'come', 'heel', 'sit', 'down', and 'stay'. Then the owner is requested to demonstrate the dog's obedience to a few commands (see § 22.2).

Aggression

Questions are aimed at obtaining insight into the type of aggression and its cause. Of importance are the way in which the dog bites or threatens, the circumstances under which this occurs, and the dog's posture. A low

posture combined with brief biting suggests *fear-induced aggression*. A high posture (see video on the DVD) during threatening and biting indicates *dominance*. Defense of food may be associated with either low or high posture. If there is *aggression against persons*—familiar or unknown to the dog, within or beyond the dog's territory, and characterized by unpredictable biting and snapping—one should ask insistently for the circumstances preceding the aggression. This can reveal an inducing factor, such as the reaching out of a hand, even though that may not induce the aggressive behavior every time it occurs.

If *pain* or another *physical factor* is thought to play a role, it must be sought by physical examination. Questions to reveal other behavioral changes are important: Does the dog play less? Does it withdraw from contact? Does it respond to signals? Does it greet the owner less now or not at all? *Pain-induced aggression* may be triggered by touching or even just approaching a sensitive body part, as can occur with external otitis, arthritis, or intervertebral disc herniation. After appropriate treatment of the disease that is the primary cause of the pain, the secondary aggression usually disappears. Administration of an analgesic may aid in the diagnosis of pain-induced aggression when physical examination reveals no explanatory abnormalities, but this is usually helpful only if the aggression occurs almost daily.

There are indications of the occurrence of genetically predisposed—thus breed-associated—aggression, which can even be coat-color-associated.[2,5] Food may also play a role, there being indications that high-protein food contributes to aggressive behavior.[6,7]

Aggression only toward strangers on the dog's own territory is probably *territorial aggression*. Tests may demonstrate the dog's way of biting adults (see § 22.2).[8,9] This may help in assessing the risk the dog poses.

Insufficient socialization may lead to *aggression against children*. Fear and pain resulting from intentional or unintentional harassment by a child may also induce aggression. 'Jealousy' may have a similar effect. If the child's parents exercise insufficient authority, the dog may take liberties that turn into aggressive behavior against children. A doll test may help to evaluate a dog's risk for children (see § 22.2).[8-10]

Aggression against dogs should be investigated to determine whether it is a very dangerous ('killer type') of aggression. With little or no noticeable preceding threat, a dog with this behavior runs immediately upon sighting an opponent, sometimes over a great distance, to attack by biting and shaking the opponent. In the less dangerous ('normal') aggression, there is threatening behavior and posture communication without immediate attack. 'Killer type' aggression resembles predation aggression, in which there is also no communication with the prey.[11] For dogs with 'killer type' aggression it is important to ask whether as a pup it was grabbed in the anxiety phase by a dog and whether it has been socialized sufficiently with dogs differing in appearance. As the result of such a traumatic experience in the anxiety phase, a dog may later attack others of the same breed, or having the same features, as the one that attacked it at a young age.[12,13] Generalization of aggressive behavior toward dogs of other breeds may occur.[14] Only occasionally does being attacked during adulthood give rise to 'killer type' aggression.

Often the owner plays a role in aggressive behavior of dogs, as the behavioral examination may reveal (see § 22.2). The owner may be unsuccessful in preventing the dog's aggressive behavior outdoors. The dog may find this stimulating, with an effect opposite to what was intended (see also iatrotropic problem and punishing, § 22.1.1). The owner's role may be revealed when dogs in the same household fight only in the owner's presence. Probably the presence or activities of the owner disturbs the ranking order of the dogs. One such disturbing activity is punishing the dominant dog for attacking the subordinate. This support for the 'underdog' reinforces its position and in the presence of the owner it will have the courage to threaten or attack the dominant dog.[13] Aggression among dogs is nearly always directed at dogs of the same sex.[3,14]

Fear

Anxiety about *threatening situations* is normal because it contributes to avoiding them. It becomes problem behavior if there is a relatively low threshold for arousing anxiety, since this will lead to a rather high frequency of the occurrence of fear behavior. A low threshold can be genetically determined[15] and/or develop due to insufficient socialization and other learning processes. In elderly dogs, fear or fear-related aggression is sometimes caused by loss of vision or hearing.[3]

Anxiety behavior is easily learned, not least because many owners try to reassure the dog, which actually reinforces fear behavior, whereas the emotional component may be dampened.[23] Owners do not intend to reinforce fear behavior and are not aware of it, and therefore they usually deny doing so.[12,16]

Fear aroused by sounds. This often concerns thunder, fireworks, or automobile traffic. In many dogs the manifestations of fear worsen with time due to the owner's soothing responses and/or generalization processes.[3] It is important to find out to what degree the soothing by the owner may have reinforced anxiety-related behavior. A test may reveal the behavior after a frightening stimulus, as well as the recovery from it (§ 22.2).

Anxiety about people and/or other dogs. Genetic factors as well as early experience can result in this kind of anxiety.[17] A less than optimal socialization period plays an important role. This anxiety is more likely to develop in dogs predisposed to anxiety than in

those raised normally. Unpleasant experiences can also have this effect in older animals.[3,18]

Other behavior

Inappropriate urination. When urinary incontinence has been excluded as the reason for inappropriate urination, questions are asked about the way the dog urinates (with leg raised?) and in what circumstances (when the owner comes home? following punishment? in the owner's absence?). Urination with the leg raised may indicate dominance. Other possible causes include insufficient house training, excitement, or fear of the returning owner. Sometimes the cause is the combination of a sensitive dog and an owner with an impressive appearance and/or a low voice. Aging may cause the loss of house training.[19] The dog's urination in the house only if alone indicates separation anxiety.[20]

Problems of being alone. The manifestations are usually interpreted as being the result of stress due to the absence of the owner. However, there are dogs who do not show symptoms of stress in the absence of the owner (no barking, howling, whining, running back and forth, urination, and panting)[3,18] but nevertheless quietly start to 'demolish things'. Pure separation anxiety probably occurs primarily when the bond with the owner is very strong, which is indicated by continuously following the owner in the house, begging behavior, sleeping in the bedroom, and frequently attracting attention (also during the consultation!). When the owner is asked to walk around the examination table, such a dog often follows like a shadow. Video recording of the behavior of the dog when it is alone (camera on tripod) is an important diagnostic aid. The video should reveal some of the above symptoms of stress.

Excitement when a bell rings or visitors enter. Questions are asked about examples such as running to the front door, jumping up on people, hyperactivity when a bell rings, mounting people and objects, barking, growling, and begging. With discretion the owner is asked about his response to this behavior. The answers give an impression of the owner's authority over the dog as well as of the owner's approach when the bell rings and of the effect of corrective measures.

22.1.3 Living pattern and living conditions

Function of the animal. Dogs with a role other than as companion animal, such as hunting or guarding, may have undergone conditioning for aggression or barking. Especially with regard to territorial defense, the learned and desired behavior may easily get out of hand because in some breeds it coincides with the natural inclination to alarm and defend.

Grooming care. Questions about grooming care are concerned with the way the dog tolerates this, thereby giving insight into the dominance relationship and/or the presence of pain.

Sleeping place. Questions about the sleeping place are relevant in cases of separation anxiety and control problems. If the dog sleeps in the bedroom, and especially if it sleeps on the bed of the owner, there is close contact between dog and owner. Such a strong bond may lead to separation anxiety. Allowing the dog to sleep in the bedroom, and especially allowing it on the bed, is often associated with lack of control over the dog.

Exercising the dog. It is important to obtain a picture of how the dog is exercised (frequency, duration, intensity), especially if the dog is restless or unmanageable.

Origin. If the dog is derived from a breed of working dogs, restlessness in the house is to be expected unless it receives adequate exercise. An inquiry about this is important.

Obedience training. The owner is asked whether and how often the dog is given obedience training. Obedience training can to some extent help prevent problem behavior.

22.1.4 Past history

Behavior in the litter and early living conditions. Afraid, shy, neutral, or spontaneous? The answer enables comparison of the animal's present behavior with that in its past (if a reliable picture of the latter can be obtained). Questions about the living conditions with the breeder or the previous owner can provide insight into the socialization or other influential experiences. This information can aid in guiding further examination and treatment.

Age at which the animal was taken into the household. Dogs with behavioral problems may be found to have had more than one owner or to have remained with the breeder longer than usual.

Medical information. Sometimes this is important in connection with problem behavior, as with neurological abnormalities and also with disorders of the locomotor system, the skin, the ears, and the digestive tract if associated with pain. Disease at a very early age may contribute to the later occurrence of problem behavior.[21]

22.2 Behavioral examination

Some owners have difficulty in describing the problem behavior of their dog. Also, their appraisal of the dog's obedience may be somewhat optimistic. To obtain an impression of the communication between the owner and the dog, additional information is often needed.

For this purpose the examiner begins his own observation of the behavior of the dog and the owner in the examining room, in their interaction in the video

recording made at home, and in the performance of behavioral tests. Asking the owner to comment on the video reveals how he interprets the dog's behavior, the intentions he ascribes to the dog, and something about his own behavior.

In addition, tests can be carried out. Although most of these tests still have to be assessed for sensitivity, specificity, and predictive value[8,9] (§ 3.1.5), they probably provide useful information (§ 22.2.2). Even if the owner responds to the behavior of the dog during a test with the remark that the dog doesn't normally do this, it has the advantage of conversation on specific behavior, which makes it easier for the owner to tell how the dog usually behaves.

The tests are described briefly below and are illustrated by video recordings on the DVD. The tests should be performed by a man, because dogs usually find men more threatening than women.[22]

22.2.1 Obedience and dominance tests

Obedience tests

Indication. Need for information on dominance and obedience.

Performance. The exercises 'sit', 'down', 'follow', 'come', and 'stay' should be carried out in a sufficiently large room, or better, outdoors.

Interpretation. Indications of insufficient dominance by the owner are the dog's refusal to 'sit' and especially refusal to lie 'down', protests and diversions (such as growling or giving a paw) while reacting to the 'down' command, a stretched leash, a high posture, ignoring the command to 'follow', and delaying the response to 'come'. If several family members are present, the tests should be carried out with each of them.

Grasping the muzzle

Indication. Suspicion of a dominance problem.

Performance. The owner is asked to hold the dog's muzzle for 5 seconds.

Interpretation. If the dog tolerates this, there is probably an acceptable dominance relationship, even with insufficient obedience. If the dog growls or tries to bite, a dominance problem is likely. Note: Head pain or discomfort should be excluded by physical examination.

22.2.2 Provocation tests

Doll test

Indication. Appraisal of the behavior toward an unfamiliar child, the extent to which the dog has to be challenged before it bites, and the way it bites.

Performance. The dog is not muzzled. The examiner holds the doll by one of its arms directed backward while the doll's other arm is stretched forward. The dog is approached calmly to within a distance of about 1 meter, without looking at it. The doll is held slightly away so that dog, doll, and examiner are not in a straight line. The forward movement is stopped to allow the dog to approach the doll. Then the examiner tries to pet the dog with the outstretched arm of the doll for about 1 minute.

Alternatively, the doll can be mounted on a board with wheels and pulled toward the dog by a rope passing around a pulley or post behind the dog. To pet the dog as described above, the examiner lifts the doll together with the undercarriage.

The test can be extended by running away with the doll, in order to test the dog's inclination to chasing.

Interpretation. A dog that is familiar with children and behaves well with children will approach the doll with tail wagging and will sniff at the doll's hands and face. Usually this behavior ceases quickly. If the dog shies away or flees from the doll, it is not familiar with children. This may be accompanied by its hair standing up and by growling. Anxiety-aggression is revealed when the examiner tries to pet the dog.

Roughly 20–30% of dogs tested do not recognize the doll as a child, but respond to it as a threatening object or a toy.[8] Dogs that try to bite, with or without threatening behavior, are considered to be *very hazardous*, especially if they bite forcefully in the face of the doll. Dogs that respond to the doll's 'behavior' by threatening and/or snapping are considered to be *hazardous*. Dogs that threaten but try to flee are considered to be *moderately hazardous*. Dogs that only try to flee or behave in a socially positive way to the doll (inviting it to play, licking its hands and face) are categorized as *low risk*.

The predictive value of the doll test was studied recently in dogs with or without a history of aggressive behavior to a child. Over 80% of the dogs that responded aggressively to the doll had a history of aggressive behavior to a child, whereas 65% of those not responding aggressively had a history of being good with children. The authors concluded that the doll test may be useful in determining aggressive tendencies of dogs. The major limitation of the test was the excessive numbers of false positives and false negatives.[10]

Hit-kick test

Indication. Appraisal of aggression and anxiety reactions to challenging behavior by an unfamiliar person and the capacity to recover from this social stressor.

Performance. The dog is held firmly or if necessary tethered to a post or a ring in the wall. The collar and leash must be strong enough to withstand the dog's lunging. The examiner makes three hitting movements

and three kicking movements toward the dog, while remaining safely out of its reach. Then the dog is approached from a distance of about 5 meters, while looking straight in its eyes.[9] The *manner and force of biting* can be tested by mimicking the kicking with a boot held in the hand.

The dog's capacity to recover is tested by the examiner squatting beside and turned slightly away from it and *absolutely not looking at the dog*. The examiner then attempts to engage the dog with an open hand, then with some food in it. The tendency to *follow people aggressively* can be tested by running away from the dog.

Interpretation. This test seems to predict future responses to meeting with strangers who may be threatening. Anxiety and aggression reactions, and seeking the protection and support of the owner can be observed. It also reveals how quickly the dog responds with physical aggression and what type of aggression. Some dogs interpret the hitting or kicking movements as the throwing of a ball. When recovery is slow (taking minutes) or absent, treatment is likely to be troublesome and lengthy. Note: Performing this test is risky and best avoided by the veterinarian involved, since it may leave the dog with an undesirable and unpleasant association.

Testing sensitivity to and recovery from visual and acoustic stimuli

Indication. Dogs with fear of specific events or stimuli.

Performance. Depending on the dog's problem(s), one or more visual or acoustic stimuli are presented, with sufficient intervals for recovery. A visual stimulus could be the opening of an umbrella and an acoustic stimulus could be the sound of a ladle striking a pan or its lid. Recovery from a visual stimulus can be tested by placing the opened umbrella on the floor and allowing the dog to examine it. If the dog does not approach the umbrella, the owner can be asked to walk calmly to the umbrella and touch it.

Interpretation. Great sensitivity (fright from a minor stimulus) and poor recovery probably indicate that treatment will be troublesome. These tests also reveal whether the owner is inclined to comfort the dog or to behave inadequately.

Testing feeding bowl aggression

Indication. Feeding bowl aggression.

Performance. The examiner attempts to push away the dog's *own* feeding bowl with an artificial arm. This is repeated for about half a minute.

Interpretation. The test reveals the dog's body position, whether it responds by threatening and/or biting, and the frequency and force of biting.

Testing the response to petting

Indication. Aggression during petting.

Performance. An artificial arm is used to pet the dog in the way which the owner describes as normally leading to aggressive behavior.

Interpretation. Petting in various ways reveals how and where the dog wants or does not want to be petted, how long petting is tolerated, and how the dog responds (threatening and/or biting).

22.2.3 Confrontation with dogs and the role of the owner

Confrontation with dog of same gender

Indication. Uncertainty about the type of aggressive behavior toward other dogs.

Performance. The dog is held on a leash and is muzzled if necessary, then confronted with a dog of the same gender that is also on a leash or fastened, and muzzled if necessary.

Interpretation. If the dog runs immediately from a great distance (>15 m) at the second dog without threatening behavior (growling, showing teeth, retracted upper lips, stiffening), it is considered to have killer aggression. This interpretation is even stronger if the dog looks at its owner during the conflict. In 'normal' aggression the posture of the dog indicates whether either dominance or anxiety plays a role. The behavior of the owner is included in the observations.

Influence of the owner on aggressive behavior

Indication. Uncertainty about the role of the owner in aggression of the dog toward people or dogs.

Performance. Aggression toward people can be tested indoors and aggression toward dogs can be tested outdoors. If the test is considered to involve a risk, the dog is securely tethered and muzzled. The dog to be tested is challenged by an approaching dog or a person entering the room. The owner is asked in advance to walk away from the dog (to leave the room) as soon as the dog starts barking or growling.

Interpretation. If the dog concentrates on the disappearing owner and gives scarce attention to the provocation, the presence (support) of the owner is taken to be important in developing and maintaining the problem behavior, especially if this behavior declines when the owner leaves. In killer aggression, the outcome is expected to be independent of the owner.

22.3 History taking for cats

The history concentrates on aggressive behavior, anxiety, urinating in inappropriate places, spraying, and defecation.

22.3.1 Iatrotropic problem

The questions are very similar to those for dogs (§ 22.1.1), but it is also important to ask about the duration of the problem. Cats are creatures of habit and tend to continue certain behavior in the same place (object).

22.3.2 Present behavior and functioning

Aggressive behavior toward people and other cats

Physical causes of aggression. Pain (e.g., dental), disorders of the central nervous system (tumor, epilepsy), endocrine diseases (hyperthyroidism), and senility should be excluded.[24,25]

Aggression toward people. It is first necessary to confirm that there is aggression, for which purpose questions are asked about vocalizations that might occur with an 'attack'. Cats usually play and catch prey silently, but their aggressive behavior is accompanied by growling, spitting, and screaming.[26] However, playful young cats can direct their silent prey-catching behavior and/or play aggression at people if they do not have sufficient opportunities to express this behavior otherwise.[24,27]

The examiner should also determine where the 'attacks' occur. For example, redirection aggression may occur close to window seats, windows, or doors.[28,29] Observing an 'enemy' outdoors may induce aggression that can be redirected at a person. Redirection aggression can occur indoors during or after a conflict with another cat, and a person may become the victim. The intervals between episodes of aggressive behavior should be documented, together with the context.

Some cats tolerate petting only on certain areas, such as the head and neck, and/or only for short intervals. Usually no physical cause can be found for this, but poor socialization might be a causative factor.[24] Some cats attack visitors, which is regarded as *territorial aggression*[3] that often has anxiety components. The cat's low posture and the way it walks along walls and under chairs, but without stalking, are indications of this type of aggression.

Aggression toward other cats. Aggression toward neighboring cats (*territorial aggression*) is common, as is aggression toward cats in the house (*competition, jealousy-like aggression, territorial aggression, redirection aggression, and pain-induced aggression*).[24] The last two of these may play a role in sudden fights between cats that have gotten along well, especially if one cat is consistently the offender and the other consistently the victim. Food allergy has been suggested as a possible cause, but this requires further investigation.[30]

Spraying, urinating, and defecating in the house

From observations (owner's video) of the position of the cat and/or the location of urine traces, it should be clear whether the cat sprays while standing (marking) or urinates while sitting, although marking can also occur while sitting.[31] The owner should be questioned about the duration of the problem and the number of locations used to spray or urinate. The possibility that the urine is from neighboring cats that have entered the house via a cat flap, window, or door should be excluded.

A possible cause of *spraying* in the house is stress caused by changes in the house that are relevant to the cat, such as moving furniture, the arrival of a baby, a child leaving home, the arrival of another cat, or bad relations with another cat. The onset of puberty may play a role, as can territorial conflicts with neighboring cats that lead to territorial marking.[2,32] The problem may also be the result of frustration due to inadequate social contact or a feeding pattern with only rare access to food.[3]

For the problem of *urination or defecation* outside the litter box it is important to ask for the number of locations where the cat urinates or defecates. If it uses one or two fixed locations, there may be something wrong with the litter box. It may be a new box, one that is covered or filled with a new kind of litter; or it may be dirty or not in a quiet location; or the cat may be frightened or annoyed while using the litter box.[3,33] If the cat urinates or defecates in several places, a physical cause is more likely.

Urinating or defecating on the doormat often indicates territorial marking,[29] sometimes as a reaction to markings of other cats against the house. Such markings may also occur at other locations in the house when another cat is introduced. Senility may cause loss of house training.

Anxiety

Cats may refuse to be petted or they may be afraid of visiting persons or other cats.[34] Questioning about the past history often reveals insufficient socialization.[3] Traumatic experiences with children or adults, or an unpredictable social situation (some people are nice to cats, others are not) may also lead to anxiety behavior. A traumatic experience with another cat may lead to avoidance of areas where that cat might be met.[24] Fearful cats tend to hide themselves and/or find high places on which to sit.

22.3.3 Living conditions

Questions about social situation include the age and gender of any other cats in the house and their social relations, the presence of young children, and whether the owner is often away. Other information of interest

concerns the type of house (apartment or house with or without a garden), whether there is a cat flap or outside exercise area for the cat, the number of rooms accessible to the cat, locations of food and water, and the number of litter boxes, their position and type (covered or not).

22.3.4 Past history

Origin

It may prove to be of interest to know whether the cat was obtained from a farm, a shelter, a breeder, a private owner, or was found in the street.

Age when introduced into the household

Sometimes kittens are taken into a family before they are 8 weeks of age. They may also be fed artificially. Information about the age of weaning may explain abnormal behavior such as aggressive playing with the owners.[34]

Medical information

See § 22.1.4.

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23 Emergencies

J.H. Robben and F.J. van Sluijs

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Acutely diseased or injured patients should be examined quickly and efficiently, for they may suffer from life-threatening or organ-threatening conditions. Swift help may reduce the morbidity and the risk of a fatal outcome. Traumatologists have coined the term 'the golden hour' to emphasize the importance of early intervention. Mortality occurs in three peaks after trauma: immediately after the injury, due to fatal damage to the brain or the circulation, such as rupture of the aorta; after one hour, due to injuries such as rupture of the spleen or tension pneumothorax; and after several days, due to complications of the initial trauma or inadequate first aid.

Adequate action may decrease mortality in the second and third peaks. This applies not only to trauma but probably also to poisoning, severe acute illness, acute decompensation of a chronic illness, and acute complication of a medical or surgical intervention.

Quick and efficient intervention requires that the veterinarian:

1. remains calm and maintains an overview
2. is well prepared:
   - Both the veterinarian and the staff should have thorough ready knowledge of acute conditions.
   - The entire team must be well trained and have practical experience.
   - Essential equipment and instruments should be accessible and ready for use.

In emergency medicine the sequence of steps in the management of an acute case is often described as a 'chain of survival.' This chain starts at the scene of the calamity and continues into the hospital. For humans there are detailed evidence-based protocols for the management of common acute conditions (trauma, heart failure).[1-3] Veterinary medicine lacks such a system but important parts of the protocols for humans can be used

as a basis for protocols to manage emergencies in companion animals.[4,5]

Two important links in the chain of survival are basic life support (basic cardiorespiratory cerebral resuscitation) and advanced life support.[2] The diagnostic protocol for basic life support is simple and focuses on the ABCs (see below). Is the patient conscious? Is there a free airway? Are there respiratory movements? Can a pulse wave be detected? Basic life support has a certain simplicity, for it is to be provided at the calamity site by laymen without the help of medical equipment.[6] For animal victims this kind of help is still rare and most dogs and cats receive first aid only after they have been brought to a veterinary practice.[4] Upon their arrival treatment can begin according to advanced life support guidelines, for these are executed by professionals (the veterinarian and his or her assistant) with equipment and instruments readily available.

This chapter concerns the diagnostic protocol for advanced life support. The protocol is divided into two sections: primary survey and secondary survey.[3] The primary survey comprises a brief history, a brief general impression, and a physical examination according to the ABCDE protocol. Once the condition of the patient is stabilized and treatment of life-threatening conditions has been initiated, the secondary survey is carried out. This comprises a complete history and physical examination.

23.1 Primary survey: brief history

In an emergency it is more important to identify possible threats to organ functions or the animal's life than to define the exact nature of the animal's problems. An extensive history is not required and may even be undesirable insofar as it interferes with rapid and adequate action. The history can often be limited to the following questions:

- What has happened?
- How did it happen?
- When did it happen?

There may be additional questions, depending on the situation (trauma, poisoning). For example, following trauma it is important to know whether the patient has been unconscious. A short period of unconsciousness (seconds to a few minutes) followed by a period of confusion usually points to brain concussion without serious brain damage. Unconsciousness for several minutes may indicate more serious damage, such as brain contusion or rupture, with or without hemorrhage. In cases of poisoning the history attempts to determine the type of poison, the amount ingested, when it occurred, and the course since the ingestion.

23.2 Primary survey: physical examination

Abnormalities that can cause death within minutes or hours share a common trait: they quickly lead to tissue hypoxia that in turn causes cell death. Brain damage due to hypoxia may be irreversible within 5–7 minutes.[7] Physical examination is therefore focused primarily on the route that oxygen takes to reach the tissues. The most generally accepted approach is the ABCDE protocol: Airway, Breathing, Circulation, Disability, and Environment.

In nonemergency cases additional examinations are based on problems defined after a complete history and physical examination, but electrocardiography is often an integral part of advanced life support protocols. In addition, life-threatening or organ-threatening conditions are treated immediately, without waiting for a complete diagnostic work-up. Consequently, diagnosis and treatment cannot be clearly separated in emergencies. Valuable information may be lost as a result of early initiation of treatment and to minimize this risk, samples for additional examinations are collected as early as possible. Common laboratory tests in emergencies include packed cell volume, total protein and albumin, sodium, potassium, urea, creatinine, and glucose. Blood gasses and coagulation profiles are also requested, if indicated.

Because emergency patients are usually unstable, physical examination should be repeated regularly. This ensures timely recognition of deterioration and provides information that can be used to evaluate the effect of treatment.

A complete physical examination cannot always be carried out. Certain parts of the examination may be too stressful for the patient; the presumed benefits of an examination should always be weighed carefully against the disadvantages. The actual examination may thus be less detailed than described earlier in this book. For example, the examination of the heart and lungs may be less comprehensive in a patient that is recumbent and unable to stand.

23.2.1 Brief general impression

Level of consciousness

The first impression of consciousness usually indicates whether an emergency approach is needed. For example, cardiac arrest can be excluded if the patient is still able to stand but is a possible diagnosis if the animal is recumbent and cannot be aroused.

Behavior

In emergency situations animals may behave in unexpected ways and a muzzle is sometimes necessary (§ 24.2.2), but it should be borne in mind that restraint

may endanger the patient, such as by impeding airflow when applying a muzzle.

Posture

Recumbent patients are positioned with the head and neck in a neutral position before being examined. Traumatized patients should be treated with caution because they may have injuries to the head or vertebral column. They should be placed on a solid surface ('back board') and if necessary fixed to it with adhesive tape to prevent further damage by spontaneous movements. Dyspneic patients that are recumbent should be turned in dorsal recumbency for examination because the lungs are better ventilated in this position. The upper airways should be kept free from external pressure. Especially in cats, forceful positioning should be minimized, to avoid the patient's resistance and exertion. This follows an important principle in emergency care: 'first do no harm'.

Notable abnormalities

These include dyspnea, abnormal position of the limbs, and open wounds. Early listing of these abnormalities may modify the approach to the patient, for fractures are painful and traumatized areas need to be protected to prevent complications, as well as to protect the examiner against being bitten.

23.2.2 A: Airway

The primary goal in examining the airway is to assess its patency. If the patient is breathing freely and without stridor, the airway is not obstructed and further examination of it is not needed. Signs indicating airway obstruction include excitation (due to hypoxia), decreased consciousness, harsh barking, stridor, labored inspiratory movements including those of the auxiliary respiratory muscles, apnea, tachypnea, and cyanosis.

Stridor

Breathing sounds help to identify the site of the obstruction. A nasal stridor is characterized by a sniffing sound, a pharyngeal stridor by a snoring sound, and laryngeal or tracheal stridor by a harsh g-sound.

Oral cavity

Dyspneic patients often attempt to breathe through the mouth and therefore it should be free of obstruction. Thus the mouth is opened and the mobility of the mandibular joint examined. The oral cavity is inspected for saliva, food, vomitus, blood, foreign bodies, broken teeth, a swollen or abnormally positioned tongue, and other swellings such as salivary cysts.

Oropharynx

The area between the two halves of the mandible is inspected and palpated for pain, open wounds, or deformities, and to determine whether stridor is elicited by *light* pressure. Using the fingers or the blade of a laryngoscope, the base of the tongue must be pressed down to enable inspection of the pharynx, but this can only be done if the patient is unconscious. The pharynx is inspected for obstruction by a foreign body, severe swelling of the mucosa, enlarged tonsils, or the abnormal shape or position of the soft palate.

Larynx and trachea

External inspection and palpation of the larynx and trachea is performed to detect any pain, open wounds, deformities, or swelling, or the rustling sounds caused by subcutaneous emphysema. Subcutaneous emphysema indicates that there is a perforation of the larynx or trachea. If laryngeal paralysis is suspected, the glottis should be examined and for this the conscious patient must be anesthetized. To examine the glottis, the neck is extended (taking great care in patients with neck trauma), the mouth is widely opened, and the base of the tongue is depressed with the blade of a laryngoscope.

23.2.3 B: Breathing

Respiratory movements

The depth, type, rhythm, and frequency of thoracic and abdominal respiratory movements are evaluated. Attention is given to labial breathing, the use of the nostrils, breathing with an open mouth, and the use of accessory respiratory muscles (see also § 8.3.1).

Chest wall

The chest wall is inspected for deformities, wounds, or abnormal movement such as the paradoxical movement of a flail chest. A flail chest is the result of fractures of two or more successive ribs in two or more places. During both inspiration and expiration, the direction of movement of the wall between the fractures is opposite to that of the remainder of the thorax. This paradoxical movement reduces the efficiency of ventilation. Wounds of the thorax are inspected for evidence of perforation. Palpation is used to detect subcutaneous lesions and deformities such as fractured ribs, ruptured intercostal muscles, and subcutaneous emphysema (causing rustling sounds). Palpation can also locate pain.

Auscultation of the lungs

See § 9.2.4.

Percussion of the chest

In emergency patients attention is primarily focused on detection of a very hollow tone (pneumothorax), a reduction in tone ventrally (fluid or a mass), or dull sounds in the lung area (lung cavity or solid mass). See also § 9.2.4.

23.2.4 C: Circulation

Pulse

If the patient must be examined in lateral recumbency, the symmetry of the femoral pulses cannot be assessed as described in Chapter 8. If no pulse wave can be detected, the thorax is examined to determine whether the heart is still beating (see below). This situation may occur in cats that are presented in shock.

Mucous membranes

It is not necessary to examine all of the mucous membranes during the primary survey. Inspection of the conjunctival and/or the oral mucosa will suffice. The examination is limited to evaluation of the color, moistness, capillary refill time (CRT, § 8.3.5), and the presence of hemorrhages.

Heart

The presence of the ictus cordis is assessed by palpation on both sides of the thorax. If there is a fremitus (§ 10.2.4) its location is noted but in this examination its location is not important.

During the initial examination auscultation of the heart is limited to three essential aspects: Is there a heart beat? Are the heart sounds of normal intensity? Is there a cardiac murmur?

Hemorrhage

Hemorrhage can be arterial or venous, internal or external. Acute blood loss is usually much more severe with arterial than with venous hemorrhage and can be fatal within a short period of time. Arterial bleeding can be recognized in the acute stage by its pulsation. External hemorrhage is usually clearly visible, assessing the amount of blood loss can be difficult. The history and the results of examination of the circulation may be helpful. Internal hemorrhage cannot always be detected by physical examination but may be confirmed by diagnostic aspiration of body cavities. Internal hemorrhage can result in a dull tone ventrally in the thorax during percussion and by undulation in the abdomen. Subcutaneous hemorrhage can cause swelling and discoloration of the skin and hemorrhage in muscle can also cause swelling. Hemorrhage in the gastrointestinal tract can result in hematemesis, hematochezia, and/or melena.

23.2.5 D: Disability

In emergency cases disability generally concerns cerebral functions. When peripheral neurological dysfunction becomes life threatening, it usually does so via effects on A, B, or C (e.g., dyspnea in polyneuropathy) and will be detected when these systems are examined.

The primary survey reveals (1) whether there is cerebral dysfunction and (2) how serious it is. Repeated examinations may reveal (3) whether it is progressive. The latter may suggest the cause and the prognosis. For example, rapid deterioration is more consistent with hemorrhage and slow progression with cerebral edema.

The neurological examination is especially informative if there is primary cerebral damage due to trauma. It is less helpful in cases of poisoning, severe metabolic disorders, or after the ingestion of drugs that affect the central nervous system (e.g., anesthetics).

Asymmetrical neurological signs suggest a localized brain disorder and generally have a poor prognosis. Symmetrical signs suggest a diffuse disorder and may have a favorable prognosis.

Level of consciousness

Consciousness is maintained by the cerebral cortex and the reticular formation in the brainstem (Fig. 23.1). Effective communication between these systems is essential for normal function. Elimination of the reticular formation or loss of the connection between it and the cerebral cortex results in coma. Damage to the cortex alone will not seriously decrease the level of consciousness. Focal lesions will only cause stupor or coma if they are located in the brainstem, because a focal lesion is usually too small to block the extensive communication network between the reticular formation and the cerebral cortex. But a diffuse lesion such as cerebral edema may have this effect.[8]

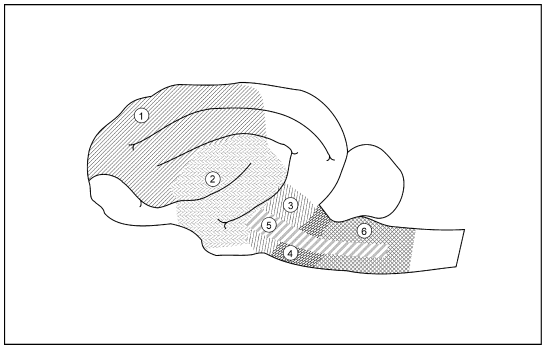


Fig. 23.1 Schematic representation of the cerebrum, cerebellum, and brainstem: 1 cerebral cortex, 2 diencephalon (thalamus), 3 mesencephalon (midbrain), 4 metencephalon (pons), 5 reticular formation, 6 myelencephalon (medulla oblongata).

The different levels of consciousness (awake, sopor, stupor, and coma) are described in § 18.2.2.

Pupil size and pupillary light reflex

Abnormalities of the pupils may help to identify primary cerebral lesions if peripheral abnormalities and toxic, metabolic, and pharmacological causes can be excluded. The latter is not always possible in emergency cases and this makes the interpretation of the neurological examination difficult. Repeating the examination may be helpful by providing insight into the course and the prognosis.

Pupil size and the pupillary reflex help to locate and characterize the abnormality (Fig. 23.2).[8-10]

Locomotor system

Motor abnormalities caused by neurological dysfunction may provide clues to the location of the primary lesion and the prognosis. The following locomotor abnormalities indicate nervous system dysfunction:[9]

- Asymmetrical loss of function (hemiparesis/paralysis, unilateral hypertonia) in combination with a severely decreased level of consciousness suggests focal damage to the brainstem and has an unfavorable prognosis.
- Decerebrate hypertonia is hypertonia of the extensor muscles of the extremities and the trunk (i.e., hyperextension of the front legs with extension of the neck and head [opisthotonos]).

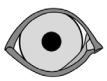
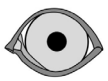
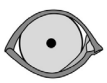
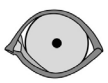
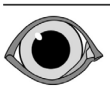
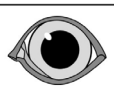
OD	OS	Pupil size[1]	Pupillary reflex[2]	Localization[3]	Prognosis[4]
		normal	normal	—	good
		bilateral miosis	normal[5]	non-specific	diverse
				metabolic cause	good
		bilateral miosis ('pin point')	absent	pons	moderate
				poisoning with opiates or cholinesterase inhibitors	good
		unilateral miosis enophthalmos ptosis protrusion of 3rd eyelid (Horner's syndrome)	—	hypothalamus lateral medulla oblongata	moderate
				peripheral sympathic nerve tract	good
		unilateral mydriasis	slow or absent (OS)	unilateral parasympathetic oculomotor nerve (transtentorial herniation)	moderate to poor
				peripheral (oculomotor nerve/optic nerve/ocular globe)	good
		unilateral mydriasis ptosis divergent strabismus	absent (OS)	unilateral oculomotor oculomotor nerve (transtentorial herniation)	moderate to poor
		normal	absent	mid brain	poor to very poor
		bilateral mydriasis	slow or absent	diffuse cerebral anoxia bilateral oculomotor nerve mid brain	poor to very poor
				poisoning with atropine increased sympathetic tone	good

Fig. 23.2 Pupil size and pupillary light reflex related to location and prognosis of brain lesions. OD = oculus dexter (right eye), OS = oculus sinister (left eye). 1 Evaluated under normal lighting conditions (diffuse daylight or artificial light). 2 Only the direct (ipsilateral) pupillary light reflex. Must be performed in a darkened room, using a bright light source (§ 19.4.1). 3 See also Fig. 23.1. 4 Possible recovery of the central nervous system, not the patient as a whole. 5 Difficult to evaluate if there is miosis.

If combined with a severely decreased level of consciousness, it suggests a lesion in the rostral part of the brainstem and has a poor prognosis.

Respiratory pattern

Although also mentioned in the section on respiration, some abnormal respiratory patterns are discussed here because of their association with brainstem lesions:

- Cheyne-Stokes respiration.* The respiratory rate increases gradually, then slows down again gradually. This pattern alternates with episodes of respiratory arrest. It occurs in patients with severe damage to the cerebrum or the diencephalon and has a poor prognosis.
- Neurogenic hyperventilation. The respiratory rate is high and regular. It suggests damage to the midbrain and has a poor prognosis.
- Apneic respiration. The inspiratory phase is prolonged ('bated breath') and there is a long pause after expiration. This pattern is repeated 1–1.5 times per minute. It suggests a lesion in the caudal part of the pons or the medulla oblongata.[9]
- Atactic respiration. Respiration is irregular and there are variations in both frequency and depth. There are long periods of apnea. It occurs in patients with severe damage to the myelencephalon and is considered a premortal pattern.[11]

23.2.6 E: Environment

This part of the survey focuses on the direct influence of the environment on the body and mainly concerns body temperature and damage to the haircoat and skin. Hyperthermia must be distinguished from fever (§ 8.3.3). Hyperthermia can occur if a patient has been kept in a hot, enclosed environment (e.g., in a closed automobile parked in the sun). Hypothermia occurs primarily in patients immobilized by an accident or disease. Severe hypothermia may induce irreversible coagulopathies. Shivering to restore normal temperature increases energy demand and may aggravate tissue hypoxia.

The entire body is inspected for wounds, both traumatic (e.g., gunshot, automobile) and due to burns (including chemical).

23.3 Secondary survey

When the patient is stable (at least temporarily) a secondary survey is started. The history is completed (§ 6.1.4) and depending on the findings, the examination is extended to a general physical examination and examination of the relevant organ systems. Based on the findings of these examinations, a problem list is generated and diagnostic and therapeutic plans are made. If a complete history and physical examination are omitted, important findings may be missed and problems may be overlooked. This can result in serious complications.[1,5]

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* First described by John Cheyne (1777–1836) and later by William Stokes (1804–1878). Both played an important role in the foundation of the Dublin School of Medicine.

24 Positions and restraint

A.M. van Dongen and J.H. Robben

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In the paragraph on handling (§ 8.2), specific positioning of the patient is indicated for certain parts of the physical examination. If the patient does not readily accept the prescribed positioning, some form of restraint should be considered.

24.1 Positions

24.1.1 Standing

Several parts of the physical examination require a square stance, meaning that the legs are vertical and the four feet form a rectangle. Large dogs are most easily examined if allowed to remain standing on the floor. Dogs that are frightened often object to standing on the table but may accept doing so if they are supported from behind. An assistant can place one hand between the dog's hind legs and quietly but firmly raise the dog up to provide this support.

Cats are strongly inclined to take a sit-and-watch position on the table. They can be induced to stand by gentle tickling along the spine from the head to the tail. The cat should not be allowed to lean against the examiner, which defeats the square stance.

24.1.2 Sitting

This position is not only useful for examination of the head, neck, and front legs, but also for collection of blood from the cephalic or jugular vein (see § 25.3.1). Many dogs respond to the command 'sit' but if they do not, they can usually be made to sit by pressing down on the back. Most do not resist once they are in a sitting position. The sitting position can also be used as an intermediate step between standing and sternal or lateral recumbency (see below). Cats do not as a rule respond to commands such as 'sit' but can nevertheless usually be persuaded to do so.

24.1.3 Sternal recumbency

Examination of the ears and eyes is generally performed with the dog lying on its sternum (sphinx position). A cooperative animal with a painless disorder can often be restrained for this purpose by simple restraint of its head, as shown in Figure 24.1. An animal that is anxious or has a painful ear must usually be restrained more thoroughly. In this case, the assistant not only restrains the head but also leans slightly over the animal to prevent it from rising (Fig. 24.1).

24.1.4 Lateral recumbency

Small dogs can usually be placed and held in lateral recumbency quite easily, without following any special procedure. Medium-sized dogs can be placed in lateral recumbency by reaching both hands over the standing dog in order to grasp the front and hind legs *on the side of the handler*. By pulling away both legs the dog is made to lean against the body of the handler. This cushions its fall against the handler and the dog is

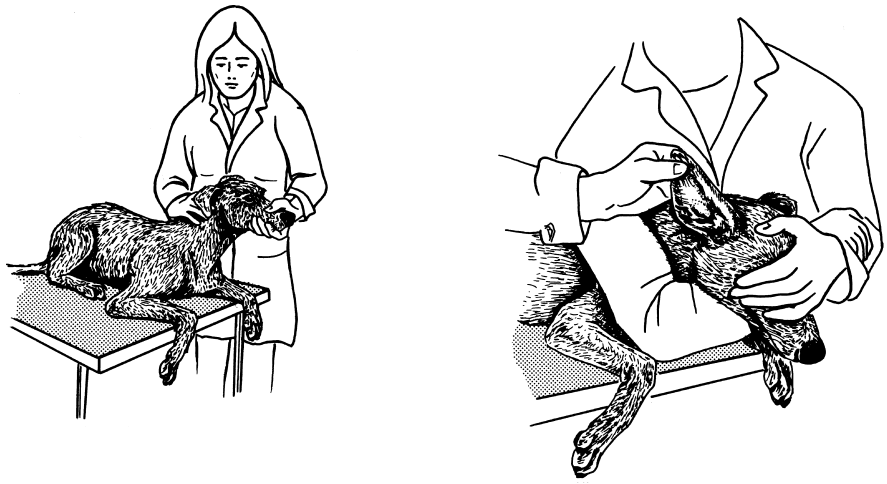


Fig. 24.1 A dog in sternal recumbency with its head lightly restrained (left). If resistance is to be expected, the head can be restrained more firmly by leaning over the animal slightly and by holding the head and neck as shown (right).

rolled down onto the table without an abrupt fall. In this action the dog's head can move freely and one should be alert to the risk of biting. Once the dog is on the table, the grasp on its lower legs is maintained for fixation.

Large dogs are handled in a slightly different way. To place a large dog on its side without a struggle it is best to first have the animal sit (Fig. 24.2). The dog's head is then slightly restrained by grasping its collar or by placing a hand under its jaw. The other hand reaches over the dog to grasp either the front or the hind leg that is *close to the handler* and slowly pull it out from under the dog. The effect is to roll the dog over in a smooth and continuous movement onto its side without giving cause for anxiety or resistance. Then the dog is fixed in lateral recumbency.

Very large dogs should be lifted by two persons and placed directly on the table in lateral recumbency. For this purpose, they should agree in advance exactly how to handle the dog, for example, 'Now let's lift him and lay him on the table on his left side, with his feet toward the window.'

Fixation in lateral recumbency can be performed better by one person than by two. Standing behind the dog's back, the assistant can reach over the animal to grasp the lower legs (Fig. 24.3), leaving the upper legs free. Although it seems natural to many people to place one arm across the dog's neck and when necessary to compel the animal to remain quiet by pressing down on its neck, this restraint is achieved by causing pain. It may be necessary with large and

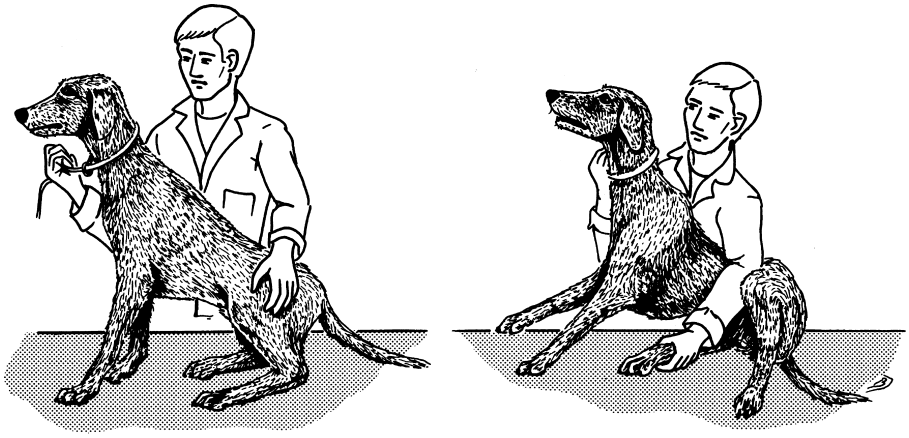


Fig. 24.2 A dog to be placed in lateral recumbency is first placed in a sitting position. Its head is restrained slightly by grasping its collar or by placing a hand under its jaw. The other hand reaches over the dog to grasp the near front or hind leg and slowly pull it out from under the dog. The effect is to roll the dog over in a smooth and continuous movement onto its side, without giving cause for anxiety or resistance.

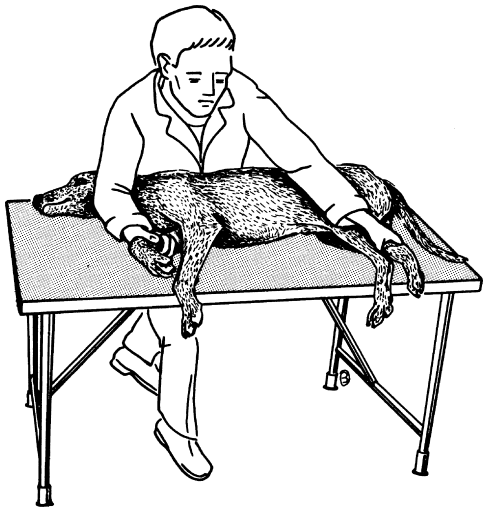


Fig. 24.3 Restraining a dog in lateral recumbency. The right elbow rests on the table so that the dog's head and neck can be held between the upper arm and chest. The lower legs are held to prevent the dog from rising.

aggressive dogs but it is generally better to place the elbow and forearm on the table so that the dog's head and neck are held between the assistant's upper arm and chest. If the dog begins to struggle, the upper arm can be used to draw it more firmly against the chest of the assistant. Held in this way, the dog cannot bite the assistant but its respiration is not hindered and pain is avoided. When the dog relaxes, its head and neck can be allowed more freedom of movement. If the dog continues to struggle, the assistant can bend over and lean upon the animal's body slightly, taking care not to hinder its respiration.

The height of the table should be suitable for the procedures to be carried out, as well as being comfortable for the person holding the dog. An electrically-controlled hydraulic table can be adjusted easily, so that its height can be adjusted during a procedure without disturbing the patient.

24.1.5 Suspended

Small dogs—and especially cats—tend to resist being restrained in lateral recumbency. Firm restraint may be required, but this impedes such procedures as a neurological examination. An alternative is to suspend the animal with one hand under each axilla. The animal's body hangs freely, with its back held against the chest of the owner or assistant. Note, however, that its head can move freely, which may involve a risk of biting. In addition, cats may not hesitate to use the claws of both the hind and front feet.

24.2 Restraint

Whenever an animal must be held in a certain position, it is best to find out first whether the owner can do this safely alone. If the owner cannot, the help of an assistant must be obtained or other measures must be considered, such as sedating the animal. The problem must be taken seriously and part or all of the examination should be postponed if necessary until adequate help is obtained. This is better than venturing an attempt which may not only result in injury to oneself but in which the owner and the patient are exposed to danger, as well. Usually the cooperation of the patient is inversely proportional to the number of attempts to restrain it.

There are many methods of restraint. The choice depends on the behavior of the patient, the species, the planned procedure, and the personal preference of the examiner.[1,2] Here we present some of the possibilities.

24.2.1 Manual restraint

Dogs can usually be restrained quite simply by firmly grasping the skin on both sides of the neck just below and behind the ears (Fig. 24.4). This grip causes little discomfort while allowing good fixation of the head, and in this way an anxious or aggressive dog can be adequately immobilized for minor procedures such as taking the rectal temperature or giving an injection.

A cat may suddenly and without warning resist being restrained and the handler should be prepared for this sometimes explosive behavior. When such an abrupt change in attitude occurs, the first response should be a full-handed grasp of the skin on the back of the neck. The struggling cat can thereby be lifted with one hand, so that its claws cannot strike instruments or equipment, or the owner, assistant, or veterinarian. Once the cat is suspended, its hind legs can be grasped by the other hand, and then its front legs by another person. In this way it can be returned to the table and restrained.



Fig. 24.4 Restraining the dog's head by firmly grasping the loose skin at the side of the neck behind the ears.

24.2.2 Muzzle or cloth band

If a dog was aggressive and attempted to bite during a previous examination, or it is anticipated that the present examination may be painful, the animal should be muzzled with a cloth band and the reason for this should be explained to the owner. It is best to ask the owner to assist with this while the animal is still calm. If the owner is unable to apply the muzzle alone, the two-handed grasp described above (§ 24.2.1) will be needed to restrain the dog for this purpose. Lateral movements can be controlled, whereas forward outbursts are less easily controlled. It is thus safer to approach an aggressive dog from the side.

Ready-to-use muzzles are available for most dogs and cats (Fig. 24.5). Choose a muzzle that is close fitting with regard to both length and diameter. The mouth should be enclosed without impeding the animal's breathing. There are muzzles for cats that also cover the eyes and many cats accept this without difficulty if the muzzle is applied calmly while reassurance is given by contact and voice.

When a muzzle is not available or a dog does not allow one to be applied, a cloth band can be used. The band should be 4–5 cm wide, made of strong cloth that will lie flat, not gauze bandage or a cord, for these will cause pain when tightened.

The band is placed on the dog in a loop with a half-knot over the nose. The loop is held between the thumb and forefinger of one hand and is stretched over the forefinger of the other hand. This loop, which should be very wide, is placed over the dog's muzzle and the ends are pulled quickly to close it (Fig. 24.6, left).

In this maneuver the hands come quite close to the dog's mouth. If this is thought to be too risky, the hands can be kept at a distance by preparing a loose loop with a half-knot. Via the long ends the loop is placed over the muzzle and then turned 180° so that the knot can be tightened under the jaw. This can also be achieved by first tightening the prepared loop dorsally and then turning the long ends around the muzzle again and making another half-knot under the jaw (Fig. 24.6, right).

The two ends of the band are brought behind the ears and tied firmly. If it is decided that the dog must be muzzled in this way, the band should be tied tightly enough and knotted securely with a bow knot. This means that the loop with the half-knot that is placed around the jaws is tightened sufficiently to completely prevent the jaws from being opened. If the loop behind the neck is tied too low on the neck, it can creep up



Fig. 24.5 Left: one size of muzzle for cats. Right: different sized muzzles for brachycephalic and dolichocephalic dogs.



Fig. 24.6 How to apply a cloth band. A wide loop with half a tie (at the bottom) is slid over the muzzle. The drawings show how to keep a distance from the dog. A loop with half a tie (at the top) is slid over the nose and then turned 180 degrees. The tie is then fastened below the lower jaw. Finally the ends of the band are tied in a bow directly behind the ears.

during the examination, resulting in sufficient slack to allow the dog to open its jaws.

When the examination is finished, the dog may try to remove the cloth band with its front paws. The bow knot allows the examiner or assistant to remove it quickly.

24.3 Restraint or sedation

It may be thought prudent to sedate certain patients, because adequate restraint cannot be assured by the methods described above without some risk to the patient itself, as well as persons and equipment. Cats can injure with their claws as well as their teeth, they tend to resist restraint more than dogs, and they are nimble and do not give in easily.

In many brachycephalic dogs the muzzle is so short that neither a cloth band nor a muzzle can be used. The dog's muzzle may appear to be long enough (e.g., boxer, Shar Pei) to allow a band to be used, but then the band is found to lie mainly on the soft tissue of the nose, with great risk of closing off the cranial part of the nasal passages. In such cases, the two-handed grasp must be used rather than a muzzle.

Especially in small brachycephalic dogs such as the Pekingese, the two-handed grasp must be used with great caution to avoid excessive traction on the skin of the head, which during a struggle can result in prolapse of the eye. Even when the two-handed grasp is used carefully, the periorbital skin may be placed under tension and if so, the manner in which the dog is being held should be changed to avoid this tension.

On warm days special attention must be given to the way in which a large dog with a thick coat is restrained. A St. Bernard, for example, may be panting heavily in the examination room. Sometimes excitement (which also results in greater production of body heat) contributes to this. If such a dog is restrained in lateral recumbency, it may become quite anxious because its thermal polypnea is being hindered. This can lead to increasing resistance to restraint and if the cause for this is not recognized and the restraint is increased instead of being decreased, the dog may resist explosively, with serious risk to all who are involved.

With every dog and every cat that offers strong resistance and becomes dyspneic, all attempts at restraint should be stopped immediately. It may be sufficient to place the animal in a quiet room until it has calmed down, but oxygen should be administered if its condition warrants. In the meantime, the owner can be consulted, adequate help can be arranged, and plans can be made for further examination and/or treatment. Although a second attempt of restraint may be successful, sedation is often preferable. Particularly in dyspneic animals, attention should be given to the respiratory system and the circulatory system during the preanesthetic examination.

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25 Collection of material for laboratory examination

J.H. Robben and A.M. van Dongen

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At the end of several chapters there is a short list of options for further examination, among which laboratory examination is often mentioned. In many cases results of laboratory examinations are important in the diagnostic process to test the hypotheses resulting from the history and physical examination (see also § 3.2). Laboratory findings may also provide information about the severity and the course of the condition. In this chapter methods are described for the collection of body fluids and substances often used for laboratory examination.

25.1 Preparation, packaging, and shipping

Decisions about the laboratory examinations to be performed and the collection technique should be made before specimens are collected. The materials needed for collection (syringes, needles, catheters) and for processing (tubes, microscope slides) should be ready for use. Provision should be made for samples that must be cooled immediately to stop enzymatic breakdown. This includes collection tubes chilled in ice and a refrigerated centrifuge.

Samples should be collected with high standards of hygiene and orderliness, both to protect the patient and personnel (zoonoses!), and to prevent contamination and mix-up of samples. For the latter purpose it is important, *prior to collection*, to label all tubes with the number and/or name of the patient and the origin of the specimen, using either preprinted stickers or a permanent marking pen, and to label the frosted end of microscope slides with a lead pencil.

The tubes and slides should be packed carefully to avoid breakage during shipping and should be accompanied by identification of the patient, and the date, time, and method of collection. Other

information that may aid the laboratory in interpreting the results includes pertinent findings in the history and physical examination, whether the animal was fasted, and any medications it has received.

Some diagnostic laboratories provide pickup service and the necessary materials and containers for sample transportation. These are based upon international regulations for transport of biological materials. Couriers also require packaging according to these regulations. The European regulations can be found at www.eurobiobank.eu/common_docs/ (Transport document).

25.2 Materials

25.2.1 Urinary catheters

Many types of urinary catheters are available. The length is usually given in centimeters (cm) and the outer diameter in both cm and according to the Charrière (Ch) or French (F) scale.* The quality of the catheter is important. One that is too rigid may injure the urethra and bladder, while one that is too soft is difficult to direct blindly, as necessary in female dogs and cats. Catheters should not be reused, because resterilizing makes them rigid and gives a rough surface.

Catheters for use in dogs are typically 50 cm long, with a diameter of 3.0 mm (color code orange) for large and medium-sized female dogs, 2.0 mm (color code yellow) for males and small females, and 1.5 mm (color code white) for small males (Fig. 25.1).

The white-coded catheter can also be used for female cats. In cats, especially males, a smaller catheter having a length of 11 cm and a diameter of 1.0 mm (3F) is often used. Because such a thin catheter is insufficiently rigid, it is stiffened by a metal wire (mandrin) that is easily withdrawn after the catheter reaches the bladder (Fig. 25.2).

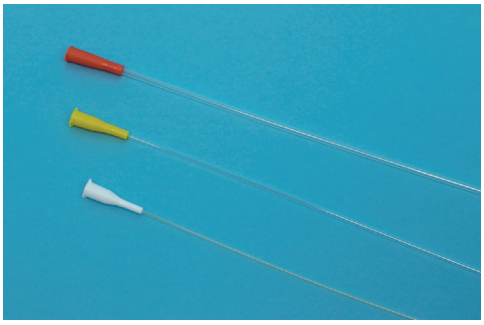


Fig. 25.1 Urinary catheters for dogs with diameters of 1.5 mm (color code white), 2.0 mm (color code yellow), and 3.0 mm (color code orange).

25.2.2 Needles

Disposable needles for injection or blood collection are clean, sterile, and sharp. The length is given in mm and the diameter in mm or as a gauge (G).† The thinner the needle, the less pain it causes, which is especially important in cats.

The needle most commonly used in dogs and cats is 30 mm long and 0.7 mm in diameter (22 G) (color code black). For collecting 10 ml or more of blood, needles of 0.9 mm diameter (20 G) (color code yellow) are used. Small volumes of blood are collected with needles 25 mm long and 0.6 mm in diameter (23G) (color code blue) or 12 mm long and 0.45 mm in diameter (26 G) (color code brown).

The needle package should be opened at the hub end of the needle. The needle should not be placed on the syringe by pressing on its plastic cover, which may make the cover difficult to remove. The needle is placed on the syringe after removing the needle cover. The opening at the tip of the needle should be aligned with the calibration of the syringe (Fig. 25.3).

The needle should be discarded without attempting to replace its cover, putting it directly into a small container designated for disposal of sharp objects.

25.2.3 Syringes

Disposable syringes are available in sizes of 1 to 50 ml. The movement of the plunger is improved by the presence of a rubber cap on the tip of the plunger. The conical tip for the needle is centrally located on small syringes but on large syringes it is eccentric, which facilitates insertion of the needle into subcutaneous veins. The calibration is conveniently placed on the opposite wall of the syringe.

The tip of the syringe can be a simple cone that slips snugly into the hub of the needle or it can be a threaded 'Luer lock' into which the hub of the needle is firmly locked with a half twist.‡

The syringe package should be opened at the plunger end to avoid contaminating the tip, and not by pushing the tip through the package.

Handling the syringe

One hand is used to localize and fix the tissue while the other holds the syringe. For good control of the syringe, the barrel is held between the thumb and

* On the Charrière (Ch) scale, devised by Joseph Bernard Charrière (1803–1876), an instrument maker in Paris, an interval corresponds to about 0.33 mm.[1]

† The 'gauge' (also 'gage') is an Anglo-American standard measure for pipes, firearms, and other tubular objects. A catheter gauge is a plate with graduated perforations for measuring the outer diameter of catheters. In contrast to the Charrière (French) scale for catheters, the gauge of needles is not linearly related to millimeters. In addition, the gauge increases with decreasing size.

‡ Named after the German instrument maker Luer, who worked in Paris (died in 1883).[1]

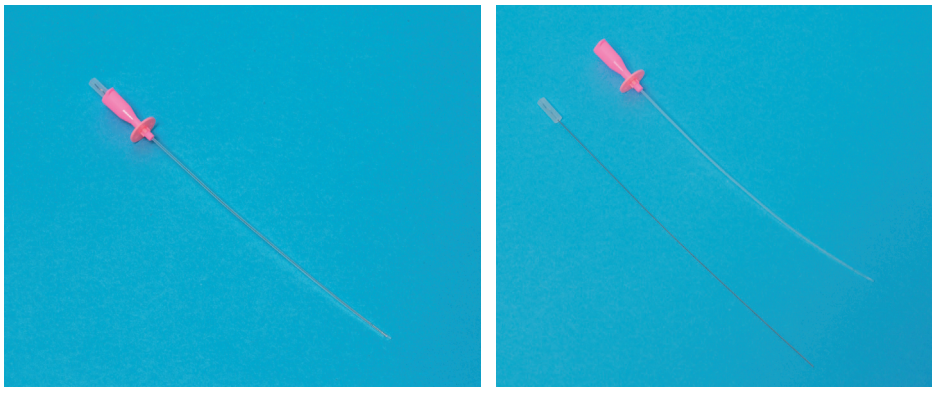


Fig. 25.2 Urinary catheters for cats. On the left the catheter contains a mandrin. On the right catheter and mandrin are shown separately.

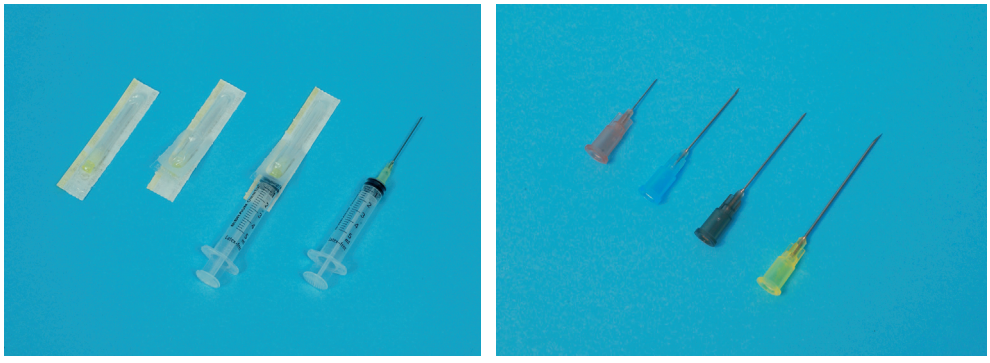


Fig. 25.3 Needles in different stages of use. From left to right: needle still in package, package opened at the hub end of the needle, needle placed on the syringe, package and needle cover removed. Right: the four most commonly used needles in dogs and cats: 0.45/12 mm (color code brown), 0.6/25 mm (blue), 0.7/30 mm (black), and 0.9/30 mm (yellow).

forefinger or middle finger. The ring finger or little finger is used to pull the plunger backward (Fig. 25.4). This motion of the ring finger or little finger may at first be a little awkward, but with practice it can be done without any movement of the syringe and needle.

The negative pressure exerted by pulling the plunger draws in blood or cells for cytological examination. If the suction is too great during blood collection, the vessel wall can be drawn into the opening of the needle, blocking it. If too much suction is used in collecting cells for cytological examination, the cells can be damaged sufficiently to impair interpretation of the smear.

Note: In human patients blood samples are usually collected by use of an evacuated tube with a special needle. This simplifies the procedure and reduces the risk of contact with the patient's blood. This system is not widely used in dogs and cats but it is used in small mammals (Chapter 29 and the DVD).

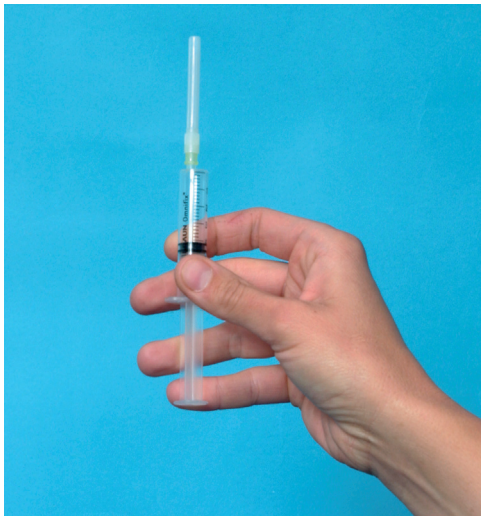


Fig. 25.4 To collect blood, the ring finger or the little finger is used to pull back the plunger.

25.2.4 Disinfection

In dogs and cats subcutaneous and intramuscular injections are usually given without prior skin preparation. Hair is not clipped and a disinfectant is not used. When a blood vessel is to be punctured, for either intravenous injections or blood collection, the hair is often clipped or the skin is even shaved and the skin is disinfected with alcohol. The needle is inserted into the vessel within a few seconds, while the skin is still wet with alcohol.

Studies in humans have shown that all of this preparation is unnecessary. Comparisons after subcutaneous, intramuscular, and intravenous injections with and without skin disinfection have revealed no infections in any form when the skin was not disinfected prior to injection.[2] Nevertheless, a well-performed skin disinfection does decrease the number of skin bacteria considerably.[3,4] It seems advisable to clip the hair and disinfect the skin prior to procedures for which it has not specifically been shown to be unnecessary, including inserting needles into body cavities (§ 25.7 and § 25.8).

The recommendation to stop using skin disinfection prior to injection and blood collection is apparently not easily accepted. In a British hospital in which disinfection prior to injection was officially discontinued, it was still being used by 70% of the doctors and 90% of the nurses 8 years later.[5]

In veterinary medicine there is another reason to clip the hair and to moisten the skin prior to venipuncture: it does improve visibility of the vein. It should nevertheless be avoided or done only with the owner's permission if the animal is used for show and also with the knowledge that in some breeds, particularly among cats, the hair can regrow with a somewhat different color initially.

25.3 Blood

The requirements for blood samples (volume, anticoagulants, storage temperature, maximal duration of transport) should be obtained in advance from the laboratory. Heparinized blood is satisfactory for most clinical chemistry measurements, but samples for measurement of glucose must contain sodium fluoride to prevent glycolysis. Serum is required for determination of the protein spectrum and for immunologic tests. EDTA is used as the anticoagulant for most hematology examinations.

If plasma is required, it is best to centrifuge blood promptly and transfer the plasma to a plain tube, to avoid hemolysis during storage.

If serum is required, the blood sample should be left at room temperature for 10–20 min for formation and retraction of the clot. Placing the tube in an upright position prevents the clot from extending over the full length of the tube and usually results in a larger serum sample, which can be further separated by centrifugation. Tubes designed for obtaining serum contain a gel or synthetic granules that promote clotting and clot retraction. Following centrifugation, the granules or gel forms a layer between the serum and the clot, which facilitates pipetting or decanting of the serum.

25.3.1 Venipuncture

It is usually possible to palpate a vein after it is distended by pressure applied by an assistant. The hair should be clipped if the animal has a thick coat or the vein has been used repeatedly. The syringe is held as described above, with the opening of the needle facing upward (Fig. 25.4).

The cephalic, jugular, and saphenous veins are commonly used in dogs and cats. The cephalic vein is preferred for small samples. Most dogs are restrained on the table in sternal recumbency (sphinx position) (Fig. 25.5). Some may accept a sitting position better, but their sudden movements are less easily controlled.

Cephalic vein

The assistant's task is threefold: to prevent the dog from biting, to extend and fix the front leg, and to compress the cephalic vein. The assistant stands beside the table, grasps the dog's muzzle, and turns its head away from the person collecting the blood (Fig. 25.5). With the other hand the assistant holds the foreleg at the elbow. Leaning over a large dog may help to prevent it from rising. Placing the fingers behind the dog's olecranon will automatically extend the leg. A second assistant may be needed to control the rear legs of a cat.

The cephalic vein lies on the medial side of the carpus and continues up the dorsomedial side of the front leg to the elbow. It lies just beneath the skin. The assistant compresses the vein with the thumb at the level of the elbow, turning the hand slightly outward to shift the vein dorsally. Firm contact between the hand and the table prevents the animal from pulling the leg backward.

The needle should be firmly fixed on the syringe with its opening facing upward and the calibration markings on the syringe should also be facing upward. The person collecting the blood holds the animal's leg lightly in the palm of the hand, just above the carpus. The thumb is placed along the cephalic vein to prevent the vessel from moving away when the needle is inserted through the skin. The hand should not grasp the leg too firmly, which may compress the vein. Resting the syringe against the heel of the thumb after insertion of the needle helps to control unexpected movements of the leg.

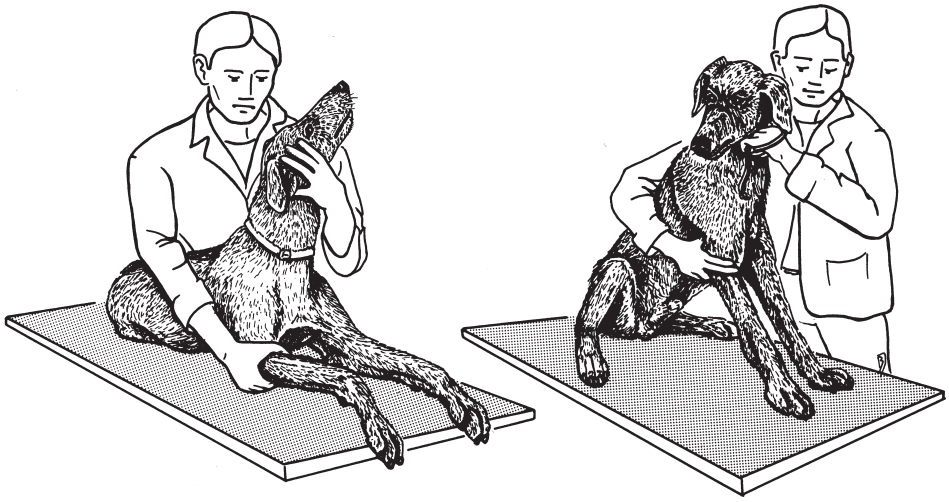


Fig. 25.5 Restraint of a dog in sternal recumbency for collection of blood from the right cephalic vein (left). Some dogs may be more easily restrained in a sitting position (right).

The needle is inserted at an angle of 20–35°. It can be inserted in one movement into the lumen of the vein or in two steps, first through the skin and then into the vein. With the latter approach there may be less rolling away or flattening of the vein by the advancing needle and less likelihood of passing completely through the vein.

When the tip of the needle passes through the skin, retract the plunger slightly and if blood is obtained, advance the needle a little further into the vein. If no blood is obtained, be certain that the vein is not being compressed at the carpus and then try withdrawing the needle 1–2 mm while maintaining slight traction on the plunger.

When the sample has been obtained and the needle is being withdrawn from the vessel, the assistant's hand is advanced beneath the leg until the thumb on one side and the forefinger on the other can pull the skin downward slightly for about one minute. If necessary, a bandage is applied.

Jugular vein

In dogs and cats the jugular vein is used primarily when more than ~5 ml of blood is to be collected (Figs 25.6 and 25.7). A dog is restrained in the sphinx or the sitting position. The assistant stands beside the table and reaches over the dog's back to grasp its muzzle in order to extend its neck and turn its head away from the person collecting the blood. Cats and small dogs are held in the sphinx position with the front legs over the edge of the table. Pulling the leg downward slightly provides enough room for the person collecting the blood to advance syringe and needle parallel to the vein. The assistant restrains the front legs by moving the free hand forward under the front legs for fixation with one finger between the legs. Extending the neck and front legs provides better control if the animal resists restraint, but an additional assistant may be needed to fix the rear legs.

The external jugular vein passes from the base of the ear to the thoracic inlet and can be distended by pressing with the thumb at the thoracic inlet. There are three ways to locate the vein: (1) applying and removing the pressure of the thumb may reveal the contour of the vein as it collapses, (2) using the same approach, the collapse of the vein may be palpated, and (3) tapping across the surface of the neck above the thumb produces a pulse in the vein that strikes the thumb. A combination of these methods may be used.

When the vein has been located, the thumb is raised to just below the middle of the neck. Here it serves as a rest for the needle as well as to fix and distend the vein. With the needle resting on the thumb, it can be inserted at an angle of about 30°. The syringe is handled in the same manner as for the cephalic vein (Fig. 25.7).

Saphenous vein

Blood can also be collected from the lateral saphenous vein in dogs and the medial saphenous vein in cats. The assistant restrains the dog in lateral recumbency and grasps the upper hind leg just above the stifle. This extends the leg and simultaneously distends the vein. This always makes the saphenous vein visible but inserting a needle into its lumen can be hindered by the tendency of the vein to roll away from the needle.

With the cat restrained in lateral recumbency, the upper hind leg is moved away so that pressure can be applied in the groin of the lower leg. The thinness of the skin enables good visualization of the medial saphenous vein (Fig. 25.7).

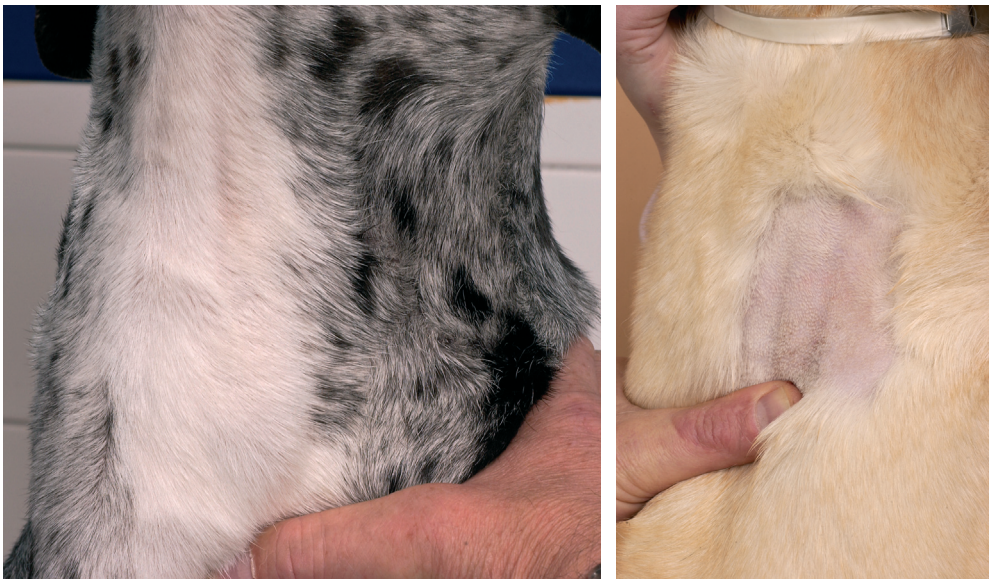


Fig. 25.6 In a short-haired dog with a long neck, pressure applied just above the thoracic inlet distends the jugular vein (left). In long-haired and obese dogs and in cats, the jugular is visible after clipping the hair.

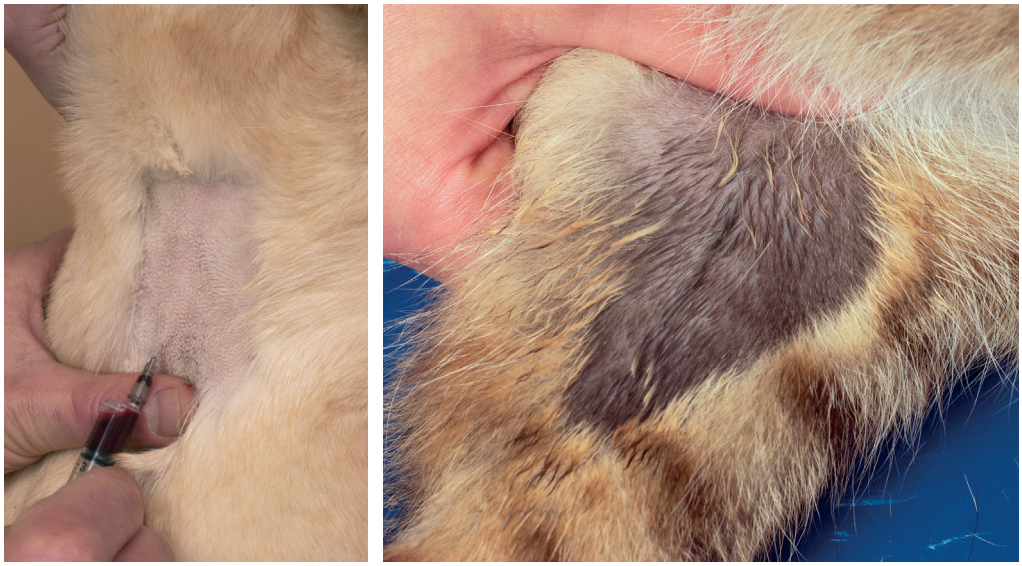


Fig. 25.7 Distended jugular vein in a dog (left) and a distended medial saphenous vein in a cat (right).

25.4 Urine

Just as for blood examinations, there are certain requirements for examinations of urine. Urine for bacteriologic examination should preferably be obtained by cystocentesis and applied to the culture medium as soon as possible.[6] Only drops are needed for measurement of specific gravity by refractometry or osmometry and to test for glucose, but 10 ml are required for a comprehensive examination of the urine sediment.

The first morning urine is usually the most concentrated and therefore more likely to reveal abnormalities, although in highly concentrated urine the cells in the sediment may loose some of their cytological characteristics. The owner can be asked to collect urine every two hours in order to examine the course of urinary concentration during the day.[7] Urine samples for measurements of the cortisol/creatinine ratio should be collected at home in order to avoid the effect of stress associated with a visit to the veterinarian.[8]

25.4.1 Collection methods

Voided urine

Collecting urine during the middle of micturition reduces but does not completely avoid contamination from the lower urinary tract. Urine collected by cystocentesis from healthy dogs is sterile.[6]

Some cats allow the owner to collect urine in a shallow dish during micturition. If not, a modified litter can be used. The usual litter is replaced by washed gravel for use in aquariums or commercially available granules of synthetic material. Many cats will accept this change in the litter if given a day or two to become accustomed to it. The urine is decanted through paper filter or gauze into a small container with hermetic cap.

In some cats urine can be obtained by bimanual compression of the bladder, using moderate pressure while stretching the bladder cranially as much as possible.

Urethral catheterization

A lubricated catheter can normally be introduced into the bladder without meeting significant resistance. The volume of the urine obtained via the catheter is measured. If the animal has urinated shortly before the examination, this residual volume should be no more than a few milliliters.

Urine obtained by catheter can be used for laboratory examination, taking into account that it often contains more erythrocytes than that obtained by spontaneous micturition. It can also be used for bacteriological examination but is easily contaminated by bacteria from the lower urinary tract in spite of aseptic procedures of catheterization.[6]

Catheterization of male dogs and cats (Fig. 25.8). The preputial opening is cleansed with a disinfectant cream and the penis is exposed slightly. The tip around the urethral orifice is also cleansed with the cream after

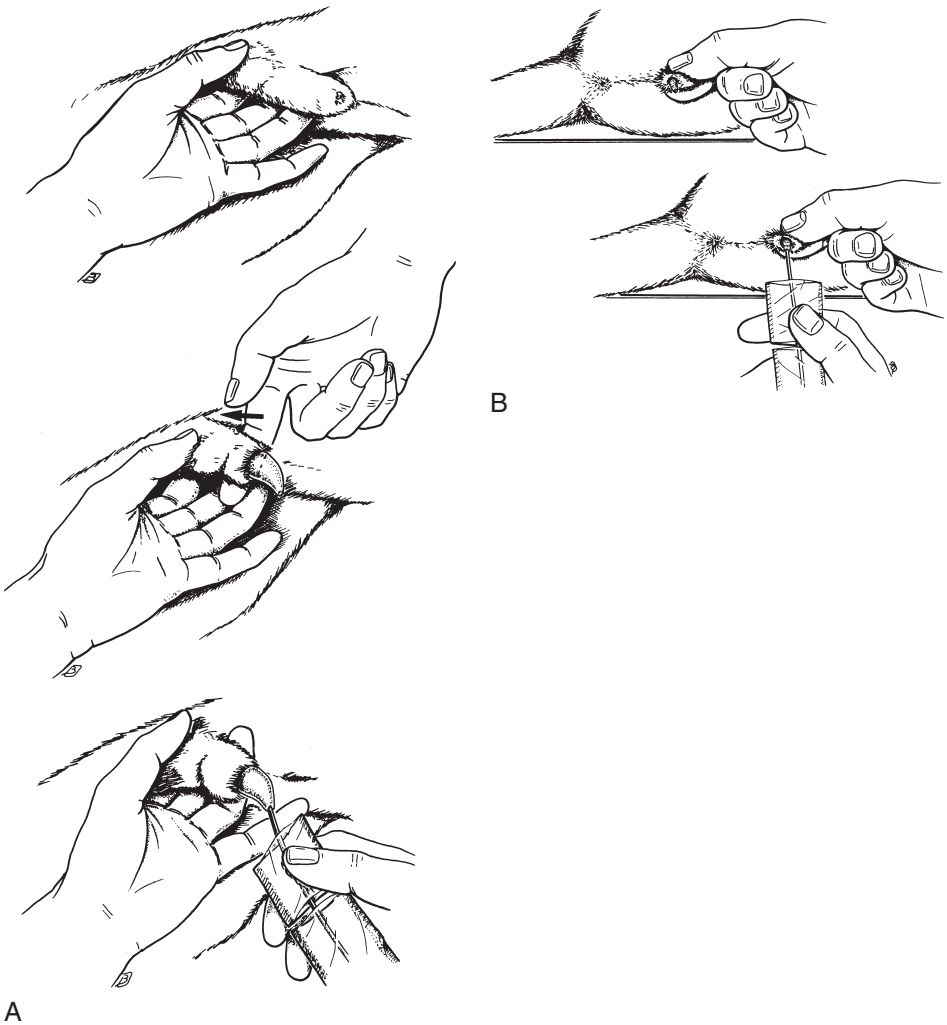


Fig. 25.8 Catheterization of a male dog (A) and male cat (B) with minimal contamination.

being anesthetized with 10% lidocaine spray. The same cream is applied to the catheter as a lubricant. With the penis extended from the prepuce, the catheter is inserted until urine appears. In a healthy male dog the insertion of the catheter will meet very slight resistance at the level of the os penis and again as the catheter passes around the ischiatic arch, where the urethra makes a sharp turn. If careful manipulation does not overcome the resistance quickly, the possibility of a calculus in the urethra should be considered.

In the male cat the urethra is stretched out by grasping the base of the exposed penis and pulling it caudally (Fig. 25.8). A sufficiently thin catheter can then be inserted into the bladder without hindrance.

Catheterization of female dogs and cats (Fig. 25.9). Hair is clipped from around the vulva if necessary and the vulva is disinfected. The external orifice of the urethra is not visible externally in female animals but is located at or directly cranial to the transition between the vertical and horizontal parts of the vagina (Fig. 13.3). This is considerably cranial to the clitoral fossa, which is sometimes mistaken for the urethral orifice. In large female dogs in which the transition from vestibule to vagina is not too narrow, it may be possible to introduce the catheter under the guidance of a finger. The forefinger is introduced into the vagina until the horizontal part is reached. By bending the finger the urethral orifice can usually be palpated at the transition from the vertical to the horizontal part of the vagina and the tip of the finger is kept just cranial to the orifice to guide the catheter. The catheter is introduced beneath the finger and by slight pressure of the finger it is guided into the orifice. If the catheter can be advanced further without being felt by the finger, it is in the correct position.

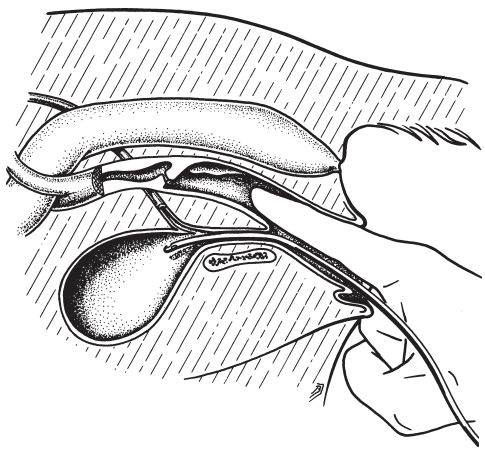


Fig. 25.9 Position of the guiding finger during catheterization of the female dog.

In smaller female dogs a vaginoscope is used to visualize the orifice of the urethra. Catheterization can also be performed completely blindly. Slight traction on the vulva stretches the vagina caudally to bring the vestibulum into a horizontal position. Then a catheter used for a medium-sized male dog is carefully introduced via the dorsal edge of the vulva to avoid entering the clitoral fossa and is advanced over the floor of the vestibulum. Careful manipulation is necessary because repeated disturbance of the cervix can cause considerable resistance. Certainty about the position of the catheter will only be provided by the flow of urine.

Cystocentesis

The bladder, which should be moderately filled for this procedure, is located by palpation, with the animal standing or lying on its side. If the animal is standing the bladder is easily located against the ventral wall of the abdomen, but the animal has appreciable freedom of movement. If restraint is required, the animal should be placed in lateral recumbency. This is also the best position for small and medium-sized dogs. The neck of the bladder is grasped between the thumb and forefinger to push the bladder slightly in the cranial direction. This is analogous to holding a somewhat tense balloon between the thumb and forefinger. The bladder is less easily palpated in dogs in dorsal recumbency but this position is well suited for cystocentesis in cats because the animal can be restrained more easily.

The needle is introduced into the bladder through the abdominal wall in the midline, cranial to the pelvis, usually at the level of or just cranial to the caudal nipples (Fig. 25.10).

25.5 Feces

For a rapid test for parvovirus infection, only a drop of fecal material is needed. Fecal samples on three consecutive days should be used for examination for parasite ova. Parasites such as Giardia do not survive long in the open air and can only be detected in fresh feces. Bacteriologic examination of feces seldom provides useful information.

Bacteria normally present in feces can affect the proportions of carbohydrate, protein, fat, and fatty acids and thus samples for determination of these should be refrigerated.

25.5.1 Collection methods

Spontaneous defecation

A sample of fresh feces can be collected in a plastic container having a small spoon in the cap, taking care to avoid contamination with soil, which may also contain parasites.

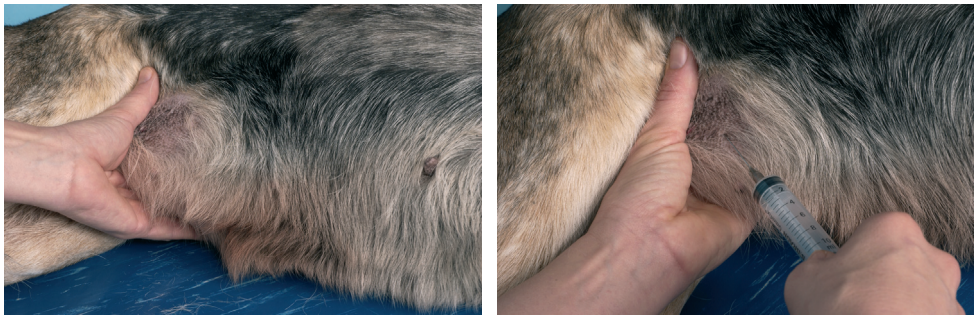


Fig. 25.10 Cystocentesis in a dog in a lateral position.

Collection from the rectum

Feces can be collected from the rectum by use of a gloved finger with a lubricant. Defecation can sometimes be provoked by stimulating the anus with a ball of cotton.

25.6 Tissue cells

25.6.1 Fine-needle aspiration biopsy (FNAB)

Aspiration biopsy is usually performed with a fine needle.[9] The method is relatively easy to learn and inexpensive, and in an institution with facilities for staining, the results can be available within half an hour. FNAB is usually performed without anesthesia, which allows it to be used during a consultation. In veterinary practice, the slides are sent to a laboratory for staining and interpretation. FNAB can also be repeated at intervals for follow-up. The risk of induction of metastases with FNAB is negligible.

A choice can be made between surgical biopsy for histological examination and FNAB for cytological examination. For cytological examination the predictive value of a positive result is higher than that of a negative result (see also § 3.1.5). In other words, the absence of cancer cells in a cytological examination is less reliable than the finding of cancer cells. There can be various reasons for false-negative results. Also, FNAB cannot, of course, provide a histological diagnosis.

25.6.2 Collection of the specimen

Equipment needed for FNAB:

1. glass slides with one matted end
2. 10-ml syringe
3. *thin* needle (0.7 mm, color code black)

The name and number of the patient is written on the matted end of the slide with a lead pencil, which does not dissolve or smear in the staining fluids. Thicker needles do not provide better aspirates. Instead, they aspirate thicker clumps of cells which give thicker smears with more damaged cells, and they are more difficult to stain and to interpret. In addition, the use of thick needles increases the chance of aspirating blood.

The patient is restrained by the owner or the assistant. The mass to be aspirated is fixed with one hand and the needle is inserted (Fig. 25.11). Retraction of the plunger only 1–2 ml is usually sufficient to aspirate material. To obtain a representative sample, the needle is moved in and out at various angles without removing it from the mass and while maintaining the slight vacuum in the syringe. Usually only a small amount of material appears in the tip of the syringe during this process.

If blood suddenly appears in the syringe, it is better to replace the needle—and syringe if necessary—and begin again, for blood interferes with interpretation of the smear. Before withdrawing the needle from the tissue, the plunger should be released to cancel the negative pressure. This ensures that the aspirate remains in the needle and syringe tip and is not drawn into the body of the syringe, from which is difficult to expel without great damage to the cells.

The needle is removed from the syringe, the plunger is retracted to the 4-ml mark, the needle is reattached, and the material in the needle is expelled onto a glass slide. The preparation of the smear is the same as for smearing out a drop of blood. A second glass slide is placed at an angle of 45° against the material on the specimen slide and the smear is made in a smooth movement.

The most widely used methods for staining FNAB smears in veterinary medicine are Romanovsky-type stains[§]: Giemsa, May-Grünwald, Hemacolor. The smears are fixed by drying in air at room temperature and the dried smears can also be stained satisfactorily after long storage.

§ The Russian physician Dimitri Leonidow Romanovsky (1861–1921) developed one of the first contrast stains for malarial parasites with a concentrated solution of methylene blue and eosin. This principle is also applied in the stains introduced by William Boog Leishman (1865–1926; English health officer), Gustav Giemsa (1867–1948; pharmacist and chemist at Berlin and Hamburg), and others. The well-known May-Grünwald stain for blood smears is named after the German physicians Richard May (1863–1936) and Ludwig Grünwald (born 1863).[1]



Fig. 25.11 Position of the needle and syringe for fine-needle aspiration of a mass. After the needle enters the mass, the plunger is retracted 1–2 ml (A). The aspirated material is expelled onto a glass slide (B) and is spread with the end of another glass slide (C).

25.7 Thoracocentesis

If there is pleural effusion, only 10–20 ml of the fluid need be aspirated (thoracocentesis) for cytological, chemical, and bacteriological examinations.

In dogs and cats the mediastinum contains little connective tissue. In several areas it consists of no more than two sheets of pleura.[10] Pleural effusion and/or the underlying process often leads to damage to the fragile mediastinum to the extent that fluid accumulates on both sides. The fluid may also be in separate cavities. If it is uncertain whether fluid cavities on the two sides are connected, it is advisable for diagnostic purposes to consider each half of the thorax as a separate compartment and to aspirate from both.

25.7.1 Method

Contamination of the pleural fluid can have life-threatening consequences and therefore the site is thoroughly prepared and disinfected (see also § 25.2.4). In order to decrease the chance of pneumothorax and of contamination, a closed system is always used. A 10–20 ml syringe with a three-way stopcock is connected to a 0.7-mm needle (color code black) by intravenous extension tubing. Alternatively, a butterfly needle with its flexible tubing can be used (Fig. 25.12).[11] The flexible tubing allows freedom of movement for both the patient and the person handling the syringe and needle.

The patient can be standing or in sternal recumbency. The needle is inserted in the 7th or 8th intercostal space ventral to the line of dullness found by percussion, which is often below the costochondral junction. Thus there is little risk of piercing the heart or the abdominal cavity. When the tip of the needle is in the subcutis, the plunger is retracted 1–2 ml. This slight vacuum is maintained as the needle is moved slowly through the thoracic wall, directly cranial to the rib to avoid the costal vein and artery, which lie caudal to the rib. Immediately after penetration of the pleura, fluid will flow into the syringe and there is no reason to advance the needle further.



Fig. 25.12 Equipment for diagnostic thoracocentesis: a 10 or 20 ml syringe with the needle attached directly (top), or connected by flexible tubing (middle), or replaced by a butterfly needle (bottom).

25.8 Abdominocentesis

Aspiration of fluid from the abdominal cavity (abdominocentesis) is usually confined to the amount needed for diagnostic purposes. Certainly if the fluid is a transudate, removal of a large amount is contraindicated. Unless the cause of the ascites has been removed, the fluid will be replaced quickly and the abdominocentesis will only have led to considerable loss of fluid, electrolytes, and protein. If the fluid is an exudate or urine, its complete removal may be beneficial. Nevertheless, attention should be focused on the cause of the problem.

25.8.1 Method

The dog should preferably be standing, so that the fluid will accumulate in the ventral part of the abdomen. The site is prepared as described in § 25.7. The equipment is the same as for thoracocentesis (§ 25.7.1). With careful insertion of a 0.7-mm needle the risk of piercing or damaging the intestine is negligible. The needle is inserted on the ventral midline, a few centimeters caudal to the umbilicus, which avoids the falciform ligament as well as the urinary bladder, which should be emptied prior to abdominocentesis. If there has been previous abdominal surgery, the needle should be inserted off the midline to avoid possible adhesions of abdominal structures to the abdominal wall along the previous midline incision.

Only slight suction should be used to aspirate fluid, to avoid drawing omentum or other structures against the tip of the needle. Passive flow of fluid through the needle may be sufficient.

If there is only a small amount of fluid in the abdomen, a diagnostic lavage may be helpful.[12]

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26 Preanesthetic examination

L.J. Hellebrekers

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The history and physical examination are not only used to clarify or resolve a problem noted by the owner of a companion animal but can also be performed at the request of the owner or, as discussed here, prior to general anesthesia.

26.1 Principles

The administration of pharmacological agents to achieve sedation, analgesia, or general anesthesia can be viewed as a controlled intoxication. This leads to both desirable and undesirable changes, the severity and duration of which are dependent on the general and emotional condition of the patient, the specific characteristics and dose of the drug administered, and its metabolism and excretion by the patient.

By means of the preanesthetic examination one tries to determine the anesthetic risk in order to inform the owner and to determine the most appropriate method of anesthesia for the patient. The anesthetic risk is then weighed against the importance of the indication for anesthesia. To determine the anesthetic risk one must have good insight into the functioning of those organ systems which, if abnormal, could adversely influence the progress of the anesthesia. Often there are several options to achieve the desired level of anesthesia. Apart from the available knowledge and experience of the veterinarian, the choice of the method of anesthesia is determined by the specific problems of the patient. If necessary, supportive measures are added.

The initial examination will not always have provided the specific information needed to determine the anesthetic risk and to choose the best method of anesthesia. Hence a preanesthetic examination is performed to obtain an impression of the functioning of the vital organ systems. Both the initial examination and the preanesthetic examination may reveal abnormalities which need to be more fully defined by further examinations. In this regard there are always two important considerations:

1. To what extent is it likely that abnormality of a specific variable is due to an abnormal organ function?
2. To what extent is it to be expected that the abnormality will affect the operative and postoperative course?

If the information from the history and preanesthetic examination is always assessed in this way, adequate characterization of the problem can usually be achieved with a minimum of additional investigation.

The preanesthetic examination should preferably be performed the day before anesthesia so that there will be sufficient time for any additional examinations that may be needed. On the basis of the findings, part or all of the preanesthetic examination can be repeated just before anesthesia. If the preanesthetic examination has been carried out more than a couple of days in advance, it is advisable, even if no abnormalities were found, to at least re-examine the functioning of the heart and lungs. If this reveals any important change, the entire preanesthetic examination should be repeated.

26.2 Basic examination

The following elements are included in the basic preanesthetic examination.

- *Signalment*: in addition to age and gender, the breed is important because of certain breed predispositions (impaired liver function in Bedlington terriers, upper airway obstruction in English and French bulldogs, sensitivity to some anesthetics in greyhounds).
- *History*: in addition to information about the disease or abnormality, questions should be asked about the animal's exercise tolerance, alimentary tract function, and behavior.
- *General impression*: the animal's level of consciousness, behavior, and nutritional condition are noted.
- *General examination*: special attention is given to respiration, pulse, temperature, and mucous membranes (color and capillary refill time, see § 8.3.5).
- *Respiratory system*: the lungs are auscultated carefully.
- *Circulatory system*: in addition to evaluation of the peripheral pulse, the heart is auscultated and the venous circulation is assessed.

If no abnormalities are revealed by this basic examination, no further examination is needed.

26.3 Further examination

If abnormalities have been found, the preanesthetic examination is extended by *further examination of one or more organ systems or parts thereof*. There may be a need for additional examinations such as an ECG, diagnostic imaging, or laboratory examinations.

The indication for laboratory examination should be based on relevant information gathered in the history and physical examination. The routine performance of preanesthetic laboratory studies, as in elderly humans, does not improve prediction of the course of the anesthesia.[1]

One should not only be aware of the predictive value of laboratory results but also have decided upon so-called 'action-limits'. These values, above or below which further examination or a change in the planned anesthesia or surgery will be considered, do not necessarily have to be the same as the 'reference limits' for the variable.

26.4 Risk categories

On the basis of the information from the basic preanesthetic examination, together with information from any further examinations, the anesthetic risk can be categorized. For this purpose the classification of the American Society of Anesthesiology (ASA) can be used.[2] The definitions of these categories are as follows:

category 1: healthy individual with no detectable disease

category 2: slight systemic disease without loss of function

category 3: severe systemic disease with moderate loss of function

category 4: severe systemic disease with life-threatening loss of function

category 5: moribund, life expectancy without treatment less than 24 hours

The assignment of a risk category serves especially as a warning. For each category, guidelines can be developed for special treatment or special supportive measures to be taken in connection with the anesthesia.

26.5 Notation

The indication for anesthesia, the results of the preanesthetic examination, categorization of the risk, and instructions for the anesthetist or the surgeon can be noted on a standard form such as that shown on the DVD.

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2 http://www.asahq.org/clinical/physicalstatus.htm

27 Health certification

F.C. Stades and A.A. Stokhof

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An examination for health certification is usually made at the request of the owner, often for litters at the age of 6–9 weeks, sometimes for newborn animals or litters in which congenital abnormalities have been observed. A health examination may also be performed routinely with the first vaccination, or as part of a legal procedure when a new owner is not satisfied with an animal, or in any animal intended for purchase or sale.

27.1 Health certification in young animals and/or animals changing owners

The discovery of abnormalities which could lead to serious problems later is obviously of great importance to the owner. The approach to the examination does not differ in essence from that described in Chapter 8. It has, however, a more screening character, directed to the detection of congenital abnormalities, hereditary or not, which could adversely influence the life expectancy or the functioning of the animal. The term congenital refers not only to abnormalities detected immediately after birth, but also those present at birth but not discovered until later.

Health certification shortly before purchase or transfer of an animal decreases the chance of nonconformity with the expectations of the buyer. However, the buyer could also be dissatisfied with the conditions (which should preferably be in writing) agreed at the transaction.

In several countries, the new owner is under obligation to examine the animal to the best of his ability for undesired characteristics, preferably prior to the purchase. For greater certainty, the buyer may request an examination by a veterinarian, preferably one chosen in agreement with the seller. Once the transaction has been completed, it is still possible for an examination to be performed by the veterinarian representing the buyer, possibly in agreement with the seller.

In this way the buyer's attention is drawn at an early stage to the presence or absence of pertinent characteristics or conditions. There may be specific expectations concerning the fitness of an animal as a guard dog, the qualities of a show cat, the suitability of an animal for training, or the absence of hereditary diseases. If the expectations have been made explicit prior to the transaction and are not met, the buyer may wish to stop the purchase procedure, to ask for restitution of part of the purchase price, or to cancel the transaction. Early detection of an abnormality during a health examination can also improve the prospects for a good response to treatment.

When the purchase examination has revealed undesirable characteristics that give rise to an unsettled dispute, the buyer may claim default by the seller and attempt to achieve restitution of the purchase price or nullification of the transaction via a legal procedure.

To ensure that the examination is performed as efficiently and completely as possible, a standard checklist or form can be used. After a short case history, the general physical examination is performed and then more specific attention is given to the eyes, ears, respiratory system, circulatory system, digestive tract, urogenital system, and locomotor system.

27.2 Notation

The form on the DVD can be used simply as a checklist or as a health certificate. A place is provided for the signature of the veterinarian.

The third column contains important characteristics which should be found in a healthy animal. The 'wad

of paper' refers to the reaction of a pup or kitten to a wad of paper thrown before it. The expected reaction by a pup is to run after it and possibly even to retrieve it. A healthy kitten can be expected to play with it.

The fourth column provides space for important abnormalities; unmentioned abnormalities can also be noted. The fifth and the sixth columns give an overview of whether or not abnormalities have been found, and this is summarized at the top of the form by checking yes or no. If yes is checked, it will be of concern to the owner whether the abnormality is considered to be severe or less severe and whether further diagnostic examination is desirable. In particular, the estimated life expectancy of the patient will be important to the owner in reaching a decision about purchase. A few points in the fourth column are explained below:

- *Eye examination*: ppm means persistent pupillary membrane, aplasia means not formed, dysplasia means abnormally formed. Other examples are microphthalmus, entropion, dermoid, and cataract.
- *Nose, respiration, and circulation*: when examining for deformity of the thorax, also take note of the sternum, and congenital heart disease such as stenoses, valve defects, and shunting!
- *Digestive tract*: attention is given to the incisors, canine teeth, premolars, molars, and palate. In comparison with the dental formula of the normal animal, the absence of elements or the presence of too many elements is noted. Severely abnormal placement of elements is also reported, as well as a fissure of the palate.
- *Urogenital system*: look for congenital abnormalities. In the pup the testes reach the scrotum at around the 35th day postpartum.[1]
- *Locomotion*: the toes are examined for the presence of dewclaws and (taking them into account) the presence of the normal number of toes should be confirmed.

The fontanel should be closed at birth. In some small breeds of dogs it remains open, which obviously constitutes a risk. A prominently rounded skull can also be found in small breeds and can be a sign of hydrocephalus.

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28 Birds

J.T. Lumeij

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About 150 million years ago birds (class Aves) developed from lizard-like reptiles. Many of the anatomical and physiological characteristics of birds are similar to those of reptiles. An important difference is that birds are homoeothermic and reptiles are poikilothermic.

The characteristics which birds have in common are: a plumage, jaws without teeth, extensive systems of air sacs with connections to the pneumatic skeleton, a four-chamber heart, and the absence of both a diaphragm and a urinary bladder. All birds are oviparous.

There are about 8900 species. On the basis of different anatomical and physiological characteristics they are divided into 1800 genera, 160 families, and 27 orders. This classification is a good starting point for the veterinarian in making use of the normal anatomy and physiology as a basis for pathophysiology. Knowledge of the veterinary aspects of known species in a given order or family can be utilized in dealing with less well known species in the same order or family.

28.1 History

The first contact from the owner of a bird that is ill is usually via the telephone. In order to achieve the most from the visit to the veterinarian which can follow, it is worthwhile to provide the receptionist with a list of instructions that can be given to the owner by telephone (see Addendum at the end of this chapter).

History form

If the condition of the patient allows time for it, a printed history form is given to the owner to fill in while waiting (shown on the DVD). The history form does not go directly to the iatrotropic problem but obtains a fairly complete picture of the functioning of the bird, the living conditions, and the past history. At the first consultation the owner is instructed to answer all questions and then at subsequent consultations concerned with the original problem, only the questions under A need be answered.

Signalment

After the iatrotropic problem has been well defined and has been noted on the examination form (see the DVD) the signalment is checked to be certain that the signalment recorded by the receptionist is correct. To which species does the bird belong? In addition to the common name, the Latin name can be important in order to search for specific information in the literature.

Within many species of birds there are many known subspecies which can be distinguished on the basis of size or color. As an example, the nominate form of the African gray parrot (*Psittacus erithacus erithacus*) has a black beak and a red tail, while a smaller subspecies, the 'timneh' (*Psittacus erithacus timneh*), has a horn-colored beak and a rust-brown tail. Now and then a timneh parrot is sold as a young bird of the larger subspecies.

It is also important to know how old the bird is, how long it has lived in captivity, and how long it has been with the present owner. In macaws and African gray parrots the color of the iris can aid in determining the age. In the first year of life of macaws, the iris is darkly colored. Between one and three years of age the iris is white, and in birds older than three years (adults) it is yellow. In African gray parrots the iris color changes from brown to gray to white.

It is of clinical importance to differentiate between birds that have been in the possession of the owner for a long time and those that have only recently been acquired. A disease that is not seen in newly imported parrots but does occur in those that have already been in captivity for many years and fed a deficient diet is vitamin A deficiency (see below).

Gender

It can also be important to know whether the bird is male or female, although in many species of birds this can be difficult or impossible to determine by external characteristics. Occasionally one is confronted with a bird that does not appear to be of the gender the owner supposes, sometimes leading to surprising findings (such as the diagnosis of egg peritonitis in a supposedly male emu).

The gender of certain species of birds can be differentiated on the basis of external sex characteristics. Thus in most white cockatoos the gender can be determined by the color of the iris. The iris is red-brown in adult females and brown to black in adult males.

In many species of birds (such as the mallard, see under Feathers in § 28.3.2) the gender can be determined by the color of the feathers. In budgerigars the gender can be determined by the color of the cere. In some species gender can be confirmed by cloacal examination, because of the presence of a large phallus in the males (see Examination of the cloaca in § 28.6).

Often it is difficult or impossible to determine gender on the basis of the above characteristics and endoscopic examination of the gonads is necessary for this purpose. Gender can also be determined by chromosome analysis (karyotyping) and by DNA analysis. These methods are based on the difference between the sex chromosomes of females (zw) and males (zz). The W chromosome on the CHD-W gene has been strongly conserved during evolution. It occurs in almost all bird species and is used in the universal method of gender determination in birds. An almost identical CHD gene occurs on other chromosomes in both male and female birds. The presence of this CHD-NW gene serves as an internal test control for false-negative results. After PCR

primers amplify the CHD-W and CHD-NW genes, they can be separated by electrophoresis, revealing whether the bird has only one (CHD-NW) and is thus a male, or has both and is thus a female.[2]

Problem

After the signalment of the bird has been verified as far as is possible and has been noted, the history form filled in by the owner is used to determine whether there are important points requiring clarification.

Housing and feeding

Then information about housing is noted and questions are asked to determine whether the feeding is adequate. For example, a frequently occurring feeding error is feeding Psittaciformes a diet that is deficient in calcium and vitamin A. Parrots are often fed a diet of seeds alone, sold in pet shops under the name of 'complete parrot food'. The affected birds often have a distinct preference for sunflower seeds and peanuts. The calcium content of such food is too low and the Ca/P ratio is incorrect. This can lead to demineralization of the skeleton. Fractures can occur if such a parrot resists handling for examination, which is extremely undesirable during a consultation. In carnivorous birds in captivity nutritional secondary hyperparathyroidism (all-meat syndrome) can also lead to inadequate mineralization of the skeleton. Complete parrot food is now commercially available as extruded pellets.

Symptoms in contact persons

The question of whether symptoms of illness have been observed in contact persons not only serves the purpose of obtaining information necessary for the diagnosis in the bird but also makes the owner aware of the fact that keeping birds is not completely free of danger to his or her health. Chlamydiosis (psittacosis) is occasionally found in recently-purchased parrots and the disease can be transmitted to people. The signs very closely resemble those of the flu. Chlamydiosis can be fatal in people and it is the responsibility of the veterinarian in case of suspicion of this disease to contact the physician of the owner or advise the owner to do so. Chlamydiosis is a notifiable disease, both in humans and in birds. There is also a genuine risk of infection for veterinarians who are regularly in contact with birds. Fortunately the prognosis is favorable if treatment with tetracycline is started promptly.

Vaccination

If the owner has indicated on the history form that a vaccination has been given, information about this should be given on the examination form, including what type of vaccination, the date and method of vaccination, the type of vaccine, and whether or not there was a vaccination reaction.

Falcons

In falcons there are other specific questions of importance in taking the history. A serious falconer can give you detailed information about any recent change in the patient's weight.

By means of a qualitatively and quantitatively adapted system of feeding, hunting birds used in falconry are held at a lower body weight during the hunting season than during the molt. This system, which must lead to an optimal balance between good physical condition for hunting and as great as possible a capacity to hunt and return to the falconer, has disadvantages. These must be managed by a number of measures, including the daily weighing of the bird. During molting there is less daily contact between the falconer and the bird. The bird is not used for hunting, is not weighed and is fed ad libitum with nourishing prey, such as pigeons. Behavioral abnormalities which could indicate poor health are generally noticed less quickly in this period than in the hunting season.

28.2 Examination of the cage or aviary

Examination of the cage or aviary and its immediate surroundings often provides important diagnostic information. During a house call the aviary can be inspected. A bird cage can be brought to the office of the veterinarian. Various points can be taken up by using a checklist on the examination form.

Feces of other animals

In aviaries which can be contaminated by feces of wild birds or of rodents, infection with *Yersinia pseudotuberculosis* (rodentiosis) is found occasionally. Infections with *Mycobacterium avium* (avian tuberculosis) or *Syngamus trachealis* (gape worm) can occur in the same manner.

Toxic materials

Various toxic materials can cause problems in birds. The most frequently occurring and most frequently reported intoxication in wild and captive birds is lead poisoning. An important risk group is formed by the psittacine birds. Because of the destructive way in which they treat their surroundings they are predisposed to ingestion of lead. This heavy metal is still widely encountered in the household environment. It can be important in taking the history to go through the following list of possible sources: lead weights in curtains, air rifle pellets, lead solder, lead foil from wine bottles, lead weights for fishing, lead-containing toys (self-righting puppets), Christmas tree decorations, lead paint, lead weights of various kinds, leaded glass windows, linoleum.

Position

The position of the cage or aviary is important with regard to the influence of the weather and of

temperature changes. Hence a bird in a cage on the window sill is exposed to great changes in temperature, to humidity, and often to direct sunlight, sometimes without the possibility of escaping into shadow. Combustion products of butter and fat and of polytetrafluorethylene (PTFE), the nonstick coating used for cooking utensils, can be lethal for birds, as can many kinds of household aerosol sprays.

Freely moving birds

If birds can move freely in the room, there are other potential dangers such as the closing of doors, windows, pans with hot cooking oil, hot-plates and stoves, threads, and possibly predatory animals in the house. If an animal bite is not directly fatal, sepsis can still be caused by *Pasteurella multocida*. Immediate treatment with an intramuscularly or intravenously administered penicillin preparation is then indicated in order to save the bird.[2]

General hygiene

It is important to form an impression of the general hygiene of the place in which the bird is kept. Is the construction such that good cleaning and disinfection is possible and is this also indeed carried out? It is impossible in an outdoor aviary with a sand floor to maintain good hygiene.

Daylight

In birds several physiological processes are determined by the length of the period of daylight. Birds that are kept in the living room of a home are (unconsciously) exposed to an unnatural daylight length because lights are turned on in the evening. In the average living room the daylight length in the summer is about the same as in the winter. In some species of birds it has been shown that manipulation of the daylight length can lead to problems in molting. Reproduction is also determined by daylight length in many species of birds. Lengthening of the daylight in the winter months is, for example, used to bring about egg production in chickens during the entire year.

Design

The safety of the cage or aviary is assessed by looking to see whether the bars are close enough together so that the bird cannot get its head or wings between them. The distance between the bars should also be the same overall so that the bird cannot get part of its body through at one place and then become trapped.

The perches must be of such a diameter that the bird's foot cannot completely encircle them. If the perches are too thick, pressure sores can develop on the soles of the feet and these can become infected (bumblefoot). If there are perches of different diameters in the cage, the pressure points on the bird's foot will vary and the bird can choose its perch. Perches that are covered with sandpaper 'to keep the nails filed down' promote foot sole ulcers. Smooth plastic perches are too smooth to enable birds to get a good grip on them. Ribbed plastic perches provide a constant source of infection for the foot sole because feces accumulate between the ribs. The best solution seems to be smooth wooden perches. Cracks on the underside and at the ends of the perch should be examined for the presence of the 'red mite' (*Dermanyssus gallinae*). These parasites also remain during the day in nesting boxes, on the cuttlebone, or under the bottom of the cage. It is helpful to use a magnifying glass to detect them. The location of the perch is of importance in connection with possible contamination of food and water dishes.

Regurgitation

Cage 'enrichment' with mirrors and plastic birds sometimes causes male parakeets to begin regurgitating. This is a component of the display behavior and should not be mistaken for an illness. Some species of birds regurgitate undigested parts of the food in the form of castings or pellets. This is known to occur in crows, sparrows, thrushes, falcons, and owls, among others. In the case of birds used for falconry, it is necessary to ask how long it was after eating that the pellet was regurgitated, whether the prey was adequately digested, and whether it was mixed with mucus or blood.

Food and food residues

In addition to the information given by the owner about the bird's food, it is worth looking at the food and the residues of food present in the cage, to see whether all of the food is eaten or whether the bird has a preference for certain seeds. A frequent problem is that although a reasonably balanced diet is provided, the bird very selectively picks out the parts it prefers and leaves the rest, after which the owner provides the next 'complete meal'. During the taking of the history and the examination of the cage one can see whether the bird has an appetite.

Feces

The macroscopic appearance of the feces varies greatly among species of birds and experience is required to assess what is normal or abnormal. The presence of blood, mucus, tissue, or pseudomembranes is obviously abnormal. In order to examine the feces of hospitalized birds, the floor of the cage can be covered with a sheet of waxed paper. The urine and the feces are excreted together from the cloaca. The urine of birds contains uric acid as the end product of nitrogen metabolism and it is normally visible as a 'white flag' on the feces.

When there is polyuria, a pool of clear fluid is seen around the normal feces. A bird that is restless (for example, as a result of being brought to the veterinarian for examination) may defecate more frequently, with the result that the feces appear like those of a bird with polyuria, because the resorption of urine from the ureter in the terminal intestine is reduced.

The number of excretions per 24 hours can provide an impression of a bird's appetite. A parakeet can produce 25 to 50 excretions per 24 hours. Racing pigeons produce up to 25 excretions per 24 hours. In a pigeon sitting on a nest of eggs, this is reduced to no more than 10 excretions per day.

In birds with a well-developed cecum (such as Galliformes), two types of feces can be distinguished: noncecal feces and cecal feces. The noncecal feces form the larger part. In the chicken these are grayish green and are covered with a white layer of urates. The cecal feces are only excreted a few times per day. They are very homogenous, fairly sticky, and slightly thinner than noncecal feces; the color is chestnut brown and the surface is smooth and glistening. Cecal feces give off a typical slightly aromatic odor.

If birds have little or no appetite, a green discoloration of the feces is often observed. This is caused by biliverdin, the main bile pigment of birds. In almost all species the bile produced in the left half of the liver is delivered via a bile duct to the intestine. The bile produced in the right half of the liver can be stored in a gall bladder in some species (chicken and duck) but in others (pigeon and parrot) it is handled in the same way as that from the left half of the liver. Because the production of bile continues in spite of anorexia and the bile cannot be partly stored in a gall bladder, the feces produced by a bird with anorexia will consist largely of bile.

Some abnormalities in the feces are fairly pathognomonic for a certain disease in a certain species. Undigested grains in the feces of a racing pigeon indicate a traumatic gastritis (usually caused by a nail), while blood in the feces of racing pigeons usually indicates infection with *Echinoparyphium* sp. ('intestinal flukes').

If undigested material is observed in the feces of Amazon parrots, the first possibility to be considered is proventricular dilatation disease or neuropathic gastric dilatation. If hemoglobinuria is observed, lead poisoning is the most probable diagnosis. Mixing of hemoglobin with urates can give the urine the appearance of tomato soup.

Undigested grains in the feces of birds in general usually indicate a functional disturbance of the gizzard, while red discoloration of the excreta (hematochezia) indicates a disorder of the caudal part of the gastrointestinal tract, or the oviduct or cloaca, or it indicates hemoglobinuria. Black discoloration of the fecal part of the excreta (melena) may indicate bleeding in the proximal part of the gastrointestinal tract, as can occur with a tumor of the proventriculus or ventriculus.

Examination of feces (preferably still at body temperature) for flagellates or nematode ova and protozoan oocysts (preferably after sedimentation and flotation with zinc sulfate or saturated sugar solution) belongs to the routine examination of birds presented as patients. This examination can take place before the bird is taken out of the cage, by obtaining some feces through the bars of the cage by use of an inoculating loop.

Streaks of blood

Streaks of blood on the walls of the cage are usually an indication of blood loss from a wing, often due to a damaged flight feather in the growth phase.

Down or feathers on the floor

The presence of down and/or feathers on the floor of the cage or aviary can provide useful information. Keepers of racing pigeons sometimes come with the complaint that 'the pigeons don't shed their down anymore'. The down molt continues in pigeons all year long; if the birds are ill the stagnation of the down molt is often the first sign (see under Plumage). In parrots the presence of down or feathers under the cage can be an early indication of feather picking and parrots which are hospitalized because of illness may begin picking feathers during the same period. If this is not recognized in time and preventive measures taken, there is a chance that the bird will return home picked bald.

28.3 Physical examination: introduction

In searching for the cause of signs of disease in birds we make a distinction between diagnosis in the individual and diagnosis in a group or flock. In the individual bird the physical examination and subsequent laboratory[3] or radiographic examinations have an important place, while in flock problems the postmortem examination plays an important role. Often one or more affected birds from a flock can be sacrificed for necropsy. This is especially important in species of birds in which the possibility of examination is limited (small Passeriformes, such as finches).

28.4 Physical examination: inspection at a distance

By inspection at a distance the examiner tries to collect as much diagnostic information as possible without contacting the bird. If possible, birds that are presented in a box are removed and placed in an observation area, such as a cage. After allowing the bird a short period to become familiar with this new situation, the

examination is started. A protocol is included on the examination form and is explained below.

Aspects which must be given attention at this stage of the examination can in principle be divided into four main groups: nervous and locomotor systems, respiratory system, plumage, and immediately noticeable abnormalities.

28.4.1 Nervous system and locomotor system

In evaluating a bird's level of consciousness we take into account that a seriously ill bird in strange surroundings can appear to be relatively attentive, certainly if surrounded by people in white coats. On the other hand, a bird that sits hunched up or with its head in its feathers or a bird that repeatedly falls asleep in the examination room is obviously suspected of being ill.

The behavior of the bird gives indications about the relation between the bird and its owner and about the length of time that the bird has been in captivity: a parrot that is easily handled and can talk has clearly been in captivity for a long time.

Attention is given to the presence of signs that indicate an abnormality of the nervous system. Often on the basis of the nature of the nervous signs and the species, a probable diagnosis can be made. In racing pigeons torticollis is usually caused by an infection with *Salmonella typhimurium* var. *copenhagen* or the pigeon paramyxovirus.

Ducks presented for examination in the middle of the summer with paralysis of the neck muscles ('limber neck') are most likely to have botulism. In swans with lead poisoning there is also paralysis of the neck muscles, via which the neck can no longer be held vertically but is bent backward to rest on the back. Older budgerigars with a unilateral paresis or paralysis of a leg often have a kidney tumor that compresses the nerves to the leg.

Rhythmic lateral movements of the head can be seen in some species of birds (especially falcons and owls) with disorders of the vestibular organ. This sign is comparable to nystagmus in mammals. In many species of birds the movements of the eye are limited and are compensated for by movements of the head.

Although the manner in which the wings are held may not be directly visible at the time of the examination, a disorder of the wing can be indicated by soiling of the outermost flight feather with dirt and feces. If the bird is placed in a quiet area and is unaware of being observed, the affected wing will be seen to slide over the ground.

A drooping wing can be due to a neurological abnormality but more often there is an abnormality of the skeleton, joints, ligaments, or muscles. The manner in which the wing droops can give an indication of the location of the lesion. If the lesion is distal to the shoulder joint the tips of the flight feathers are held lower than those of the wing on the healthy side. When there is a lesion of the shoulder joint and the coracoid, the proximal part of the wing droops but the tips of the flight feathers on the affected side extend above those on the healthy side.

28.4.2 Respiratory system

The walls of the infraorbital sinus in birds are bordered by soft tissue. The connection with the nasal cavity lies in the dorsal wall. The latter results in poor drainage of the sinus, whereas the former allows bulging of the lateral wall when there is a sinusitis. A bulging between the beak and the medial canthus of the eye is often seen in various species of birds and indicates an overfilling of this sinus. Bilateral sinusitis can take extreme forms. In Galliformes it sometimes results in what is referred to as an 'owl head' (Fig. 28.1).

In parrots there is a connection between the infraorbital sinus and the air sacs located under the skin of the head and neck. This cervicocephalic air sac system is not connected to the pulmonary air sac system (Fig. 28.2). When there is narrowing of the connection between the infraorbital sinus and the cervicocephalic air sac, the connection can act like a valve, causing the air sacs to become overfilled, increasing the circumference of the neck. This overfilling should not be mistaken for the escape of air from a ruptured air sac.

The vocal organ in birds is not the larynx (vocal cords) as in mammals but the syrinx at the bifurcation of the trachea. Abnormal vocal sounds in birds thus generally indicate a more deeply located disorder.

The lungs of birds are rigid and the air transport through the lungs is dependent on volume changes in



Fig. 28.1 'Owl head' in a peacock, due to overfilling of the infraorbital sinus.

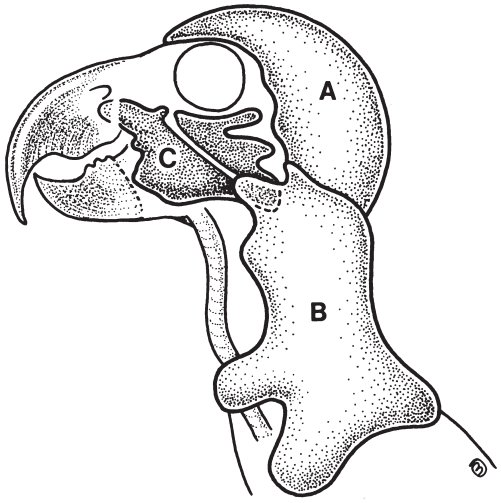


Fig. 28.2 The position of the subcutaneous cervicocephalic air sac system in a parrot: A cephalic part, B cervical part, and C infraorbital sinus.

the pulmonary air sac system connected to the lungs (Fig. 28.3).

These volume changes are possible via a cranioventral movement of the sternum during inspiration and a caudodorsal movement during expiration. The air stream in the lungs is predominantly unidirectional. During inspiration the caudally-located abdominal and caudal thoracic air sacs fill with oxygen-rich air from outside the body, while oxygen-poor air from the lungs flows into the cranially located clavicular and cranial thoracic air sacs (Fig. 28.4). During expiration the oxygen-rich air flows out of the caudally-located air sacs through the lung, while the oxygen-poor air from the cranially-located air sacs flows to the outside. In contrast to mammals, birds have no diaphragm. In birds the coelomic cavity is subdivided by peritoneal, pleural, and pericardial reflections (one pericardial, two pleural, and five peritoneal cavities), in addition to the eight cavities that are formed by the air sacs.

Dyspnea in birds can be caused not only by disorders in the respiratory tract but also by processes outside the tract. An example is the hyperplastic thyroid enlargement (goiter) that causes compression of the trachea in budgerigars. External compression of the trachea does not otherwise cause problems so quickly in birds as, for example, in dogs, because birds have closed tracheal rings. Another cause of dyspnea by external compression is a space-occupying process in the body cavity. Because the abdominal air sacs cannot then fill completely with air, the air stream through the lungs decreases. Space-occupying processes can include an increase in size of abdominal organs (e.g., hepatomegaly, uterus with an egg), or tumor (e.g., of the testicle), or inflammatory tissue (e.g., egg peritonitis).

One must differentiate between thermal polypnea and dyspnea. By means of thermal polypnea the bird rids itself of excessive warmth mainly by evaporation of water from

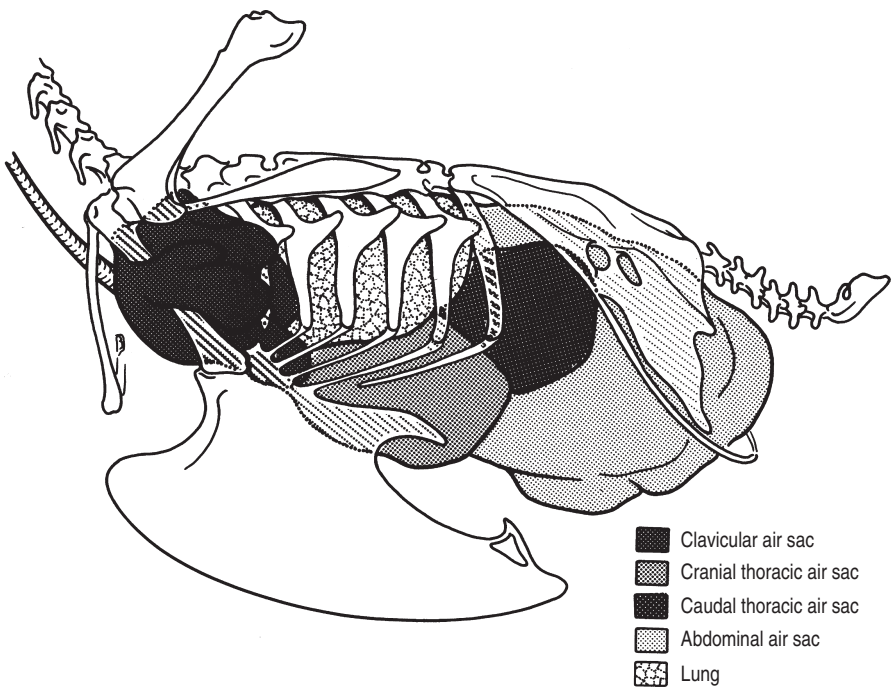


Fig. 28.3 The position of the lung and the pulmonary air sac system in a racing pigeon.

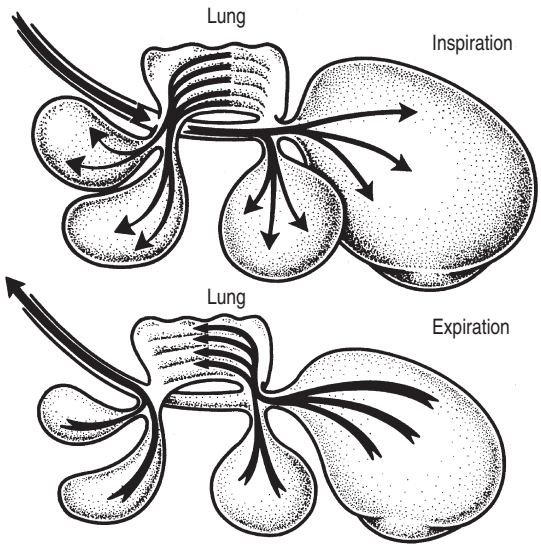


Fig. 28.4 Schematic representation of the air flow in the respiratory system in birds. During inspiration the caudally located air sacs (caudal thoracic and abdominal) are filled with fresh air from the primary bronchi, while the air that has already passed through the lungs (paleopulmo) flows to the cranially located air sacs (cranial thoracic and clavicular). During expiration air flows from the caudally placed air sacs to the lungs, while air in the cranially located air sacs flows via the primary bronchi and trachea to the outside. In the parabronchi of the lungs the air thus always flows in one direction. (Modified from: King AS, McLelland J. Birds. Their structure and function. 2nd edn, London: Baillière-Tindall, 1984;139.)

the oral mucosa. In this case the respiration is rapid and superficial, with an open mouth. Many species of birds can increase the effectiveness of this mechanism by rapid rhythmic movements of the walls of the oropharynx (see Body temperature and thermoregulation).

In birds with blood circulation through decorative parts of the head (such as the comb of the chicken), the color of this part can give an impression of the oxygenation of the blood.

Dyspnea in birds is characterized by rapid and deep respiratory movements. A well-known example of secondary respiratory movements in birds is tail bobbing. In very extreme dyspnea cloacal movements can be observed during inspiration and expiration.

In some birds certain signs are almost pathognomonic for a certain disease: clicking sounds in an aviary of canaries indicates an infection with tracheal mites, while yawning and head shaking indicate an infection with tracheal worms. In parrots the loss of voice and a tracheal stridor are usually caused by a fungal infection at the level of the bifurcation of the trachea.

28.4.3 Plumage

The plumage is an important insulation and enables most species of birds to fly. In a number of species the color of the plumage plays a role in reproduction.

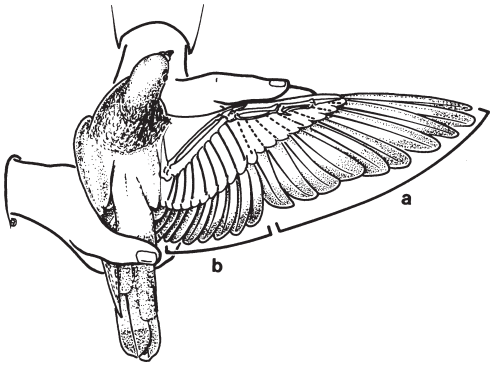


Fig. 28.5 Racing pigeon with the wing spread out as described in the text. The tops of the fingers are held against the flight feathers, while the thumb lies on the leading edge of the wing. The wrist joint (intercarpal joint) is then extended by applying pressure with the palm of the hand. The junction between (a) primaries and (b) secondaries is clearly visible. The primaries are attached along the metacarpal bone and the phalanges, while the secondaries are attached along the ulna.

Structure

The plumage consists of different types of feathers. The contour feathers are the most immediately noticed and determine the outer color of the bird. Contour feathers can be divided into flight feathers of the wing, covering feathers of the wing, tail feathers, and body contour feathers. The flight feathers of the wing are divided into primaries and secondaries. The primary flight feathers are fixed to the carpometacarpal bone and phalanges, while the secondary flight feathers are fixed to the ulna (Fig. 28.5).

The transition between primary and secondary flight feathers is clearly visible if the wing is spread out. Primary flight feathers are numbered from medial to lateral, while secondary flight feathers are numbered from lateral to medial. Species of birds that are able to fly have between 9 and 12 primary flight feathers per wing. The racing pigeon has 10 or 11.

In most species of birds contour feathers are not uniformly distributed over the body but grow only in certain areas, the so-called feather fields (pterylae). These are readily visible on a bird that has been plucked. The areas of skin between them are called apterylae.

A *contour feather* consists of a main shaft (rachis), a vane (vexillum), and the bare part of the shaft (calamus), which is embedded in the feather follicle. The calamus is a hollow tube with a round opening (umbilicus proximalis) at the tip. In this opening is a protrusion of the dermis of the feather follicle, the dermal papilla, which undergoes transition into the pulp. In a full-grown contour feather the calamus is hollow but in a growing contour feather it is filled with pulp in which an artery and a vein are located. In the maturation of the contour feather these vessels regress and the pulp is resorbed. The calamus extends

distally over the rachis. This has a groove on the body side and gives the contour feather its stiffness. On the opposite edges of the shaft there are barbs attached at an angle of about 45°. These barbs are asymmetrical on flight feathers and symmetrical on tail feathers. On the opposite sides of each barb there are two barbules which project at an angle of 45° from the axis of the barb. The barbules of two adjacent barbs are thus at an angle of 90° to each other. The distal barbules have hooks (hamulae) which go around the proximal barbule of the adjacent barb. In this manner an almost airtight vane is formed. If the hooks become loose, the bird can correct the problem by pulling the vane through its beak. The connection of barbs and barbules is somewhat comparable to a zipper (Fig. 28.6).

The maintenance of the structure of the contour feathers is very important for keeping the plumage waterproof. For water birds this is of vital importance, for these birds drown if the plumage is not waterproof. One is occasionally confronted with 'leaking' water birds. In these the plumage is inadequately water-resistant and the birds thus sit too deep in the water. The contour feathers on the ventral side should always be inspected, because they are in contact with the water, and it should be noted whether the feathers are soiled and whether they are dry. Water placed on the feathers should run off like pearls.

Another category of feathers is the *down* (plumae). These feathers form an insulating layer under the contour feathers. Down feathers have no shaft and no vane. Some birds, such as ducks, have down feathers distributed over the entire body, but among other species down is only found in the pterylae (Tinamiformes), the apterylae (most Galliformes), or is completely absent (Passeriformes, Columbiformes).

The barbules of the so-called powder down (pulviplumae) continually break off during growth, resulting in a 'feather powder', consisting of small keratin granules with a diameter of less than 1 µm. The feather powder forms a water-repellant layer over the contour feathers and also aids in keeping them clean. The powder down is mainly encountered in species which do not have a tail gland, but it does occur in some other species. Those who keep pigeons are pleased to see the bath water of the pigeons covered with a white layer of feather powder. If racing pigeons are kept in good condition, the feather powder makes them feel very soft and it comes off onto the hands and clothes.

Hair-like feathers (filoplumes) are distributed over the entire body. They have a proprioceptive function and serve to hold the contour feathers in optimal position. Barbs, if present, are typically at the distal end of the filoplume.

Bristles are observed around the mouth of some species of birds (e.g., the European night swallow), around the nostrils (e.g., the honey buzzard), or eyes (an ostrich has real eyelashes). The bristles have a filtering and tactile function. Barbs on bristles are at the proximal end of the rachis.

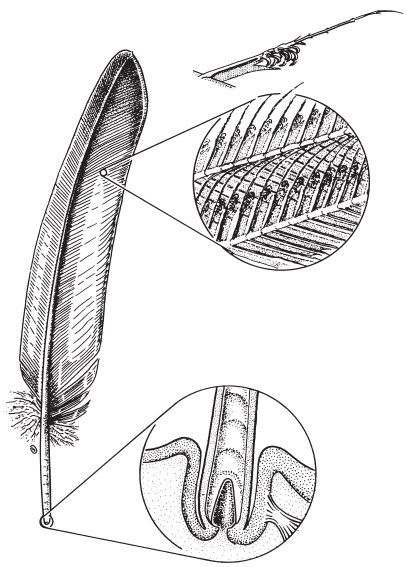


Fig. 28.6 Drawing of a contour feather.

Molt

Birds change their feathers regularly. The molt serves to replace worn feathers with new ones. In some species of birds the molt also serves to provide the birds with an attractive covering in the mating season (breeding or nuptial plumage). After a bird emerges from the egg it goes through a number of changes of feathers which result in the adult plumage. In most species of birds this takes two years and in some species even longer. An albatross only obtains its adult feathers after seven to eight years. The adult feathers are changed at least once per year, usually after the nesting season. In some species the molt occurs two times per year and in some even three times. The molt is initiated by external influences such as daylight length and temperature, which stimulate essential hormonal changes. The thyroid and gonads play particularly important roles. In most birds not all of the feathers are replaced at the same time. The flight feathers and tail feathers usually molt in pairs, so aerodynamic characteristics are maintained.

In *ducks and geese* there is a special form of molting. Pairing of mallards occurs in the fall. Mallard drakes have their characteristic breeding plumage in this period: silver-gray flanks with chestnut brown breast, a green head with white neck bands, and a black curl in the tail. The females are speckled brown.

Copulation takes place during the entire fall and winter. The eggs are produced at the end of February at the very earliest. Most ducklings are not seen until April. The female hatches the eggs and remains by the ducklings until they are self-supporting. The drakes have hardly any function in this season unless ducklings are lost. In this period one often sees groups of a few drakes following female ducks that have just left the nest. Around May the drakes gather together and the molting of the contour feathers occurs. The attractive breeding plumage disappears and makes way for the brown eclipse plumage.

At first glance the eclipse plumage of the drakes bears a strong resemblance to the plumage of the female. Yet there are clear differences between the female and the drake in this period: (1) the brown of the drake is less mottled than that of the female, (2) the head of the drake is definitely beige-gray, (3) the head and neck of the drake more sharply contrast with the breast than they do in the female, (4) the breast of the drake is fox-brown, without much pattern, (5) the mottling on the flanks of the drake is vague and less sharp than in the female, (6) the beak of the drake is green, and (7) the skull of the drake is black and lacks the pronounced eye stripe of the female.

In their eclipse plumage the drakes leave in masses after the first half of June to areas of reeds and rushes, where they molt all of the flight and tail feathers at the same time. As a result they are not able to fly for about four weeks. The eclipse plumage gives the drakes a camouflage in this period. The flight feather molt in drakes occurs between mid-June and mid-August. The female ducks must take care of the ducklings and the molt of their flight feathers begins in July and lasts until mid-October. From September onwards the drakes can again be seen in their colorful breeding plumage, first the young drakes and later the older ones.

In *racing pigeons* knowledge of the molt, especially of the flight feathers, is important for the racing flights, because the best performances can be expected from birds with a 'full wing', a wing in which all flight feathers are present. In racing pigeons the first flight feather usually molts after the first nest of chicks is 'weaned' (around April/May). In young pigeons the first flight feather emerges at around the age of seven weeks. If growth proceeds normally the next emerges when the first has reached three-fourths of its length, and so on until all ten flight feathers are changed (the sequence of molting is from inner to outer and so the outermost feather is the tenth. Often when the fifth feather is lost a reduction in flight performance is observed.

If the pigeons are separated ('widowhood'), the molting of flight feathers is delayed. Use is made of this in order to have pigeons with 'full wings' later in the racing season. The timing of the molting period can be manipulated by mating the birds very early or very late.

The secondary flight feathers and tail feathers are only changed when the seventh primary flight feather has been lost. Usually only a few secondary flight feathers are changed each year. The tail feather molt begins with the innermost pair or with the pair adjacent to them and proceeds from inside to outside. The two outermost tail feathers are, however, molted before the pair adjacent to them. The last feather that the pigeon molts is thus the one just inside the outermost tail feather.

The molting of the contour feathers also begins about the time of the loss of the seventh flight feather. In general this is a gradual process but the molting of the contour feathers of the neck often involves many feathers at the same time.

About mid-December the entire molting process must be complete. This is often used as the time when the birds must be vaccinated against various infectious diseases, for the administration of vaccine or medications during the flight feather molt can cause developmental disorders of the flight feathers.

The pulviplumae and filoplumae are changed throughout the year and cessation of this molting of the down is an indication to the pigeon keeper that something is out of order.

Apart from cessation of the down molt, a few other abnormalities can concern the molt. Especially important are abnormalities in the development of flight feathers. Because of the regular progression of the molting of the flight feathers it is possible to back-date occurrences by it (each flight feather needs three weeks to fully grow out and the next flight feather is only shed when the one medial to it is three-fourths developed.

Inadequate nourishment for the developing flight feather can be manifest in different ways.

An abnormality that has been known for hundreds of years by falconers is the constriction of the shaft of the flight feathers, associated with thinning of the vane in a band or strip at right angles to the shaft. Falconers call such stripes in the flight feathers *'hunger traces'*. At the site of the hunger traces the flight feather is weakened and can break when the wing is stressed. This abnormality has also been observed in other species of birds. It is important only in species in which the ability to fly is important. It is seen especially in young birds. Because the flight feathers of the left and right sides develop fairly symmetrically, the abnormality is usually visible on both sides at about the same location. In racing pigeons the flight feathers with this abnormality are called *'work feathers'*. Apart from inadequate provision of nutrients during the

growth of the flight feathers, stress also plays a role in the development of this abnormality. In pigeons a very difficult flight will be reflected as a stress line in the flight feathers which were developing at that time. After corticosteroids have been administered one can also observe a stress line in the flight feathers that were developing at that time.

Retained feather sheaths have a different significance. While hunger streaks result from deprivation of nutrients to flight feathers during a very short period, retained feather sheaths indicate a longer period of undernutrition. In retained feather sheaths there is insufficient development of the vane.

A *blood feather* is one whose shaft is filled with blood. This phenomenon is encountered in the flight feathers but contour feathers can also be affected. Blood feathers can occur after trauma to the feather follicle.

In racing pigeons one often sees a *flight feather that is too short* when the molt has not been optimal.

A developmental disturbance of the feathers which is encountered especially in inbred lines of canaries results in *feather cysts* or 'lumps', filled with a keratinaceous material. They can be confused with an inflammation or tumor. These cysts can also occur in other species.

Hormones

The hormones of main importance for growth and development of the feathers are thyroid hormone and the sex hormones. The juvenile feathers can only develop with an adequate concentration of thyroid hormone in the blood; the sex hormones do not yet play a role. At the time of the development of the adult feathers the bird is under the influence of both thyroid and sex hormones. The role the sex hormones have in feather development is markedly dependent on the species of bird. They can be divided into two groups: (1) birds in which the sex hormones largely determine the external sex characteristics (such as Galliformes and Anseriformes) and (2) birds in which the sex hormones have no influence on the external sex characteristics (such as Passeriformes).

Studies in species of birds in group 1 reveal that the development of the feathers in both sexes is male, or in other words that the male feathers are neutral. A castrated rooster develops the same type of feathers again after molting, while a castrated hen loses the female feathers and develops the male, i.e., neutral, feathers. If estrogens are administered to a castrated rooster or castrated hen, female feathers appear after the molt.

The role of thyroid hormone is the most important in the physiology of feathering: sex hormones can only exert their influence when the thyroid hormone level is above a certain threshold.

The influence of sex hormones in feather development is on:

- structure: a rooster, in contrast to a hen, has lancet-shaped feathers on the neck, the saddle, and the tail
- growth
- pigmentation: the influence of sex hormones on pigmentation differs according to the species

However, in all species, increasing levels of sex hormones in the plasma first affect pigmentation and only later affect structure and growth.

Color

Colors occur via the presence of melanin, carotenoids, and porphyrins. Melanin pigment is present as granules in skin and feathers and is responsible for dull yellow, reddish brown, brown, and black colors. Carotenoids are diffusely distributed in the feathers, dissolved in fat globules. Carotenoids arise from plant material and are responsible for some of the yellows (canary yellow), orange, and red. In the absence of nutritional carotenoids an abnormality can develop in the color of the feathers in some birds. Especially for birds in captivity it is necessary to provide special carotenoid-containing foods ('red factor' in colored canaries). Porphyrins are synthesized by the birds themselves and are diffusely distributed in the feathers. Porphyrins are responsible for green and red colors in some species of birds (Turaco).

Colors are produced by an interplay of reflection, absorption, scattering, and iridescence of the incoming light. The iridescence of the contour feathers of peacocks is caused by the fact that the barbs of these feathers are covered with three thin layers of keratin through which the entering light is broken up as in a soap bubble. The diverse colors of the light spectrum are thus made visible.

28.5 Physical examination: handling

When the veterinarian has collected the maximum amount of information without having handled the patient, a decision must be made about the manner in which further examination will take place, for the period during which the bird is held in the hands must be reduced to a minimum so that the bird is exposed to as little stress as possible.

Preparation

If the bird is difficult to catch or to handle, it is important to first prepare everything that will be necessary for the planned examination (mouth spreader, swabs for bacteriological examination, blood collection system, blood tubes, material for sedating the bird if necessary, etc.). This will avoid having to put the bird back into the

cage and take it out again, or having to look for various materials while also holding the bird. This is especially important in birds kept in cages or an aviary, and in wild birds. Racing pigeons, which are regularly taken in the hand of the owner, can be held in the hand of the examiner during a large part of the physical examination. If racing pigeons are handled correctly, there is no noticeable increase in the respiratory or heart rate, which is an indication that these birds quickly accept the fact that they are handled. Correct handling of a bird that is presented as a patient is the first thing required of a veterinarian practicing avian medicine. It is important that the patient experiences no undesirable consequences of the handling and that the veterinarian is not injured by the bird. In addition, handling the bird in the correct manner will contribute to the owner's trust in the veterinarian. If psittacine birds must be examined in quarantine, it is advisable to wear a mouth and nose mask to avoid the risk of Chlamydiosis. Because parrots make a great deal of noise, it is worthwhile to avoid damage to hearing. Ear protectors used in sport shooting are very suitable for this.

Examination room

Because birds, with the exception of Sphenisciformes (penguins) and Ratiles, are able to escape into the air, it is of great importance that the physical examination takes place in a room closed off from the outside world. In the examination room itself there must be no objects that are dangerous to birds, such as electric fans into which they can be drawn or heaters on which they can be burned. In the event that a bird escapes from the hands of the examiner, it is useful to have a net ready in order to catch the bird quickly. The windows of the examination room should represent a clear visual barrier to the bird by being blacked out or covered over or having nontransparent glass. The ability to darken the examination room facilitates removal of birds from the cage as well as catching a bird that has escaped.

With the exception of a few species, birds remain sitting still in the dark. If necessary, a red light can be used in the room to enable the examiner to see.

A method used by falconers to quiet a hunting bird is to place a leather hood over its head (Fig. 28.7). The bird then sits, as it were, in the dark and becomes completely quiet. It is even possible to teach hunting birds to eat with a hood on.

Birds can wound the examiner in various ways. One must remain very aware that parrots have strong beaks. Both macaws and Moluccan cockatoos are able to crush a finger. The first concern of the examiner of Psittaciformes is thus the immobilization of the bird's head. In handling the carnivorous kea, also a member of the Psittaciformes, one must also be careful of the claws.



Fig. 28.7 Falcon wearing a hood and sitting on a gloved hand.

In Falconiformes and Strigiformes it is the claws that are the most dangerous to the examiner, while in handling vultures and the bald eagle one must be most careful of the beak. If a falcon grasps the examiner with its claws, it is usually impossible to get free without someone else's help.

The ostrich and the cassowary have strong feet provided with large claws and are able with one stroke to fatally wound the examiner. These birds should not be approached without special measures being taken in advance.

In Ciconiformes, such as the crane and stork, one must avoid being pecked in the eye. Hence the first concern in handling these birds is immobilization of the head and beak. A cork can be placed on the sharp point of the beak. The beak can be held closed with adhesive tape but care must be taken not to cover the nasal openings. Fish-eating water birds and penguins are able with their sharp beak to tear pieces out of the skin of the examiner. Especially in handling swans or penguins, it is the wings for which the examiner must have adequate respect.

Stress

The handling of obviously ill birds, especially of the small species, involves a definite risk. The stress of the

handling, certainly if it is not done correctly, can result in the death of the bird in the hand of the examiner. It is thus advisable to warn the owner of this risk in advance. However, the risk is not a justification for avoiding handling the bird but simply prescribing a treatment without carrying out an examination.

If the owner has much experience with handling his bird, it may be better to have him catch the bird. Many owners, however, do not really know how to hold a bird securely. Sometimes an owner does not hold the bird firmly enough, out of anxiety about causing the bird pain.

Birds that are not accustomed to being handled will resist. In restraining them one must avoid hindering the bird's respiration. One must especially take care that the external respiratory openings are not compressed, that the neck lies reasonably straight, and thus that the trachea is not kinked. In addition, the outward excursion of the sternum must not be hindered.

The greatest of care must be used in handling of birds with long, thin legs. Flamingos have hard but very thin bones which are easily fractured and splintered. The fracture of a leg in these birds is always accompanied by severe damage to nerves and blood vessels and is thus associated with an extremely poor prognosis.

The following is a detailed description of the manner in which the most frequently encountered species of birds should be handled.

Handling of racing pigeons

Racing pigeons are usually brought for examination in a basket or carrier. In removing the bird from the carrier one must take care that the bird is brought out head first and that the flight feathers of the wings are not dragged 'against the grain' over the edge. Usually it is best to have the owner remove the bird from the carrier. The bird is restrained with its head always turned towards the examiner. The bird is enclosed with the full hand, the four fingers curved around the ventral surface of the body and the thumb on the back. Both wings are held against the body with the tips of the flight feathers of the wings crossing each other on the bird's back. The feet can be stretched backward, if one wishes a better grip on the bird, by holding them between the forefinger and middle finger (Fig. 28.8).

Handling of caged and aviary birds

In handling caged birds or those from an aviary, one should first inquire about the character of the birds and their relation with the owner. This is especially important with parrots. Some parrots are so tame that they continue chattering while blood is being collected from the jugular vein, while other parrots attack viciously with the beak if the owner or examiner so much as puts a hand in the cage. Even apparently quite tame parrots should always be approached with adequate caution. Some parrots have a preference for persons of one gender.

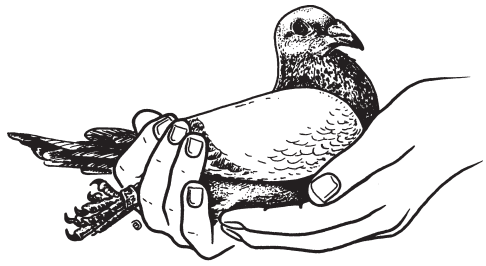


Fig. 28.8 Restraint of a racing pigeon. Both wings are held against the body with the tips of the flight feathers of the two wings crossing each other over the back of the bird. The feet are held preferably between the forefinger and middle finger.

For all caged birds it is advisable to remove the perches from the cage before taking the bird out. Budgerigars and canaries can easily be removed from a cage with unprotected hands. Sometimes it helps to put the examination room in darkness. Budgerigars should be restrained in such a way that the back of the bird lies in the palm of the hand, while the thumb and forefinger encircle the head at the level of the lower half of the beak (Fig. 28.9). The hand grip is nearly the same for small songbirds, except that the thumb and forefinger are placed a little lower and do not enclose the lower beak. Medium-sized Psittaciformes are most easily removed from the cage with a gloved hand in the manner described above.

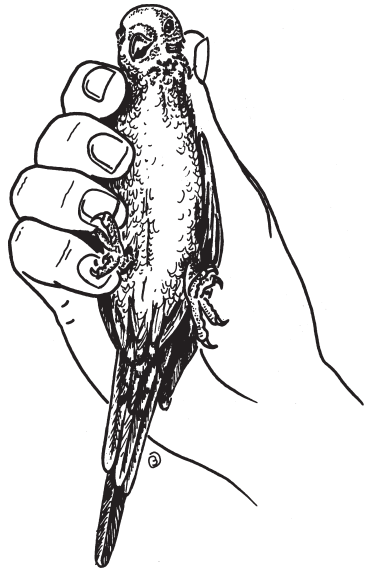


Fig. 28.9 Restraint of a budgerigar. The bird's back lies in the palm of the hand, while the thumb and forefinger partly encircle the head at the level of the lower beak. The outward excursions of the sternum, which allow the pulmonary air sac system to fill with air, must not be hindered by the restraint.

Larger parrots can be handled with the help of a towel, spread over the hand in such a way that there is a fold in the towel between the thumb and forefinger. The bird will not know where the fingers are located and will usually bite the fold of the towel, allowing the examiner to grasp and enclose the head of the bird. The head can be held from behind with the base of the lower beak between the thumb and forefinger. With the other hand, one throws the rest of the towel around the wings so that they cannot be damaged while the bird is being taken out of the cage (Fig. 28.10). Once the bird has been removed from the cage it is better to transfer it to the unprotected hand so that it can be manipulated more easily. One must always take care that the wings are held against the body and that the feet are stretched backward. When a psittacine bird is put back in the cage, the upper beak can be hooked over a horizontal bar. The bird will grasp the bar with the beak and the examiner can remove his hands unharmed from the cage.

Handling of pheasants

Pheasants are often difficult to handle and always offer resistance. They are usually brought for veterinary examination in a cardboard box. One must be aware that when the box is opened these birds can fly out very explosively.

Handling geese, ducks, and swans

Anseriformes can be caught with the aid of a blunt hook around the neck or they can be seized with the hand. First the neck should be grasped just under the head and then other parts of the body can be held.

Ducks can be picked up by using one hand to hold the neck and the other hand to hold the legs or wings. Geese can be handled in the same manner except that they may not be lifted up by the neck and legs. Especially heavier geese must be carried with a good grip around the body, for otherwise the cervical vertebrae may be damaged. When holding Anseriformes, protect your clothing by taking care that the cloaca is always directed away from you (Fig. 28.11).

28.6 Examination of the restrained bird

This section covers identification, nutritional condition, head, neck, wings, legs, and trunk (also see the Examination form for birds on the DVD).

28.6.1 Identification

It is sometimes important to identify birds individually. The most reliable methods are the numbered metal leg band or ring, which is placed on the leg soon after the bird is hatched, and the implanted transponder with a unique number. It is good practice to note the number of an identified bird on the examination form. Unringed birds or birds without a transponder can be identified by a photograph of the scale pattern on the feet (pedigram). The scale pattern is unique for each bird and comparable to fingerprints of people.

28.6.2 Nutritional condition

After picking up a bird one first evaluates its nutritional condition. This is done by palpating to the left and right of the crest of the breastbone (carina; see Fig. 28.16, u)

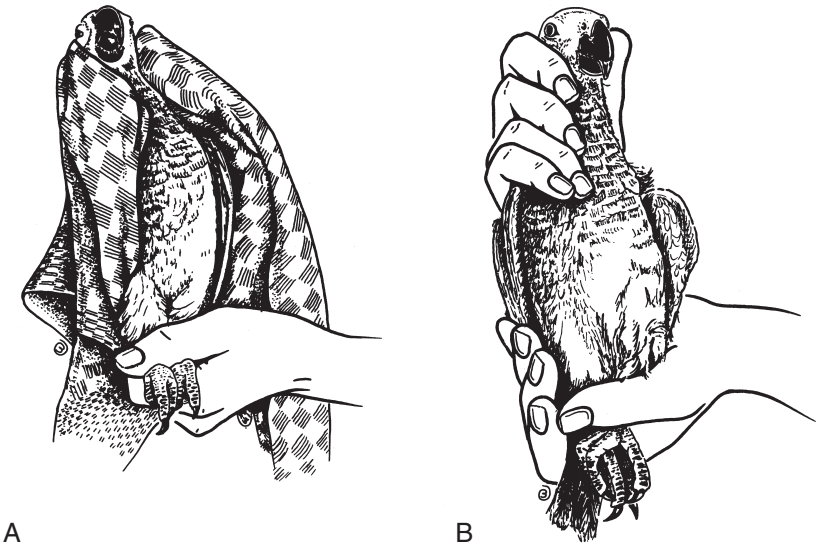


Fig. 28.10 A The restraint of a large parrot with the aid of a towel. The head is encircled from behind and restrained by holding the base of the mandible between the thumb and forefinger. B Once the bird has been taken from the cage, it should be transferred to the unprotected hand so that it can be more easily examined.

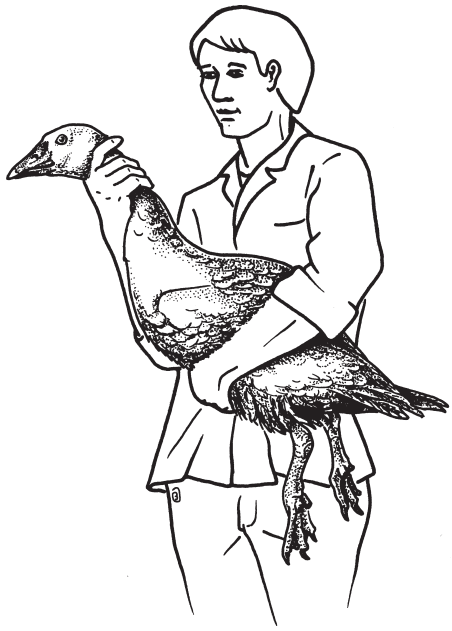


Fig. 28.11 Restraint of a goose. Ducks, geese, and swans are sometimes inclined to release a large amount of feces when they are restrained. Hence the bird's cloaca should be directed well away from the person who is holding the bird.

to determine the size of the muscle mass which is formed by the superficially located m. pectoralis and the deeper m. supracoracoideus. Evaluating the size of the muscle mass takes into consideration the degree of activity of the bird. In well-trained racing pigeons in good nutritional condition the pectoral muscles and the crest of the breastbone form a single rounded mass. Sometimes the pectoral muscles even bulge out beyond the crest of the breastbone. In caged birds and others with little training, the crest of the breastbone is slightly prominent. In birds in poor nutritional condition the crest is easily felt, resembling the keel of a boat. Laying hens have poorly developed pectoral muscles, in contrast to the breeds developed for meat.

Although evaluation of the musculature provides a good indication of the nutritional condition, small changes cannot be detected by palpation. For this purpose it is necessary to weigh the bird. Unfortunately, there is usually no reliable antecedent record of the bird's weight. If an obviously ill bird is presented for examination, it is advisable to record its weight at the first examination. This is also important for calculation of the dose of medications that may eventually be used.

28.6.3 Head

Attention is given to the plumage and to symmetry. Some species of birds have extensive decorative features on the head which could be mistakenly interpreted as abnormalities. Asymmetry of the head is often seen in parrots due to accumulation of metaplastic epithelium in the infraorbital or supraorbital sinus, caused by vitamin A deficiency. The skull can be palpated for asymmetry, deformities, and fractures (be careful with your fingers!). Discharge from the nostrils or eyes often causes soiling of the head feathers. If there is a discharge, material should be collected at this time for culture or cytology.

Ear

In contrast to most mammals, birds have no pinnas. The external acoustic meatus can be seen in most species of birds caudoventral to the eye or in some species (e.g., the wood snipe), ventral to the eye. In most species of birds the external opening of the ear canal is covered by special contour feathers, the ear cover feathers.

In owls, hearing is very important for locating prey in the dark. In the barn owl (*Tyto alba*), there is a shield of feathers caudal to the external ear opening to reflect the sound. Rostral to the external ear orifice there is a vertical flap of skin, called the operculum or concha. Perpendicular to the edge of the operculum there is a row of feathers. The operculum can be turned over by muscles in the skin in order to localize sounds better. In owls the feathers have thus taken over the function of the pinnae.

During the physical examination, attention should be given to the condition of the feathers covering the ear. Sometimes in racing pigeons these do not lie closely together but stand out slightly ('thick ears'). This condition may be related to sinusitis.

The external ear canal is examined for excessive cerumen production, inflammation, swelling, and ectoparasites.

Eye

The iris of most species of birds consists of striated muscle rather than smooth muscle as in mammals. Consequently the size of the pupil in birds is under control of the voluntary nervous system. Usually there is only a moderate pupillary response to light stimuli in birds. In excited parrots one often sees rapidly alternating miosis and mydriasis. Also in racing pigeons which are being held in the hand, one always sees alternating enlarging and narrowing of the pupils. Because the iris is striated muscle, the mydriatic used in mammals (atropine) does not produce mydriasis in birds. Instead, a freshly-prepared solution of d-tubocurarine (3 mg/ml) in 0.025% benzalkonium chloride is used. Multiple applications during a period of 15 minutes can sometimes bring about mydriasis. Injection of tubocurarine in the anterior chamber is more reliable, but because of potential complications, it is not a routine procedure.

The presence in birds of a very definite pupillary reflex to light is an indication of the loss of the influence of the cerebral cortex, hence an indication of cortical blindness. Because birds have a complete crossing-over of the fibers of the optic nerve in the optic chiasm, there is theoretically no consensual pupillary reflex (see also § 18.2.4 and § 19.4.11).[4] However, birds' eyes are very large and are very close, and exposure of one eye to light may result in exposure of the contralateral eye internally and consequently a pupillary reflex.

In some species of birds the age or the gender can be determined by the color of the iris (§ 28.1). In young racing pigeons the iris is dark brown, while in older racing pigeons it is orange-red. Some breeds of pigeons have light yellow irises. A change in color of one or both irises indicates an infection (from which the bird may have already recovered) or very severe physical exertion. The original color almost always returns in 1–2 months. In some breeds of pigeons it is normal that one iris is dark and the other is brightly colored.

An important difference between the avian and the mammalian eye is the presence of a pecten in birds. The pecten is a bulging of the choroid into the vitreous body. It plays a role in the nutrition of the retina. A practical consequence of its presence is that the papilla cannot be examined with an ophthalmoscope because it is covered by the pecten.

In many species of birds the eyelids are only closed during sleep and the moistening of the eye is provided by the nictitating membrane or third eyelid. The nictitating membrane in birds, in contrast to that of mammals, contains two striated muscles which enable it to move over the surface of the globe. In most bird species the nictitating membrane is transparent. Harder's gland (gland of the nictitating membrane) is located at its base. The mucoid secretion is drained away by a simple canal in the conjunctival sac. Harder's gland has not only a cleaning and moistening function but also plays an important role in local immunity of the eye and the upper airways. After application of antigen to the eye there is an increase in antibody-producing plasma cells in Harder's gland, followed by secretion of antibodies in the tear fluid.

In birds, in contrast to mammals, the gland of the nictitating membrane is much larger than the lacrimal gland. The latter is on the caudolateral side of the eye. The gland has no specific function other than moistening of the eye.

The tear fluid is drained via the lacrimal puncta which are located close to the medial canthus in the upper and lower eyelids. In the chicken the dorsal lacrimal punctum is about 3 mm in diameter and the lower is about 1 mm. A few mm from the puncta the two canals join to form the nasolacrimal duct, which passes along the dorsomedial wall of the infraorbital sinus to exit in the nasal cavity.

In sea turtles the glands of the orbit (Harder's gland and lacrimal gland) are able to produce a fluid with a higher osmolality than sea water, which enables these animals to drink sea water. These glands are thus called salt glands. Birds that live in a sea water environment, such as seagulls, penguins, and ducks, also have a salt gland. This is not a modified Harder's gland or lacrimal gland but a special gland that drains into the nose: the lateral nasal gland or salt gland. This gland varies in size, according to the species, from 0.1 to 2% of the body weight. The salt gland is located dorsomedial to the eye (Fig. 28.12). The presence of a 'salt water gland' explains the discharge from the nose or mouth occasionally observed in sea birds. The salt gland needs a period of adaptation in order to function maximally after a period of disuse. Before marine birds are released after being in fresh water for some time, they must go through a period of adjustment to increasing concentrations of salt in their drinking water.

Examination of the eyes should always begin by comparing the eyes with each other. A unilateral exophthalmos is often noted only when the two eyes are compared. The examination of the eyes should proceed from outside to inside. First the periorbital area is inspected and then the eyelids and the conjunctiva and only then the eye itself. Many lesions of the eyelids are observed in birds, often due to trauma or infection. In parakeets with an abnormality of the edge of the eyelid a scraping should always be made for examination for sarcoptic mites (*Cnemidocoptes pilae*). In pigeons the edge of the eyelid is often the first place where an infection with pox virus can be detected.

The third eyelid can normally be seen flicking very quickly over the eye and is not constantly visible. When the eyelids are moved apart by the thumb and index finder, the bird's attempt to cover the eye with the third eyelid makes it visible. In some species of birds parasites can be located behind the third eyelid (filaria, leeches).

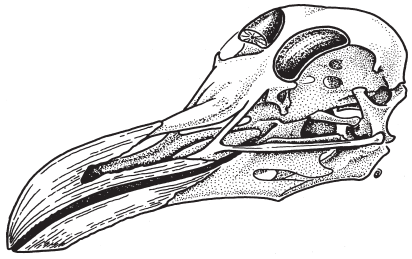


Fig. 28.12 Position of the salt gland dorsomedial to the eye in a seagull.

Beak, cere, nostrils

Among the diverse species of birds there are some great differences in the beak, mainly determined by the type of food that is eaten and the manner of eating. In parrots the beak is also used in locomotion.

Birds do not have teeth. The function of the incisor teeth is taken over by the cutting edge of the beak, while in seed-eating birds the function of the molars is taken over by grit in the gizzard. By means of the contractions of the wall of the gizzard the seeds are ground fine as though between millstones. The only 'tooth' seen in birds is the 'egg tooth'. This is a hard, sharp protrusion on the rostrodorsal side of the upper beak in birds that have just hatched. The egg tooth helps the chick to break through the eggshell.

The beak is formed by bone from the upper and lower jaws, covered by horn. The rate of growth of the horn of the upper beak of a budgerigar is about 7.5 cm per year. In some species of birds the rate is twice as great. In addition to trauma to the beak, abnormalities can develop because of disturbances in its growth or in the wearing of the horn. An example of this is the abnormal beak in parakeets with an infestation of sarcoptic mites (*Cnemidocoptes pilae*) around the base of the beak.

Damage to the germinal layer on one side of the upper or lower beak can result in curved growth, so that the upper and lower beaks no longer match and a crossed beak results. In some species of birds the occurrence of a crossed beak is normal (for example, the bird called the crossbill, *Loxia curvirostra*). These birds use their beaks to hold apart the layered scales of pine cones in order to obtain the seeds.

In birds living in captivity and provided with prepared food, the wearing of the periphery of the beak can be inadequate, so that there is overgrowth of the beak. This is seen especially in species of birds which under natural conditions are real 'nut crackers' but which in captivity receive only soft food. To assist the normal wearing of the beak, it is advisable to provide the bird with suitable material for this purpose (hard food, cuttlebone, chewing wood, stone). Calcium-deficient food can result in soft beaks (rubber beak), especially in young birds.

After examination of the beak, attention is given to the cere. In some species, such as the crow, the cere is covered with feathers. The cere of a racing pigeon should be chalk white. A brown discoloration can be caused by infections of the air passages but can also occur during the period in which young pigeons are being reared. In male budgerigars a brown discoloration of the blue cere can be an indication of feminization due to an estrogen-producing testicular tumor. In older female budgerigars the so-called brown hypertrophy of the cere is a well-known change. No pathologic significance is attached to this.

The nostrils are usually at the base of the beak. They should be examined for asymmetry, discharge, and obstruction. In racing pigeons the cere should be pressed to check for discharge. In parrots the nostrils are often obstructed. The feeding of a diet of seeds alone leads to vitamin A deficiency, the consequence of which is metaplasia of the epithelium and secondary bacterial or mycotic infections. In chronic rhinorrhea the feather growth may be retarded above the cere. Occasionally a groove in the beak can be seen as a result of chronic nasal discharge.

Oral cavity

The parakeet's mouth can be opened by making use of a paper clip (Fig. 28.13). In larger Psittaciformes, such as the African gray parrot, one half of the handle of a pair of scissors serves the same purpose quite well (Fig. 28.14). In cockatoos and macaws there is a danger of damaging the edge of the beak in this manner because excessive pressure is applied to a small surface. For these birds choose an instrument that applies pressure over a larger surface area.

To open the mouth of a racing pigeon grasp the entire beak between the thumb and forefinger from below. Then push the head backward and downward, while keeping the entire beak horizontal. While the thumb and middle finger hold the lower beak, allow the upper beak to slide through the fingers, keeping the index finger resting on the tip of the upper beak. The beak will now open by itself. The lower beak is held between the thumb and forefinger and the upper beak

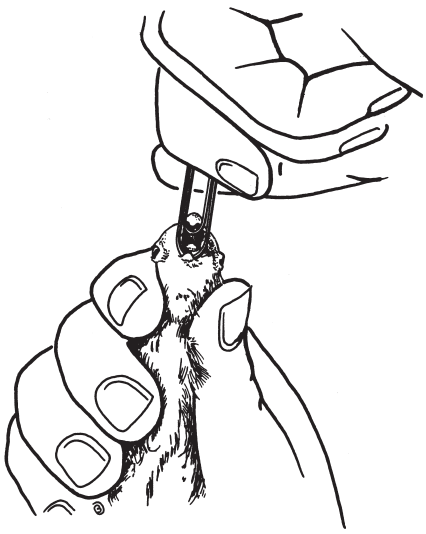


Fig. 28.13 Holding open the beak of a budgerigar by use of a large paper clip. The paper clip is introduced horizontally and then turned upward by 90°.



Fig. 28.14 Opening the beak of a parrot by using one half of the handle of a pair of scissors. In large cockatoos and macaws there is a danger of damaging the edge of the beak because of the application of excessive pressure over a small surface.

is stabilized with the tip of the forefinger. It is important to hold the lower beak along its entire length and not just at the tip.

The oral mucosa is evaluated for color, odor, moisture, and the occurrence of ulcers or parasites. In some species of birds the oral mucosa is pigmented. There should be no thickening or other abnormality of the mucosa and there should be no strings of mucus. The cleft in the palate should be open. By using a good light source, such as a head lamp, one can look into the cranial part of the trachea. Sometimes in birds infected with gape worm (*Syngamus trachealis*) the parasites can be seen moving in the trachea. There are normally papillae on the edge of the soft palate in racing pigeons. After an infection in this area, the irregularity of the edge is often lost. In many cases the cause is the protozoa, *Trichomonas gallinae*. In an active infection with this parasite yellow nodules can be found in the oral cavity. These must be differentiated from white nodules which are salivary calculi and have no clinical significance. In the past it was thought that these white nodules were scars of previous Trichomonas infection. Examination of the oral cavity must always include the area under the tongue, by using thumb forceps. In swans there is occasionally an accumulation of grass under the tongue. In birds of prey a tracheal ring of the prey can be pushed up on the tongue and cause necrosis.

Smear of throat swab

Making and directly examining a smear (at body temperature) of a throat swab should be included in the routine examination in birds. In the racing pigeon this is especially intended for diagnosis of infection with *Trichomonas gallinae* ('canker'). The smear is taken with a cotton-tipped swab that has been slightly moistened with warm water. The swab should be

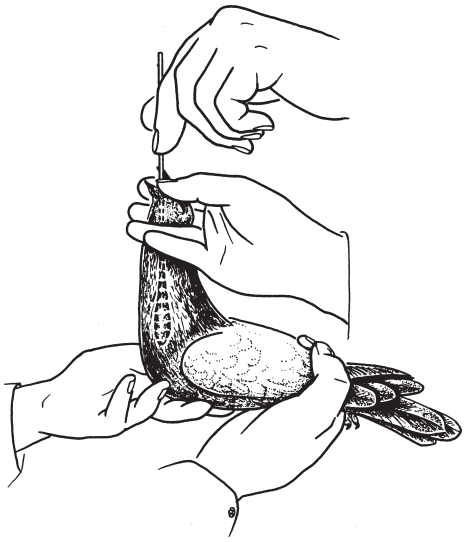


Fig. 28.15 Using a throat swab in a pigeon. Note the way in which the head is being held.

prepared by the examiner so that the cotton is twisted tightly onto the stick. The owner holds the pigeon while the examiner holds the bird's head with one hand and uses the other to obtain the sample from the throat. The bird's head is held from behind by grasping the underside between the middle finger and ring finger, while the thumb and forefinger grasp the beak at its base. The neck is stretched to make a straight line from the lower beak to the point of the breastbone. The beak of the bird is opened by a finger of the hand holding the cotton swab and it is then held open by pressing on the corners of the mouth with the thumb and forefinger of the other hand. After the neck of the bird is stretched the cotton swab is inserted with a rotating motion, about 5 cm into the esophagus (Fig. 28.15). One drop of fluid from the swab is then placed on a microscope slide, covered with a glass cover slip, and examined immediately (body temperature) under a microscope at a magnification of 100×. The presence of epithelial cells in the preparation is an indication that the smear has been made correctly. Other infections may also be diagnosed by means of a throat smear, after staining the smear if necessary.

To make a throat smear from a parrot, a cotton swab on a *metal* stick must be used, so that the parrot cannot bite off the end of the stick and swallow it.

28.6.4 Neck

The neck is examined by inspection and palpation.

The plumage of the ingluvial region on the underside of the neck is occasionally abnormal in racing pigeons ('bald breast'). One must differentiate between broken

feathers and feathers that have fallen out. In the first case the cause is usually a sharp edge on the drinking pan, while in the second case the cause can be the sarcoptic mite. This mite can be found by microscopic examination of the contents of the shaft of a feather that has fallen out.

The esophagus of birds, in contrast to that of mammals, passes down the right side of the neck. Some species of birds have a sac-like extension of the esophagus at the thoracic inlet, which is the crop or ingluvies. In both male and female pigeons, the so-called 'crop milk' is produced during the first few days after the young are hatched. It consists of a thick 'porridge' of fat-laden epithelial cells of the crop which serves as food for the young. Overfilling of the esophagus due to esophageal paralysis is seen in water-birds as a result of lead poisoning. In free-range chickens that consume much material rich in fiber (such as wood shavings or hay), crop impaction can occur. In the racing pigeon the crop should be empty three hours after the meal. Thickening of the crop of racing pigeons is occasionally caused by *Trichomonas gallinae* infection.

The thyroid of birds is located in the thoracic inlet and is normally not palpable. Only when exceptionally enlarged, as sometimes occurs in budgerigars as the result of iodine deficiency, can the thyroid be palpated. The trachea is easily palpated from the head to the thoracic inlet. In canaries in which there is a clicking sound during respiration one can sometimes see black points in the trachea if the neck is held close to a strong light source and the feathers have been moistened with alcohol and wiped aside. These black points are tracheal mites (*Sternostoma tracheocolum*), engorged with blood.

Nodules can sometimes be palpated in racing pigeons above the neck between the shoulder blades, as a result of a subcutaneous vaccination in this location ('vaccination nodule').

The cervical vertebrae can be palpated easily and typically form an S-shaped curve.

28.6.5 Wings

The shoulder skeleton of birds differs markedly from that of mammals (Fig. 28.16). The pectoral girdle consists of the scapula, the coracoid, and the clavicula. The scapula extends caudally from the shoulder joint and in most flying birds it is long and narrow. In some birds the scapula even reaches to the ilium. In penguins, which use their wings to swim, the scapula is very wide. In the ostrich the scapula is very small and is united with the coracoid. The coracoid is the sturdiest of the three bones and extends on both sides from the craniodorsal point of the sternum to the shoulder joint. This bone prevents compression of the thorax during contraction of the pectoral muscles. The clavicula lies cranial to the

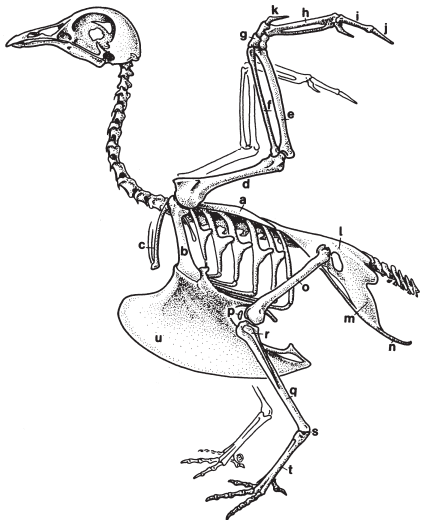


Fig. 28.16 Clinically important components of the avian skeleton: a scapula, b coracoid, c clavicula, d humerus, e ulna, f radius, g carpals, h carpometacarpal bones II and III, i phalanx I and j phalanx II of digit II, k pollex, l ilium, m ischium, n pubis, o femur, p patella, q tibiotarsus, r fibula, s intertarsal joint with lateral and medial menisci, t tarsometatarsus, and u carina.

coracoid. The two claviculae are joined on the ventral side and together they form the furcula (wishbone). The symphysis of the furcula is joined to the cranial part of the sternum by a strong cord of fibrous tissue. Dorsally the claviculae join the medial surfaces of the ends of the coracoids. The clavicula is lacking in a few species of birds, including some parrots. The foramen triosseum is located at the junction of the scapula, coracoid, and clavicula. Through this foramen passes the terminal tendon of the m. supracoracoideus (which lies under the m. pectoralis), which is attached to the dorsal side of the humerus. It allows the m. supracoacoideus to move the wing upwards. The pectoral muscle (m. pectoralis) moves the wing downwards. The m. supracoracoideus is surrounded by a strong fibrous tissue capsule which prevents the muscle from expanding. Sudden hyperactivity of the muscle can lead to accumulation of interstitial fluid, via which the pressure inside the muscle sheath increases. This can lead to circulatory disturbances, even to ischemic necrosis of the muscle. This abnormality is known in turkeys and broiler chickens by the name of Oregon muscle disease. It is also known in human medicine as compartment syndrome.

The skeleton of the wing consists of the humerus, ulna/radius, carpal and metacarpal bones, and digits.

The humerus contains air and is connected to the clavicular air sack. When the humerus is fractured, air is usually palpable under the skin and blood or exudate from the fracture can enter the clavicular air

sack. The ulna is larger than the radius in birds, in contrast to mammals.

In birds that are pinioned to prevent flying, the wing is usually amputated just distal to the proximal connection between the major and minor metacarpal bones.

The wings must be spread out for examination (see Fig. 28.5). To spread the wings of a pigeon, the tips of the fingers are held under the flight feathers and the thumb is placed on the leading edge of the wing. The carpal joint is then extended by pressing with the palm of the hand. In racing pigeons the wings should not be spread by grasping the outer flight feathers between the thumb and forefinger and pulling on them. The flight feathers should be inspected for abnormalities (see Feathers). Growth disturbances of the flight feathers must be differentiated from damage to them.

The underside of the wing is inspected for ectoparasites. They can often be found by slightly blowing away the feathers which cover the underside of the flight feathers. In the racing pigeon the long louse (*Columbicola columbae*) and the shaft mite (*Falculifer rostratus*) can be found. Shaft mites are found primarily along the shaft of white flight feathers and they are most easily seen by holding the outspread wing close to a strong light. The parasites are then visible as spots along the feather shaft.

While the wings are spread the skin of the axillae must also be examined. This is the most thinly feathered area of the body and sometimes becomes inflamed.

After the feathers and skin of the wing have been inspected, the passive movement of the wing is evaluated. Each joint is compared with its contralateral counterpart.

Then the separate joints of the wing are palpated. The shoulder joint cannot be palpated easily. In racing pigeons rupture of the tendon of the m. supracoracoideus can lead to subluxation of the shoulder joint. Overfilling of the elbow joint in racing pigeons is fairly pathognomonic for paratyphoid infection. In this species, however, tumors, hematomas, luxations, and old fractures can closely resemble chronic arthritis.

28.6.6 Legs and feet

The pelvis has no ventral symphysis in most species and the pubic bones move apart during egg laying, but a large walking bird, the ostrich, does have a pelvic symphysis.

The skeleton of the leg is very simple, compared with that of mammals, as a result of fusion of the tarsal bones with both the tibia and the metatarsus. The resulting bones are called the tibiotarsus and tarsometatarsus, respectively. The joint between these two bones is the intertarsal joint. In almost all species of birds it contains a lateral and a medial meniscus. The relative length and strength of the tibiotarsus and tarsometatarsus differ among various species of birds. Usually the tibiotarsus is longer than the tarsometatarsus. In the canary the tarsometatarsus is thin and long and in this species it fractures more readily than does the tibiotarsus. In the budgerigar the tarsometatarsus is short and thick and hence in this bird also the tibiotarsus fractures more easily. In many species of birds a spur develops on the medial side of the distal extremity of the tarsometatarsus, especially in males.

The anatomy of the avian foot varies considerably. The maximum number of toes is four. Some species have three toes and some, such as the ostrich, have only two. The classification of the toes is strongly dependent on function. A general distinction can be made between grasping toes (for climbing and for grasping branches or prey), walking or wading toes, and swimming toes. Birds with grasping toes have four toes, either three pointing forward and one backward (canary, hawk), or two forward and two backward (parrot). In birds with walking or wading toes the last one is rudimentary or absent (loss of the grasping function), while there is often a superficial enlargement of the remaining toes (longer, webs between the toes, and in the snow grouse even feathered toes). Swimming toes have a well-developed swimming membrane between four forwardly-directed toes (cormorant) or well-developed swimming lobes on four forwardly-directed toes (coot).

The skin of the avian foot strongly resembles the skin of reptiles. In some species of birds the lower part of the leg is feathered.

The examination of the feet consists of inspection of the skin and nails, inspection and palpation of the musculature, and inspection, palpation, and passive movements of the skeleton. Just as for the wings, the left and right legs are compared. If a neurological abnormality is suspected, this examination can be followed by a neurological examination.

If the bird is ringed, the ring must be checked to be certain that it is not too tight. There is often an accumulation of dirt under the ring, which results in the ring fitting too tightly. Problems with the ring occur more often in racing pigeons in which the lower leg is feathered than in those in which it is not. Any dirt under the ring should be removed. Pinching off of the circulation can occur acutely and can lead to loss of the distal part of the foot.

A skin abnormality that occurs frequently in birds involves thickening and scaling of the skin of the lower leg as a result of sarcoptic mites (Cnemidocoptes). Hence when such abnormalities are found in this location, a skin scraping should always be made for microscopic examination. The underside of the foot should not be omitted in this examination. Abnormalities that can be observed include freezing, burning, and abscess formation (bumblefoot).

An abnormality of the joints that occurs often in birds, in contrast to other species of animals, is gout. Sometimes the accumulation of urate crystals can be seen shining through the skin.

In chickens the spreading reflex of the legs can be examined in the following way. The chicken is held around the wings and is suddenly and rapidly lowered. A normal response is extension of the toes. Another reflex can be tested by holding the bird in the same way and raising it rapidly by a quick movement of the wrist, keeping the wrist itself more or less at the same level. The normal response is to draw the legs close to the body.

28.6.7 Trunk

Examination of the trunk includes examination of the plumage, the skin, and the thoracic cavity. Examination of the cloaca can also be performed if there is an indication for it.

Skin and skin adnexa of the trunk

Many birds have a tail gland, the uropygial gland, on the back just cranial to the implanting of the tail feathers. This gland is strongly developed in some water birds. In other species of birds it is noticeably less well developed (e.g., the Amazon parrot), and in some it is completely absent (e.g., the ostrich). Sometimes there is a ring of feathers around the opening of the gland. The oily secretion of the gland is used to prevent drying out of the keratin of the feathers. In addition, the secretion has antimicrobial activity.

The secretion of the tail gland contains 7-dehydrocholesterol. After the secretion has been spread over the feathers by the beak, this compound is converted by ultraviolet light to provitamin D_3, which is in chemical equilibrium with vitamin D_3. Hence if exposed to sunlight, birds are able to synthesize vitamin D_3.[5] Uptake of the vitamin occurs while the bird is caring for the feathers. Caged birds not exposed to sunlight have a greater requirement for vitamin D_3 than do members of the same species living in the wild.

The tail gland is inspected by lifting the covering feathers. This is made easier by pressing the tail feathers ventrally and pushing forward the covering feathers, which have thus been made to stand out a little. Abnormalities of the tail gland (tumor or inflammation) occur especially in budgerigars. In racing pigeons it is important to carefully inspect the covering feathers held down around the gland as they are released one by one. The inspection is for the tail louse (*Campanulotes bidentatus compar*). This parasite can cause severe restlessness in pigeons. The examination must be made quickly because these parasites crawl away rapidly in the light.

In racing pigeons the tail feathers are checked by bringing the wing tips under the tail feathers and then moving the two outermost tail feathers laterally between the thumb and forefinger of both hands, so that the tail is spread out like a fan (Fig. 28.17). The tail feathers are evaluated in the same manner as the flying feathers. Birds kept in cages with horizontal bars or a wire mesh floor often have frayed or broken tail feathers.

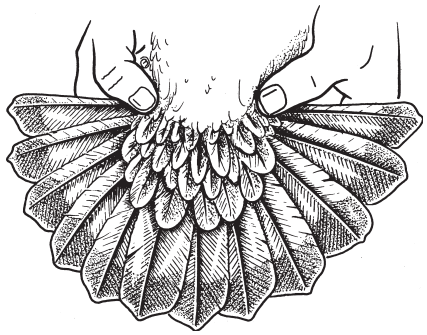


Fig. 28.17 Spreading of the tail feathers.

During examination of the ventral side of the bird attention is given to the presence of old down or covering feathers, the skin over the pectoral muscles, and the color of the pectoral muscles.

A racing pigeon is examined on the ventral side by turning it over from the normal restraint position (see § 28.5). To aid in this, the bird is held with the other hand over its back in such a way that the toes can be held stretched out with the thumb and forefinger of this hand. Now this hand can be turned so that the bird is on its back, lying on the palm and wrist of the examiner. The examination is made by wiping the full hand against all of the covering feathers. The 'old down' is visible as feathers that are darker than the rest. The presence of 'old down' indicates that the bird has not been in good condition for a period of time.

The skin over the pectoral muscles can be evaluated in many species of birds by pushing aside the feathers that cover the crest of the breast bone. Normally this skin is very thin. In some species of birds a 'brood patch' develops during the brooding period, under the influence of prolactin, and it is characterized by hyperemia or edema. The brood patch serves for the transmission of warmth from the parent to the eggs. Depending on the species, the brood patch is found on the male, the female, or both. In penguins the eggs are incubated on top of the well-vascularized and flat feet in a fold of abdominal skin. In ducks and geese the skin over the pectoral muscles is covered with down feathers and no brood patch develops; the eggs are kept warm by incubating them in a nest that is lined with down plucked from the breast.

Pigeon fanciers place great value on examination of the skin and underlying musculature. The skin must be thin and transparent and there should be no epidermal

scales. In pigeons in good condition a vein can be seen in the skin crossing the crest of the breast bone. This vein is visible as a red stripe against the white crest of the breast bone and is called the 'form dot' by pigeon fanciers. The muscles are visible through the skin and in the racing pigeon they should be pink. The pigeon fancier does not like to see bluish-purple colored breast muscles, for he associates this with poor physical condition for flying ('blue muscle'). The cause of the blue coloring is not known.

Thoracoabdominal cavity

When there is a space-occupying process in the abdomen, a subcutaneous process (excess fat, tumor) is differentiated from a mass within the abdominal cavity by following the crest of the breast bone caudally. If the process is in the abdominal cavity, there is usually a sharp transition at the caudal end of the breast bone, while subcutaneous processes often continue over the pectoral muscles.

Especially in small species of birds, organs can often be seen through the relatively thin abdominal wall if the feathers on the ventral side, caudal to the breast bone, are blown aside. In canaries it is normal to see a 2-mm wide edge of the liver just caudal to the caudal edge of the sternum. In an infection with *Lankesterella* (synonym: *Atoxoplasma*) the liver can become enlarged and hence the popular name 'fat liver disease' for atoxoplasmosis in canaries. In a bird with an enteritis the reddened small intestine is often visible through the abdominal wall.

The distance between the pubic bones and the caudal end of the sternum, which is measured by palpating these structures with the middle of the fingertips of the forefinger and middle finger and then measuring the distance between the middle of these fingernails with a ruler, can indicate the presence of a space-occupying process in the abdominal cavity. In the racing pigeon and the African gray parrot this distance is normally not more than 3 cm. In the canary, budgerigar, and Gould's amadine it is not more than 1 cm.

Usually during palpation of the abdomen only the stomach is felt. In seed-eating birds the gizzard is firm. Sometimes one can feel the grit grating in the ventral blind sac of the gizzard. In meat-eating birds the gizzard is softer, somewhat like bread dough. In large species of birds the edge of the liver can sometimes be palpated just caudal to the sternum. The other organs are usually not palpable, except that sometimes an egg can be detected in the oviduct just before laying.

The distance between the two pubic bones is normally just a few millimeters. In female birds the bones spread apart at the time of egg laying. Pathological processes in the abdominal cavity (in both male and female birds) can also cause them to be widely separated.

Auscultation of the thoracoabdominal cavity may reveal abnormalities.

Examination of the cloaca

The feathers around the cloaca are inspected for soiling with feces or blood. The skin is examined for signs of inflammation and any immediately obvious abnormalities are noted (prolapse of the oviduct or cloaca in female birds; prolapse of the penis in males of some species, such as ducks). The gender of canaries can be determined by the outward appearance of the cloaca.

Cloacal palpation can be performed only in the larger species of birds and is undertaken if there is an indication for it. This examination is performed with a finger using a finger cot or a rubber glove and a lubricant. In some species of birds (e.g., Anseriformes, Struthioniformes) one can determine the gender because of the large size of the phallus of the male bird (Fig. 28.18). In addition, a space-occupying process in the abdominal cavity can also be characterized better by the aid of cloacal palpation. Concretions can be found in the cloaca as well. If egg-laying is not proceeding, the cloaca is examined to determine the nature of the egg shell and the position of the egg. In small species of birds in which cloacal palpation is not possible, the interior of the cloaca can be examined with an otoscope.

28.7 Body temperature and thermoregulation

The body temperature is not routinely measured in birds but it can be important under certain circumstances.



Fig. 28.18 Determining the sex of a wild duck. The spiral shaped phallus of the drake can be exposed by pressing with the thumb and forefinger lateral to the cloaca.

Less is known about the elevation of body temperature and its clinical relevance in birds than in mammals. In particular little is known about the progress of changes in body temperature in the course of diseases. Some bacterial and viral infections can cause fever, certainly if there is septicemia. Hyperthermia can also be caused by the inability to discharge heat into the surroundings. There are also physiological and pathological conditions under which hypothermia can develop.

The normal body temperature is generally higher in birds than in mammals, but there are many exceptions to this. In most species of birds the body temperature ranges between 40° and 43°C. The body temperature of the large walking birds (ostrich, emu, nandu) is lower (37–39°C). This applies also to a few diving bird species, such as the penguin.

The lethal body temperature in birds lies between 46° and 47°C. The brain is the most sensitive to *high temperatures*. Some birds, including the pigeon, are able to keep that sensitive tissue relatively cool while the rest of the body has a higher temperature. This is achieved by cooling the arterial blood that flows to the brain by means of venous blood coming from the head, eyes, and upper airways, in the rete mirabile ophthalmicum. Like dogs and cats, birds protect themselves against hyperthermia by evaporation of moisture in the respiratory tract. In this regard, two types of respiration can be distinguished: thermal polypnea (or thermal tachypnea; see also Chapter 8) and buccopharyngeal fluttering.

Because of their extensive pulmonary air sac system, birds are quite able to increase total ventilation without increasing parabronchial ventilation. However, the movement of the respiratory muscles leads to more heat production.

Buccopharyngeal fluttering produces rapid rhythmic movements of the mucous membranes in the throat, which are perfused with more blood. These movements are very superficial and so the chance of hyperventilation and thus an influence on blood gasses (respiratory alkalosis) is minimal. The energy needed for the movements in the throat is small and hence the resulting heat production is also small. In species of birds in which both forms of respiratory discharge of heat occur simultaneously, the frequency of the buccopharyngeal fluttering is usually higher than that of the thermal polypnea.

Other forms of discharging heat into the environment can also be important under certain conditions. Especially during flying the heat loss via convection can be great. The extended wings provide an increase in the body surface area. The underside of the wings is poorly feathered and well vascularized. In some species of birds the heat loss via the well-vascularized feet is important. Sitting birds can increase the heat loss via convection by raising their wings. Birds have no sweat glands but can still evaporate water via the skin to a limited extent.

Birds can protect themselves against *low environmental temperature* by different mechanisms. The most extreme form is the yearly migration of certain wild species to southern regions. Another phenomenon for protection against cold is to sit 'ruffled up'. By contraction of the mm. arrectores plumarum the down feathers are lifted up from the skin, via which the thickness and thus the insulating action of the plumage increases. Some birds which are adapted to living on or in water (ducks and penguins, respectively) have in addition to the plumage a thick layer of subcutaneous fat. A special form of insulation is found in the brown pelican, in the form of an extensive system of subcutaneous air sacs over its entire trunk.

Vascular adaptations to reduce heat loss are seen especially in birds that remain standing for long periods in cold water. A very specialized adaptation consists of a vascular structure in the legs, the rete mirabile. This is of a network of arteries and veins lying close together, in which blood flows in opposite directions. Via the countercurrent mechanism heat is transferred from the incoming arterial blood to the return flow of cool venous blood. As a result of this mechanism, the temperature of the distal end of the extremity is lowered, limiting the heat loss to the surroundings. Heat loss by the same extremity can occur if the venous blood flows back via subcutaneous veins.

The *cloacal temperature* has a circadian rhythm in birds. The difference between day and night temperatures depends on body weight, among other factors. Hence the difference between day and night temperature in a hummingbird (3 g) is 8°C,[6] while in the ostrich (100 kg) it is less than 1°C.[7] The body temperature is highest during that part of the day during which most activities take place and so the body temperature of owls is higher at night. The fluctuation of the body temperature is correlated with the fluctuation of the duration of daylight and is regulated by the pineal gland. In some species of birds there are *seasonal fluctuations* in addition to daily fluctuations in temperature. The European nightjar is an example of this. This species goes into real winter hibernation, associated with a decrease in body temperature, and it can survive a body temperature of 5–8°C. Spontaneous arousal is only possible when the environmental temperature rises to between 13° and 20°C.

In addition to the physiological decreases in temperature described above, against which birds must protect themselves to prevent exhaustion of their energy reserves, a decrease in body temperature is observed in all species of birds after a period of fasting. For this reason, birds presented as patients are often hypothermic.

It is important in avian medical practice that most species of birds can maintain a constant expenditure of

energy within a certain environmental temperature range, known as the *thermoneutral zone*.

In order to cause as little stress as possible to birds that are ill, it is desirable to house them in a temperature that lies between the upper and lower limits of the thermoneutral zone (upper and lower critical temperature). For many small species of birds, such as the zebra finch (10 g), the thermoneutral zone is between 32° and 40°C. In larger species of birds the thermoneutral zone is lower. For the racing pigeon (400 g) it is between 18° and 32°C and for the chicken (2000 g) it is between 10° and 25°C. These limits for the thermoneutral zone apply to birds with an intact plumage. The lower critical temperature is higher in molting birds than in those with a full plumage. The same certainly applies to surgical patients in which a part of the plumage is removed for surgical reasons.

Dehydrated birds are not in a good state to discharge excessive heat by evaporation and therefore should not be handled in a place that is too warm.

The body temperature should always be measured in birds that are presented in stupor or coma, in water birds that are 'wet' (see Feathers), and birds which for one or another reason have lost the insulating effect of their plumage. Monitoring of the temperature is also important during prolonged anesthesia (and if necessary, the bird should be warmed!).

Because of the great temperature variation and the relatively high body temperatures in birds, the mercury thermometer is unsuitable. What is very suitable is an electronic thermometer provided with a flexible probe of a small diameter. Measuring the temperature in birds is not entirely without risk because the wall of the cloaca can easily be perforated with a thermometer if care is not taken.

28.8 Notation

The information from the history form, together with the information obtained by additional questions, can be recorded on the examination form for birds. On this form the findings from the physical examination can also be recorded (see the DVD).

28.9 Further examination

Just as for the dog and the cat, various methods (with reference values and reference illustrations) have been developed for birds. These include diagnostic imaging,[8] blood examinations (hematology,[9] biochemistry[10]), endoscopy,[11] and electrocardiography.[12]

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Addendum: Instructions for the owner

1 If the bird is kept in a cage, the cage as it is (*not cleaned*) should also be brought along with the bird for examination by the veterinarian. The examination of the cage often provides valuable information to help in making the diagnosis.

2 If possible, the bottom of the cage should be covered with waxed paper for 24 hours before the visit to the veterinarian. This will enable the veterinarian to see the number and appearance of the bird's excretions. It is also easy to collect

samples in this way if further examination is needed.

3 Before the visit to the veterinarian, make a list of the foods which the bird receives, including special foods or treats and the amounts of each. If the bird is drinking more than it has normally done, measure the amount it drinks per day as accurately as possible with the help of a measuring cup. Also bring the food package with a small amount of the food, and samples of any additional foods or treats that the bird receives.

4 Make a list of any medications the bird has been given (the name and the dose). Bring along any of the medications that you still have.

5 Before moving the cage, empty the water dish or bottle and return it to its usual place in the cage. If there is a dish of grit in the cage it should be removed before transporting the bird, to prevent the possibility that the bird begins eating grit excessively as a result of stress during the trip.

6 During transport the cage should be covered with a blanket or towel, to prevent the bird from becoming chilled during transport and to keep it quiet.

7 If the bird is very weak, has been injured, or has signs of a nervous disorder, the perches should be placed lower in the cage and any objects on which the bird could injure itself should be removed.

8 For racing pigeons, birds kept in an aviary, or other birds that are not kept in a cage, it is important to collect a representative sample of the feces from the different houses or aviaries.

9 If the bird is not one of the common types, information about the subspecies or breed, and the sex and age of the bird, should be obtained or looked up at home in advance, to avoid possible misunderstandings in giving information to the veterinarian.

29 Small mammals: rabbit, guinea pig, chinchilla, golden hamster, mouse, rat, gerbil, ferret, and mink

J.T. Lumeij

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The history and physical examination in small mammals does not differ in principle from that in the dog or cat. There are small differences in the examination and the possibilities for examination that are determined by the difference in size among the different species and differences in anatomy and/or physiology. There are differences concerning housing and feeding and thus these aspects must receive the necessary attention when the history is taken.

This chapter does not present ready-made protocols for examination species-by-species. Instead, it gives differences from the dog and cat. The general principles of the examination and a detailed description of how to perform the examination will be found in what has been described for the dog and the cat. The first concern of this chapter is the handling of various small mammals.

29.1 Handling and techniques

Some rodents have a well-developed escape mechanism in order to escape predators and this must be taken into account in handling them. Animals having such an

escape mechanism include the mouse, rat, gerbil, and chinchilla.

In the first three species the skin of the tail can be stripped off if the animal is grasped by the end of the tail. Especially in the gerbil this is not uncommon. The phenomenon of 'fur slip' occurs in the chinchilla as a result of stress during handling. Adrenalin acting on the mm. arrectores pilorum causes large patches of hair to fall out. It takes about five months for this hair to be replaced by new hair of the same length.

Rabbit (Oryctolagus cuniculus)

The skeleton of the rabbit is very fragile. The total weight of the skeleton is about 8% of the body weight (in the cat it is about 13%). If rabbits are manipulated incorrectly, fractures or luxations of the lumbar vertebrae (most often L7) can easily occur and can result in posterior paralysis. Rabbits must always be adequately restrained in order to prevent struggling.

Although it seldom happens, old bucks and does with a strong territorial behavior can bite people. One must usually be more concerned about the risk of being scratched by the rabbit's claws. For this reason it is advisable not to have your sleeves rolled up when handling rabbits. A rabbit can be grasped by bringing one hand along the side of the animal and then under its rear legs, while the other hand grasps the skin on the top of the neck. The rabbit is then lifted up and in the same movement its head can be pressed between the arm and the body (Fig. 29.1a). The animal can also be held with its head between the elbow and the body while the hand of the same arm encloses the caudal part of its body (Fig. 29.1b). Rabbits should never be lifted by their ears. If one attempts to lift a rabbit with both hands around its thorax, it will usually begin to strike with its rear feet and can injure the examiner.

For *collection of a blood sample* or insertion of a gastric tube without the assistance of someone to restrain the animal, the rabbit can be placed in a specially-designed box (Fig. 29.2) or in a nylon restraint bag for cats. A rabbit can be brought into a state resembling hypnosis by holding it stretched out lying on its back. Then the ventral side of the thorax and abdomen can be softly petted in the caudal direction and the head bent back slightly.

Both arterial and venous blood can be collected from the ear. Blood can be collected in different ways. For routine blood collection the rabbit can be restrained by an assistant or placed in the restraining box and by use of a vacuum blood tube with a 27G needle (0.45 mm), blood can be collected from the marginal ear vein after the hair over the site has been clipped or plucked and the skin has been disinfected with alcohol. The auricular artery, which lies in the middle of the ear, can also be used. Although it is more difficult to do, blood can also be collected from the jugular vein. After clipping the hair and disinfecting the skin with alcohol, blood can be collected in the same manner as in the dog and cat or the rabbit can be laid on its back with its head just over the edge of the table and then blood can be collected from the jugular vein. In this position the rabbit is in a state resembling hypnosis, as mentioned above. Intravenous injections can be given in the cephalic vein, the saphenous vein, or the lateral ear vein. For intravenous catheterization, use the marginal ear vein, the saphenous vein, the cephalic vein, or the jugular vein. The bone marrow can be

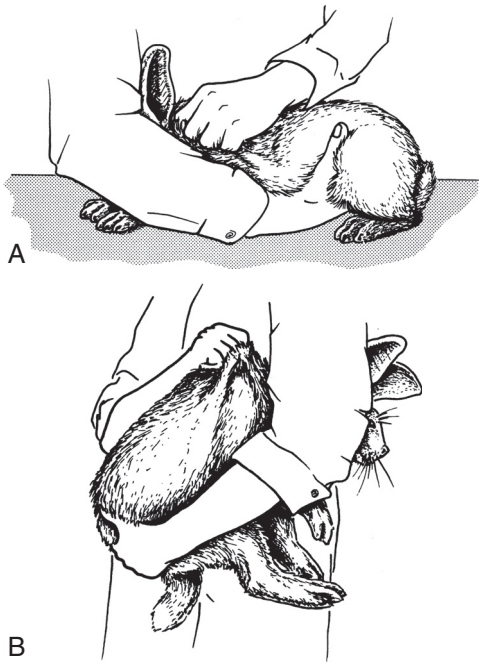


Fig. 29.1 A Correct way of picking up a rabbit. B Holding a rabbit.

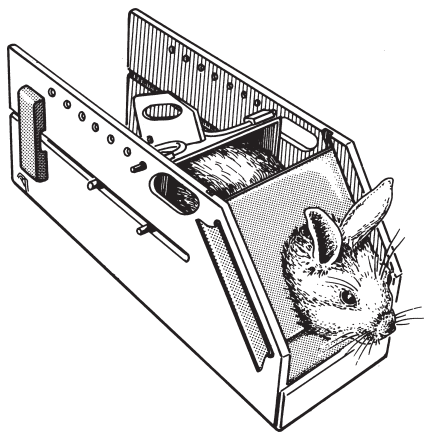


Fig. 29.2 Restraining a rabbit in a restraint box.

catheterized via the proximal humerus, proximal femur, or tibial crest.

Oral *administration of medications* with a tuberculin syringe via the diastema (the space between the incisors and the premolars) is usually easy. Medications can also be administered via a gastric tube, for which a flexible plastic urinary catheter with a diameter of 2 to 3.5 mm can be used. The distance from the mouth to the last rib is marked on the catheter. Then a wooden or plastic block with a central hole is placed in the diastema. To stimulate swallowing during introduction of the catheter, one can blow through the catheter when the tip reaches the pharynx. The catheter is inserted very carefully until it is in the stomach. If resistance is felt it is possible that the catheter has entered the trachea. Before fluid is introduced through the catheter, the position of the tip is checked by aspirating to be certain that gastric juice is obtained (Fig. 29.3) As in cats, a thin stomach tube can be introduced via the nose.

The urinary bladder of rabbits is easily catheterized. To catheterize the buck a catheter with a diameter of 1 to 2.5 mm is used (for a weight range of 1 to 5 kg). The penis should be well exposed. The catheter is sprayed with xylocaine before it is introduced. A catheter with a diameter of 2 mm is used to catheterize the doe. By pressing with the thumb below the vulva or by gently pulling on the tuft of hair below the vulva, the entrance to the vagina can be exposed. If the catheter is sprayed with xylocaine and inserted so that it glides over the ventral vaginal mucosa directed slightly ventrally, it will enter the urethra. If resistance is felt, the catheter is then lowered to a horizontal position and introduced further. It should pass without any resistance. Cystocentesis with a 23–25G needle (see § 25.2.2) is also possible (see § 25.4).

Guinea pig (Cavia porcellus)

Guinea pigs are sometimes difficult to catch. They should be picked up with a full hand under the thorax while the rest of the body is supported with the other hand (Fig. 29.4). Grasping the thorax or abdomen from the dorsal (spinal) side can cause damage to the lung or liver. Guinea pigs seldom bite but they wiggle and struggle a great deal and are very noisy, like piglets.

In some guinea pigs it is possible to collect blood from the jugular vein. The method is identical to that used in dogs. Blood can also be collected from the so-called femoral triangle. For this purpose the animal is held lying on its back. The blood will be either arterial or venous. Intravenous injections are given in the saphenous vein and sometimes in the ear vein. Transillumination and a very fine needle (27G) are needed for the latter technique. For both blood collection and intravenous administration of medications the cephalic vein and the saphenous vein can be used. The skin of the guinea pig is very thick, especially on the back, and this should be considered when giving subcutaneous injections.

Oral administration of medications is easy with the use of a tuberculin syringe via the diastema. By use of a flexible catheter and a wooden or plastic block or blunt cannula the stomach can also be intubated.

Catheterization of the bladder is possible in both males and females by use of a feline urinary catheter. In males, however, catheterization almost always causes an ejaculation, which results in obstruction of the catheter. Cystocentesis with a 25G needle is also possible.

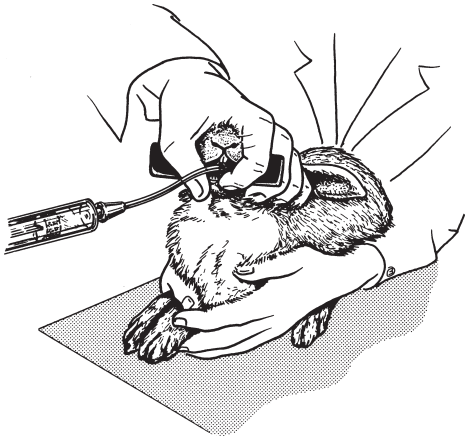


Fig. 29.3 Passing a stomach tube in a rabbit with a block held in the diastema.

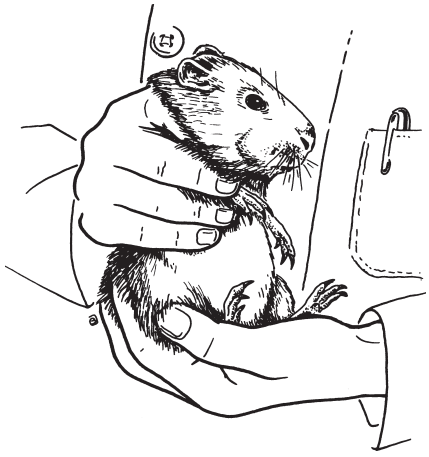


Fig. 29.4 Correct way of holding a guinea pig.

Chinchilla (Chinchilla laniger)

In handling chinchillas, one must be conscious of the 'fur slip' described above. The best way to pick up the animal is to lift it by the base of the tail and smoothly swing it up onto the forearm (Fig. 29.5). A chinchilla can be grasped in the same way as a rat, around the thorax. Keep in mind that chinchillas can squirt urine up to about 75 cm if they feel threatened.

The ear veins can be used for blood collection and for giving injections with a 25G or 27G needle. Oral administration of medications with a tuberculin syringe is easy via the diastema. If the animal will not sit still, it can be rolled up in a hand towel. Cystocentesis with a 25G needle is possible.

Golden hamster (Mesocricetus auratus)

Hamsters must be handled regularly in order to keep them tame. They are nocturnal animals and if during the day they are suddenly awakened or picked up roughly they may bite. Solitary housing is needed to prevent fighting. The hamster can be picked up in the same way as the rat, with a full hand around the thorax. In general males are easier to handle than females. Hamsters can be moved easily by using a can, into which they usually crawl spontaneously.

Blood can be collected from the retrobulbar plexus after local or general anesthesia. Small amounts of blood can be collected from the tail by use of a vaccinostyle or needle. Blood can also be collected from the jugular vein. Intravenous injections can be given in the saphenous vein. In giving subcutaneous injections it should be remembered that the cheek pouches extend to the shoulder.

Medications can be administered orally with a blunt cannula via the diastema.

Mouse (Mus musculus)

The best way to pick up a mouse is to lift it by the tail (but not by the tip, as explained above) and then place it on a rough surface. When the mouse is pulled by the tail it will try to resist by holding firmly with its front feet. With the thumb and forefinger of the other hand the mouse can now be grasped by the skin of the neck and lifted up. The hand is then pronated and the tail of the mouse is held with the ring finger or fifth finger (Fig. 29.6). If not enough of its neck skin is grasped the mouse can turn over and bite the fingers. If the mouse is held stretched out too much its respiration can be impaired.

Blood can be collected from the tail vein. For this purpose the mouse can be placed in a special holder (Fig. 29.7). Blood can also be obtained by puncture of the retrobulbar plexus with a capillary hematocrit tube, but for this the mouse must be anesthetized. Then by grasping the skin of the neck, both jugular veins can be compressed to cause venous congestion in the head. A capillary tube with the tip broken off (to give a cutting edge) is then introduced via the medial canthus along the globe into the retrobulbar plexus (Fig. 29.8). When the venous congestion is relieved and the capillary tube is removed, the bleeding stops spontaneously. This method of blood collection can have harmful consequences for the animal's vision. An inelegant but effective method for repeated blood sampling in mice is to slice off the very tip of the tail.

Medication can be administered orally via a short cannula introduced into the stomach. After the animal is restrained with its neck stretched out, as described above, a shortened cannula is carefully introduced along the palate (Fig. 29.9). Quantities of up to 0.1 ml can be administered orally via the diastema with a medicine dropper. Intramuscular injections are

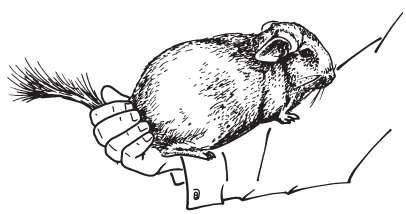


Fig. 29.5 Correct way to hold a chinchilla.

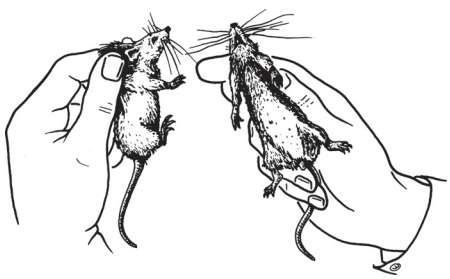


Fig. 29.6 Correct way to grasp and restrain a mouse.

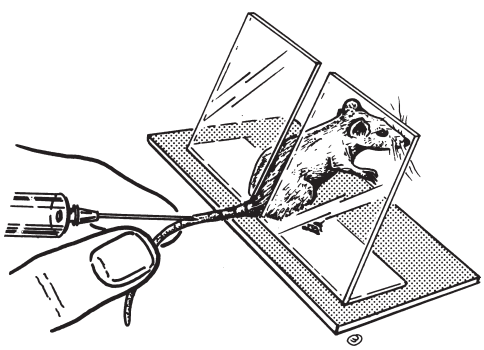


Fig. 29.7 Inserting a needle in the tail vein of a mouse.

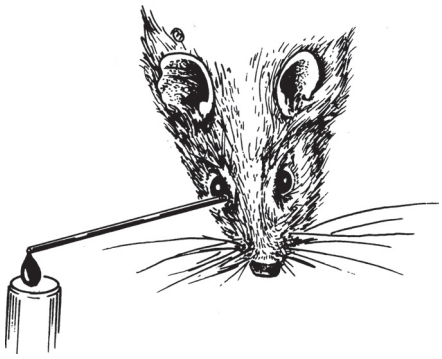


Fig. 29.8 Obtaining blood from the retrobulbar plexus of a mouse via the medial canthus.

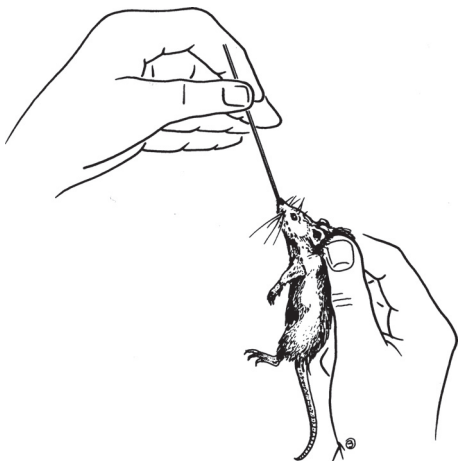


Fig. 29.9 Introducing a short cannula into the stomach of a mouse.

inadvisable because of the small volume of muscles. Subcutaneous injections can be given in the fold of neck skin by which the animal is restrained. The lateral tail vein lends itself to intravenous injections after the vein is dilated in warm water or in the heat from a light bulb. The mouse is placed in the special holder for this purpose. To obtain urine the mouse can be held upside down, which usually will cause it to urinate spontaneously. Sometimes even holding the animal is enough to cause urination.

Rat (Rattus norvegicus)

Most strains of rats are tame and easy to handle. The first step is to allow the animal to adjust to the presence of the examiner. Then the rat can be grasped by the base of its tail, not at the tip. The rat will try to walk away and this will stretch out its body. With the other hand the rat can now be grasped with the thumb under the chin and the forefinger held around the neck (Fig. 29.10). It is especially important to place the thumb correctly, for by pressing it against the lower

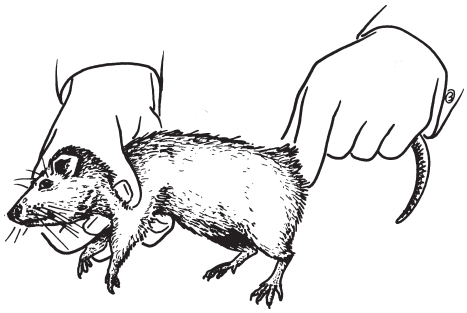


Fig. 29.10 Restraining a rat.

jaw one can prevent the rat from biting. If the rat is heavy and pregnant, the caudal part of the body must be supported with the other hand. A plastic cylinder can also be used to restrain a rat. The cylinder has various openings through which injections can be given and blood samples can be collected.

Blood can be collected via orbital puncture, as described for the mouse, but in the rat the capillary tube is introduced through the dorsal conjunctiva in a caudomedial direction. The lateral tail vein can also be used for blood collection.

Medications can be administered orally with a blunt cannula, just as described for the mouse.

Intravenous injections can be given via the lateral tail vein but the vein is much more difficult to see than in the mouse, especially in older rats. Rubbing the tail for two minutes with alcohol removes the superficial layer of keratinized epithelium and the vein is made more visible. The saphenous vein and the jugular vein can also be used for intravenous injections.

Gerbil (Merionus unguiculatus)

One of the reasons why gerbils are used as experimental animals is that some strains have a genetically determined predisposition to epileptic seizures. The handling of a gerbil can sometimes induce an epileptic seizure, which can last from 15 to 30 seconds and is quite impressive. The seizure stops spontaneously and treatment is not necessary. The procedures for handling, collecting blood, and administering medications are the same as for the mouse. Because the gerbil has a strongly pigmented tail, the use of the tail vein for clinical purposes is very difficult, in contrast to that of the mouse. In the gerbil intravenous injections can be given most easily in the femoral vein.

Ferret (Mustela putorius furo) and mink (Mustela vision)

In contrast to what many people think, ferrets are not wild animals. Like guinea pigs, they have been domesticated for thousands of years. Most ferrets kept

as companion animals are accustomed to being handled and pose no problems during examination. However, their teeth are long and sharp and can penetrate deeply through the skin, and the examiner must be prepared for less compliant individuals. Especially jills and kits should be handled with care.

Like rats, ferrets can be handled by grasping the thorax with one hand and placing the thumb under the chin. Troublesome animals are best held by grasping the neck skin with one hand, allowing the body to hang down freely. Handled in this way, most ferrets relax completely, allowing physical examination. An additional advantage is that the abdominal organs shift slightly downward, which makes them easier to palpate.

The attention of troublesome ferrets can be distracted by allowing them to lick the tip of a syringe containing a pasty food (such as Nutri-Cal). Most ferrets like this so much that they can be examined at the same time. If the ferret bites the examiner, the bitten hand should not be pulled back. The ferret's mouth should be opened by an assistant, pressing in the corners of the mouth with the thumb and forefinger. To handle nonsocialized mink, such as those raised for fur production, heavily reinforced gloves should be worn.

In ferrets venous blood can be collected from the jugular vein, the cranial vena cava, or the saphenous vein. Arterial blood can be collected from the caudal artery on the ventral side of the tail. In some ferrets it is advisable to use isoflurane anesthesia for blood collection. For collection from the jugular vein, the ferret is restrained by rolling it in a towel. An assistant holds the ferret in sternal recumbency with its front legs over the edge of the table and its neck extended upward (see also § 25.3.1). After the hair is clipped and the skin disinfected with alcohol (see also § 25.2.4), the jugular vein is distended by applying slight pressure on the side of the neck close to the thoracic inlet. Blood is collected via a 26G needle into a 3-ml vacuum tube.

Subcutaneous fat sometimes masks the jugular vein. In that case, blood can instead be collected from the cranial vena cava after the ferret has been anesthetized and placed in dorsal recumbency. A 26G needle is inserted at the cranial junction of the left first rib and the sternum. After the needle penetrates the skin, either a vacuum tube or a syringe is attached and then the needle is directed toward the contralateral hind leg at an angle of approximately 30° to the body. The needle is advanced until blood appears in the tube or syringe. If blood does not appear when the needle is inserted fully, it is then retracted slowly. If blood suddenly appears, the needle should not be moved until the desired amount of blood is collected. Small amounts of blood can be collected from the saphenous vein, on the lateral side of the hind leg just proximal to the hock joint, and from the cephalic vein on the front leg. The cephalic vein is preferred for the insertion of indwelling catheters. For clipping and disinfection of the skin, see § 25.2.4.

The caudal artery, on the ventral side of the tail, is most easily punctured when the ferret has been in a warm environment for some time. With the animal restrained in dorsal recumbency, a 26G needle is inserted for 2–3 cm in the ventral furrow of the tail, toward the body. This allows 3–5 ml of blood to be collected, after which pressure is applied over the site until bleeding stops. Blood should not be collected from ferrets by puncturing the retro-orbital plexus or by cutting a toenail.

Urine can be collected from ferrets after spontaneous urination on a smooth surface or by manual compression of the bladder. Cystocentesis with a 26G needle is also used. Bladder catheterization is difficult in ferrets but not impossible. It is carried out under anesthesia, using a 3.5 French catheter. In females the urethral opening is about 1 cm cranial to the clitoris and the catheter is used with a stylet (see also § 25.2.1). In the hob the J-shaped curve at the distal end of the baculum (os penis) may cause problems during catheterization and hence the catheter is used without a stylet.

Intravenous injections can be given to ferrets via the cephalic vein, the saphenous vein, and the jugular vein. Intravenous catheters are inserted under anesthesia. For intraosseous catheterization, a 20G spinal needle is inserted medial to the major trochanter into the marrow of the femur.

In anorexic ferrets it is possible to place an esophageal tube under anesthesia. The technique is similar to that used in anorexic cats.

29.2 History

The history form for the owner is used to obtain a history that is as complete as possible. Because infectious diseases may play a role, the history should include not only information about the individual animal that is ill but also about other animals with which the patient has been in contact.

In a group problem additional questions must be asked about morbidity and mortality, about the age and gender of the affected animals, and about the signs of disease. The absolute number of animals with signs is also important.

In taking the history of an individual animal, questions are asked about the feeding (source and composition, storage, date of preparation, additions, amount, recent changes) and about the housing (type of cage, placement and style, provisions for food and water, type of floor, hygiene, light regimen, ventilation, temperature, humidity) (Tables 29.1 and 29.2).

Table 29.1 Some physiological and animal husbandry data in small mammals

species	life span in years (max)	adult weight (g)	resp. freq.	pulse freq.	rectal temp. (°C)	housing temp. (°C)	relative humidity (%)	dry food per day (g/100 g)	water per day (ml/100 g)
rabbit	5–10 (15)	♂ 900–9000 (breed-dependent)	32–60	120–135	37.5–39.5	15–19**	50	3–4 (rationed) ad lib hay	5–10 (90 in lactation)
guinea pig	4–5 (8)	♂ 900–1200 ♀ 700–900	42–104	230–280	37.2–39.5	18–23	50–70	5–6	10
chinchilla	10 (20)	♂ 400–500 ♀ 500–600	–	700–750	36.1–37.8	15–21	–	–	–
hamster	1½–2 (4)	♂ 85–130 ♀ 95–150	33–135*	250–500*	35.5–38.9	19–23	40–60	10–12	8–10
mouse	1–2 (4)	♂ 20–40 ♀ 20–60	94–216	325–780	36.5–38.0	19–23	45–70	15 (ad lib)	15
rat	2–3 (5)	♂ 267–500 ♀ 225–325	63–179	250–500	35.6–38.9	19–23	60–80	10 (ad lib)	10–12
gerbil	2–4 (8)	♂ 50–130 ♀ 50–55	90–160	200–600	35.8–39.0	18–24	<50	5–10 (ad lib)	4–7
ferret	5–8 (13)	♂ 1350–2700 ♀ 450–900	30–40	180–250	37.8–40.0	15–19**	–	ad lib	–
mink	(11)	♂ 1700–2200 ♀ 800–1000			38.8				

*Respiration, pulse frequency, and rectal temperature decrease considerably in hamsters during hibernation.

**Rabbits and ferrets are sensitive to high temperature; never place them in full sun.

Table 29.2 Guideline for housing mice as experimental animals. Source: Preliminary recommendation of the European Council ETS 123; GT 123(2000) 57. Tables with similar data for rats, gerbils, hamsters, guinea pigs, rabbits, and ferrets are in Appendix 1 of this book

	body weight (g)	*minimum floor area (cm^2)*	*minimum cage height (cm)*	*floor area per animal (cm^2)*
In stock and during procedures	20	330	12	60
	21–25	330	12	70
	26–30	330	12	80
	>30	330	12	100
During breeding		330	12	
		Monogamous pair or trio. For each female with litter, add 180 cm^2		
Stocked by breeder* cage size 950 cm^2	<20	950	12	40
Cage size 1500 cm^2	<20	1500	12	30

*Weaned mice can be kept in a high density for a short period, provided there is sufficient room and the cage is adequately enriched. There may be no evidence of harm to health and/or welfare.

Like primates, guinea pigs are unable to synthesize vitamin C because of a genetically determined deficiency of the liver enzyme L-gluconolactonoxidase (one of the enzymes necessary for the formation of L-ascorbic acid from D-glucose). Commercially prepared diets for guinea pigs are available in which vitamin C is present in a suitably stable form. If the food is held for longer than three months, however, the vitamin C content will be too low to cover the requirement of 16 mg/kg daily. The vitamin C requirement of guinea pigs kept as house pets is provided by giving them cabbage and carrots. Vitamin C can also be given in the form of half a 50 mg tablet once daily.

Guinea pigs, like rats, are very choosy eaters. During the first few days of life the guinea pig learns to discriminate between what is food and what is not. For this reason, changes in food later in life can lead to anorexia because the new food is not recognized (neophobia). Especially in the terminal stage of pregnancy, when the energy requirement is great, this can lead to severe problems (acetonemia). Sudden changes in food in all animals with a complex gastrointestinal flora, such as rabbits and rodents, can lead to digestive problems because the gastrointestinal flora must adapt to the change in substrate. For this reason changes in the composition of the food should be made gradually over a period of at least five days. Rabbits which are fed ad libitum with pellets are often very fat and tend to have thin feces because digestion does not progress normally. It is better to ration the food of these animals to a maximum of 25 g of pellets per kg body weight per day. To prevent enteropathies there must be sufficient raw fiber in the diet, such as provided by fresh grass or hay. Although hay is not strictly necessary in the diet of guinea pigs, it does reduce the chance of their chewing hair ('hair barbering'). Chewing of hair by dominant animals is also seen in mice and gerbils. In exceptional cases it is important to know who cares for the animal(s). Small children can forget to give their animals food or water, which can sometimes have fatal consequences. The availability and the consumption of food as well as water should always be checked thoroughly in cases of weight loss, dehydration, or death without other indication of the cause. Sometimes the drinking water is chlorinated (2 ml of a 5.25% hypochlorite solution per 10 liters of drinking water) or acidified to a pH of 2.5 (2.6 ml concentrated HCl per 10 l water) to prevent the spreading of *Pseudomonas* infections.

Some types of cages predispose to disease. Foot sole problems in guinea pigs and rabbits occur frequently on mesh or grill floors. Leg fractures occur easily in guinea pigs that were not accustomed to grill floors when young. Under poor conditions of hygiene rabbits can easily develop urine dermatitis (urine burn) in the anogenital area. To prevent fights, buck rabbits must be housed separately after breeding. The does should be separated from each other at the age of 3 months. If various adult male mice are kept together, extensive wounds can be expected as a result of fighting.

The animals should be housed in adequately large cages at the correct temperature and humidity (see Tables 29.1 and 29.2). Rabbits, guinea pigs, and ferrets cannot withstand temperatures above 28°C. These animals can die of hyperthermia if left in full sunlight in the summer. Long exposure to high temperatures is a well-known cause of fertility disorders in buck rabbits and of embryonal deaths in pregnant does.

The ventilation should be sufficient to provide a complete change of air about ten times per hour.

The light regimen can clearly influence reproductive results. Hence a shortening of the light period in the fall has a negative effect on reproduction in rabbits, while with a constant light period of 14 to 16 hours per day, female rabbits can be bred during the entire year.

'Ring tail' is a disorder in rats 7–15 days old that are held in low humidity, such as can occur in the winter months in heated rooms. The tail of the rat also has a role in thermoregulation. In a relative humidity below 20% the regulation of the microcirculation of the tail can be disturbed, leading to the ring-shaped constriction due to ischemia. Necrosis of the tail distal to the constriction can follow.

It should be ascertained whether a quarantine procedure is followed when new animals are introduced.

Establishing the age of the patient is essential because many small mammals have a rather short life span (see Table 29.1). In some species questions should also be asked about the vaccination status. Rabbits can be vaccinated against myxomatosis and rabbit hemorrhagic disease; mink and ferrets against canine distemper, rabies, and botulism type C; and mink also against 'mink viral enteritis' (with feline panleukopenia vaccine).

29.3 Physical examination

29.3.1 General impression

Especially in species in which an extensive physical examination is difficult to perform because of the size of the animal, a minute observation of the animal is very important, preferably in an environment in which the animal feels secure. The points of the General impression (Chapter 7) should be followed closely. One can assess the locomotion of the animal only if it is indeed allowed to walk. In evaluating the locomotion one must know how this species of animal moves normally. The rabbit, for example, is a plantigrade cursorial animal with a unique style of locomotion, called half bounding: the two hind feet touch the ground almost in unison but the forefeet alternate. Ferrets also have a peculiar way of walking: their front and hind legs move slightly diagonally and seem not to be cooperating. When walking, their long bodies are arched in the air, which adds to the impression of two bipedal individuals in a ferret suit. During play they jump by quickly arching their midsection and are then carried by their momentum, which adds to the attractiveness of pet ferrets. In the rat and the rabbit there is occasionally a tilting of the head as a result of an illness. If the animal is not observed carefully this important abnormality could be missed. A hibernating hamster lies rolled up and appears to be in a coma or even dead. Hamsters go into hibernation at a temperature of 6 °C or lower, for periods of one to three days. Such animals must first be warmed up and an attempt must be made to awaken them before one concludes that there is something seriously wrong. In intact ferrets there is a seasonal variation of the amount of body fat. In the winter they may weigh 40% more than in the summer.

29.3.2 General examination

Respiratory movements

After obtaining the general impression of the patient, one looks first at the respiratory frequency, type, and rhythm, and only then should the animal be manipulated. This should preferably take place in an environment in which the animal feels secure. The respiration is evaluated to determine whether it is normal or abnormal under the given circumstances. This can only be assessed if one has often observed the respiration of healthy animals. Table 29.1 gives a few reference values.

Pulse (and heart auscultation)

Palpation of the peripheral pulse is often prevented by the small size of small mammals. In addition, counting the heart frequency is only possible in the rabbit, because it is too high in the other species listed in Table 29.1. In the rabbit the pulse can be palpated in the femoral artery or the auricular artery (central artery of the ear) (Fig. 29.11). The pulse frequency in a rabbit at rest is 120–150/min but when the animal is excited it can increase to 200–300/min. In the rabbit the ictus cordis is palpable in the left and right second, third, and fourth intercostal spaces (L>R). The heart can be auscultated in the fourth intercostal space on the left side and in the third space on the right side. In ferrets the ictus cordis can be palpated between the sixth and the eighth ribs.

Temperature

The temperature must be taken with a suitable thermometer, preferably digital (see also § 4.2). Because of the high metabolic rate and the large body surface area

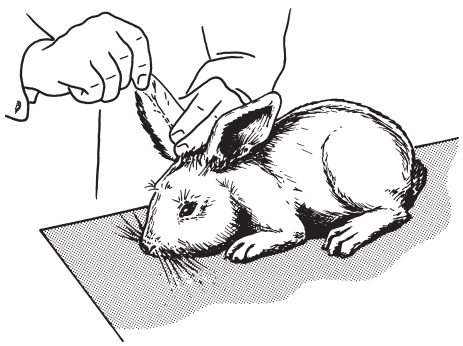


Fig. 29.11 Counting the pulse in the auricular artery of the rabbit.

in relation to body weight of small mammals, taking the temperature is especially important during *anesthesia*, when the temperature can *decrease* rapidly unless appropriate measures are taken. When inserting the thermometer in the rabbit, one can observe the skin folds filled with secretion in the perineum on both sides, the so-called inguinal fossae. This secretion is produced by the inguinal glands. It contains pheromones which serve for marking territory. In male guinea pigs there are glands on both sides of the anus which empty out in the anus. Especially in older males, these glands occasionally lead to problems because of the accumulation of secretion in the anus. Ferrets have well-developed anal sacs with strong-smelling yellow contents.

Coat, hair, and nails

In addition to what has already been given for the dog and cat, there are a few specific items of importance.

In ferrets the synchronization of hair growth is under the influence of estrogens and many hairs are in the telogen (rest) phase. During the breeding season jills in heat lose many hairs and only after cessation of heat (e.g., with mating), does new hair growth commence and the coat become thicker.

In rabbits, especially older females, there is a well-developed fold of skin under the neck called the dewlap. In elderly does the dewlap may become very large and may be confused with an abscess. Occasionally in these dewlaps warm and hard pieces of fat can be palpated. Slightly cranial to the dewlap lies the chin gland. Like the inguinal (perianal) glands, this produces pheromones.

Adult buck hamsters have darkly pigmented patches at the level of the hips. The skin in the area is slightly rough and has stiff, dark hairs. This is the location of the hip glands. In sexual excitement the coat around these glands becomes moist and the animal begins to scratch and scrape around the area. The odor from the hip glands serves, among other purposes, for marking territory. In female hamsters the hip glands are much less developed and are probably active only during estrus.

In the gerbil there is a similar gland on the ventral surface of the abdomen adjacent to the umbilicus, producing yellowish-brown secretion with a musky odor. This gland is sensitive to androgens and therefore larger in the buck than in the doe.

In ferrets sebum production increases during the breeding season, giving the animals a strong odor, a fatty coat, and yellowish discoloration of the secondary hairs of the undercoat.

Because subcutaneous abscesses or tumors occur frequently in small mammals, the entire animal should be palpated routinely in order to detect such abnormalities. The extent of such processes should be palpated and carefully described (see also § 4.1.2). The areas where lymph nodes are located (mandibular, axillary, popliteal, and inguinal lymph nodes) are also examined.

The mammary glands are also examined at this time (see Table 29.2). Mammary tumors occur frequently in mice and rats. Mastitis can be overlooked if the mammary glands are not examined carefully (rabbit and guinea pig). Because the mammary tissue in murine species can extend quite far, mammary tumors can occur in very unusual locations, such as at the level of the scapula or adjacent to the vulva. In animals that possess cheek pouches (hamster), a differentiation must be made between physiologic filling of the pouches and abnormalities. Examination of the lymph nodes is also carried out at this time.

In the rat there are depots of brown fat in the ventral cervical region that can be mistaken for salivary glands or lymph nodes. If a mite infestation is suspected, the lesions can be examined in the same manner as in dogs and cats but in the mouse it can also be useful to pluck a few hairs with a forceps from around the nose or behind the ears for microscopic examination, for mites are often concentrated in these areas.

The evaluation of the skin color in white animals can provide important information about respiration and circulation. Especially during anesthesia, the color of the nose and soles of the feet is an important indication of the oxygenation of the blood. Yellow coloring of the skin (icterus) is seen when there are elevated circulating levels of bilirubin. In a dermatitis, coloring of the skin can give an indication of the etiology. In an infection with *Pseudomonas aeruginosa* the bacterial pigment pyocyanin causes a blue-green color ('blue fur disease' in the rabbit).

During the general examination of small mammals the skin turgor should always be checked, because in some diseases (or because the drinking nipple of the water bottle has become obstructed), the animals can dehydrate rapidly.

Because of the way in which some small mammals are housed, their nails grow very long and must be clipped regularly. The soles of the feet of guinea pigs and the hocks of rabbits should be examined for lesions that can develop because of inadequacies in husbandry.

The external ear of the ferret, the rabbit, and the rat should be examined for crusts caused by mite infestation.

Mucous membranes

The mouth and conjunctivae are examined routinely. The genital mucosa is also examined, more than in dogs and cats, in order to: (1) confirm the gender, (2) determine the time of estrus in the female, and (3) exclude spirochete infection in the rabbit. The color of the sclerae is also evaluated, if possible. Rabbits

have a well developed third eyelid, on the bulbar side of which is Harder's gland, consisting of a small white ventral lobe and a large colored dorsal lobe. This gland is larger in bucks than in does, especially during the breeding season.

The mucous membranes of small rodents are difficult to evaluate. In these animals the color of the skin must often be used instead, but in rabbits and ferrets the capillary refill time can also be checked (§ 8.2.5).

Abdominal palpation

In contrast to what has been said about the dog and cat (§ 2.5), abdominal palpation should be part of the general examination in small mammals because it requires little time and is very informative.

In the *rabbit* the large intestine occupies the entire right half of the abdomen as well as the ventral third of the left half. The small intestine is in the dorsal part of the left half of the abdomen. In healthy rabbits the large intestine is a soft and doughy mass. The transverse and descending colon is recognized by the presence of formed pieces of feces which are palpable like the links of a chain. When the animal is constipated a great mass of feces can be palpated in the large intestine. In rabbits, as in cats, both kidneys can be palpated as smooth, bean-shaped organs. The right kidney is usually within the rib cage but can usually be moved caudomedially with the middle finger. The left kidney is in the medial mesogastrium and is relatively easily moved. In female rabbits pregnancy can usually be determined by palpation (see below). The bladder is palpable in the ventral hypogastrium. It should most certainly not be palpated too roughly, for it is easily damaged. The stomach and liver are not palpable under normal circumstances. In the mouse and the rat the liver is indeed palpable.

In the mouse, normal 'space-occupying processes' such as testicles and fetuses can be mistaken by an inexperienced person as abnormal findings. In ferrets a large spleen can often be palpated but its clinical significance is not clear.

29.3.3 Respiratory tract

The examination of the respiratory system in small mammals proceeds in principle in the same manner as in dogs and cats (Chapter 9). Because of the smaller size, however, large parts of the examination are technically impossible. A few specific points are discussed here.

A red nasal discharge in the rat and the gerbil is usually not due to blood. In these animals tear fluid produced by Harder's gland is rich in porphyrins which give the tears a red color. When production of the colored tear fluid is excessive (chromodacryorrhea), there is a red nasal discharge via the nasolacrimal duct. The tear fluid fluoresces under ultraviolet light.

A nasal discharge in a rabbit is not always visible by physical examination because the rabbit keeps its nose clean with its forefeet. It can often be concluded that there is a nasal discharge because the hair on the inside of the forefeet is matted.

Inspection of the nasopharynx in small companion animals is only possible under anesthesia and with the use of special instruments (a mouth spreader and a cheek spreader) and a good light source (head lamp).

Percussion of the thorax is actually possible only in the rabbit by means of the finger-finger method. Percussion can be performed on both sides of the thorax along two horizontal and three vertical lines, as described for the dog and cat. The borders of the lungs for the three horizontal lines (mid-scapula, shoulder joint, mid-humerus) are the 10th, ninth, and seventh intercostal spaces (the rabbit has 12 ribs). Because of the small surface area, definition of the relative damping of percussion by the heart is not possible.

29.3.4 Digestive tract

A difference between the Lagomorpha (to which the rabbit belongs) and the Rodentia is that the Lagomorpha have a second pair of incisor teeth behind the first pair in the upper jaw, while Rodentia have only one pair. The second pair of incisors in the Lagomorpha have no cutting surface and are called pivot teeth. Neither Rodentia nor Lagomorpha have canine teeth. Between the incisors and the oral cavity there is a haired cheek or lip fold that closes off the oral cavity. This makes inspection of the mouth relatively difficult in both orders. For inspection of the mouth in mice, rats, hamsters, and guinea pigs, Macedo-Dobrinho and colleagues (1978) described a technique in which use is made of a tube-shaped instrument. For examination of the mouth of the anesthetized rabbit, guinea pig, and chinchilla a mouth spreader is placed on the upper and lower incisors to open the mouth. The cheeks are spread apart with a cheek spreader and the mouth can then be examined with a head lamp (Fig. 29.12). In Rodentia and

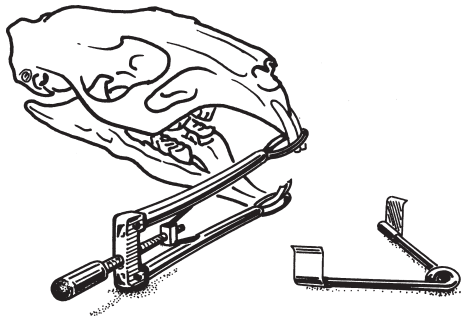


Fig. 29.12 Use of the mouth spreader to inspect the teeth of the rabbit.

Lagomorpha the incisor teeth form a segment of a circle. The incisors grow continuously and normally the upper and lower incisors wear against each other.

Enamel is deposited on the outer side of the incisors, whereas the inner side is primarily dentine. Enamel is harder than dentine and so the wearing of the two surfaces is unequal, which results in a sharp outer edge. When the surfaces of the upper and lower incisors no longer meet, a so-called elephant's bite can develop. In the rabbit this is occasionally seen as a hereditary defect. The lower incisors then project out in front of the uppers (mandibular prognathy). The molars of Lagomorpha and some Rodentia (guinea pig and chinchilla) also grow continuously. In the absence of the normal wearing process, abnormalities of the molars can occur. The continuous growth of the molars is seen only in species with open molar root canals (rabbit, guinea pig, chinchilla). There is no continuous growth in species with closed molar root canals (mouse, rat, hamster, gerbil). The dental formulas of various small mammals are given in Table 29.3.

In Lagomorpha and Rodentia coprophagia is a normal occurrence. It plays a role in the provision of essential amino acids and vitamins that are synthesized by intestinal bacteria. In rabbits this process is called cecotrophia. The feces that are eaten, called cecotrophs, are smaller and darker than the other feces and are covered with a layer of mucus. In rabbits cecotrophia has a circadian rhythm. The domesticated rabbit produces cecotrophs during the night and wild rabbits produce them during the day.

Table 29.3 Dental formulas of small mammals $\frac{ICPM}{ICPM}$

rabbit	$\frac{2033}{1023}$
guinea pig	$\frac{1013}{1013}$
chinchilla	$\frac{1013}{1013}$
hamster	$\frac{1003}{1003}$
mouse	$\frac{1003}{1003}$
rat	$\frac{1003}{1003}$
gerbil	$\frac{1003}{1003}$
ferret	$\frac{3131}{3132}$
mink	$\frac{3131}{3132}$

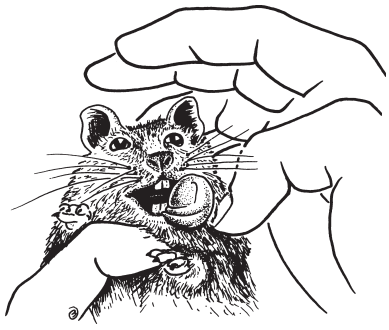


Fig. 29.13 Inspection of the cheek pouches of the hamster.

An anatomical distinction of the hamster is the presence of cheek pouches. They can be everted for inspection. The examiner holds the hamster in one hand, with the ventral side of the animal facing himself and the thumb under its lower jaw. The little finger of the free hand presses the cheek pouch from caudal to rostral while gradually pulling the corner of the mouth laterally with the thumb. This technique can be used without anesthesia (Fig. 29.13). In small species a cotton swab can be used instead of the little finger to evert the cheek pouches.

Rabbits, guinea pigs, and rats, like horses, cannot vomit. In the rat the stomach is divided into two compartments: the forestomach (without glands) and the corpus (with glands), the two parts being separated by a wall. The esophagus opens into the stomach via a mucosal fold at the location of this separating wall; this is the reason for the inability to vomit. In the golden hamster there is also a division into forestomach and glandular stomach. The rabbit and the rodents described in this chapter are monogastric. The stomach of the rabbit is never empty. In caring for the coat, hair is swallowed which cannot, as in the cat, be vomited. This is the reason why hairballs are sometimes found in the stomach of the rabbit. These trichobezoars have also been described in the hamster. In the guinea pig a gastric torsion can occur, as well as a torsion of the cecum. The appendix and the sacculus rotundus, which are located at the ileocecal junction, are very pronounced lymphatic structures of the gastrointestinal tract of the rabbit.

29.3.5 Kidneys and urinary tract

The urine of rabbits and some rodents is normally alkaline and cloudy (Table 29.4). In rabbits the cloudiness is caused by crystals of calcium carbonate and struvite. In fasting rabbits and nursing kittens ('carnivore') the urine is clear and has a neutral or acid pH. Also in acetonemia in rabbits and guinea pigs the urine is acid and clear. In rabbits the color of the urine

Table 29.4 Macroscopic appearance and pH of urine of a few small mammals

species	appearance	pH
rabbit	cloudy	8.2
guinea pig	cloudy	8.0–9.0
chinchilla	clear	6.0
hamster	cloudy	8.0
mouse	clear	6.0
rat	clear	6.0–7.5
gerbil	clear	6.5–7.5
ferret	clear	6.5–7.5
mink	clear	6.8–7.5

varies markedly, from light yellow to reddish brown or orange. The latter color is caused by porphyrins and metabolic products of bilirubin. The color increases as the pH increases and the specific gravity increases. If the drinking water becomes frozen in winter, the urine can become intensely red-orange in color and it is possible to confuse this with hematuria or hemoglobinuria. The latter abnormalities may only be diagnosed by the finding of erythrocytes and/or hemoglobin in the urine.

The kidneys and bladder can be examined by abdominal palpation and by radiography. Making an intravenous pyelogram is possible in the rabbit and the ferret.

The technique of catheterization of the urinary bladder and collection of urine in various species has already been described (see § 29.1).

29.3.6 Genital tract

General

One of the differences between the Rodentia and the Lagomorpha concerns the position of the scrotum. In the Lagomorpha the scrotum is cranial to the penis and in the Rodentia it is caudal. In both the Rodentia and the Lagomorpha the testicles can be located in the abdomen or in the scrotum. Also, the Rodentia have an os penis and the Lagomorpha do not. In both Rodentia and Lagomorpha the testicles can be located in the abdomen or in the scrotum. The inguinal canal is fairly large in diameter, which has consequences for the technique of castration. In Caviomorpha (guinea pigs and chinchillas) there is no definite scrotum. In the guinea pig the testicles are subcutaneous and in the chinchilla they are in the inguinal canal. The Caviomorpha have a relatively long pregnancy and small litters. Consequently, the offspring come into the world well developed, with a full coat, and open eyes. Young guinea pigs are able to run around directly after being born and can immediately eat hard food. The normal nursing period of this species is 10–21 days, but young guinea pigs can also grow without nursing from the mother. In all Mustelidae (including ferrets and mink) ovulation is induced by coitus, just as in the rabbit and the rat. Reproductive information of diverse small mammals is summarized in Table 29.5. The following is a brief description per species of reproduction, sex differentiation, and examination of the reproductive tract.

Rabbit

In contrast to rodents, rabbits have a very regular and obvious estrous cycle. There is a certain rhythmic period of 4–7 days in which the doe will allow copulation, followed by an inactive period of 1–2 days. The optimal period for breeding can be determined reasonably well on the basis of the color of the vaginal mucosa (Table 29.6). For mating, the doe is brought to the buck, to prevent her from defending her territory. Ovulation is induced by copulation and occurs between 10 and 13 hours after copulation. If conception does not occur, a 14–18 day period of pseudopregnancy can follow. Prenatal mortality, especially during the first 20 days of pregnancy, is a regulatory mechanism in rabbits in the wild under stress conditions, such as overpopulation. The embryos are resorbed by the uterus in three days. The doe lactates and comes into estrus as though a litter had been delivered normally. Fetal death after the third week of pregnancy results in abortion.

The average duration of pregnancy is 31 or 32 days. If the pregnancy lasts longer than this, there is usually a problem. Just before the delivery the doe plucks the fur from her chest and abdomen, exposing the nipples to enable the young to nurse and using the fur to line the nest. Young rabbits that wander outside the nest are usually lost, for in contrast to the rat and mouse, the doe does not bring them back to the nest. The doe nurses her young for a few minutes only once daily. In the wild, until the young rabbits can leave the nest by themselves, this occurs about an hour before sunrise. After the young can come and go, around the 21st day of life, the period of nursing is shifted to about two hours after sunset.

To determine the gender of newborn rabbits, the examiner holds the animal upside down in the palm of the left hand with the head facing toward the examiner. The thumb of the left hand and the forefinger of the right hand apply pressure around the genital opening. The round penis of the buck can be caused to bulge out equally on all sides. The slit-shaped vulva of the doe bulges out ventrally but the dorsal side close to the anus is not everted. Around the time of weaning the differentiation is much easier. In adult bucks the hairless scrotal sacs are easily recognized.

Table 29.5 Reproductive data for small mammals

	fertile estrus postpartum	*puberty*	*estrus cycle (days)*	*duration of estrus (hours)*	*pregnancy (days)*	*litter size*	*birth weight (g)*	*weaning weight (g)*	*weaning age*	*mammary glands*	
										thoracic	*abdominal*
rabbit	–	♂ 6–10 mo ♀ 5–9 mo	4–7 days until receptive, then 1–2 days of inactivity, induced ovulation		31–32 (28–35)	4–10 (1–23)	70–100		4–6 w		8–10
guinea pig	+	3–4 mo*	15–17 (13–20)	6–11	56–74****	1–3 (8)	60–115	180	2–3 w (0–4) (min 4 d)	0	2 × 1
chinchilla	+	4–18 mo**	41 (30–50)		105–115	2 (1–6)	30–50		6–8 w (2–3)	2 × 1 lateral	2 × 1
hamster	–	♂ 10–14 w ♀ 6–10 w	4–5	8–26	15–18	5–9 (2–16)	1½–3	30–40	20–25 d		12–17
mouse	+	♂ 50 d ♀ 60 d	4–5***	9–20	18–21	5–12 (20)	1–1½	8–14	18–21 d	3 × 2	2 × 5
rat	+	65–110 d	4–5	14	9–20	6–12 (20)	4–6	40–50	21 d	3 × 2	2×6
gerbil	+	♂ 70–126 d ♀ 65–85 d	4–7	12–18	22–26	4–6 (3–8)	2½–3½		20–30 d		2×4
ferret		4–10 mo	continuously receptive in season (1st spring season after birth), induced ovulation		41–42	5–15	8–10		6 w		8–10
mink		12 mo	8–10	48 induced ovulation	38–76	(13)			6–8 w		

*♂ puberty at 10 wks, ♀ puberty at 3–4 wks

**dependent on date of birth

***see text for explanation

****duration of pregnancy depends on litter size: the larger the litter the shorter the pregnancy

Table 29.6 Color changes in the vaginal mucosa in relation to the optimal time of mating (from Havenaar, 1986)

color of vaginal mucosa	occurrence (%)	receptive (%)	pregnancy after mating (%)
white	1	0	0
pink	35	51	31
red	63	96	84
blue/violet	1	100	0

For determination of the gender of an adult rabbit the animal is restrained as described previously (see § 29.1). The fingers of the hand on which the rabbit is lying are placed between the rear legs and the skin fold below the genital opening is pushed forward. With the other hand the tail is lifted up and pulled slightly cranially over the back.

A special characteristic of female rabbits is the presence of not only two uterine horns but also a double cervix (uterus duplex).

Pregnancy in the rabbit can be determined by abdominal palpation. In pregnant animals by 10–14 days after breeding one can palpate round objects, about 1 cm in diameter, dorsally in the abdominal cavity. Standing in front of the rabbit, grasp the skin of its neck with one hand and palpate the caudal hypogastrium with the other hand. The palpating hand is extended ventrally between the hind legs, with the thumb on one side of the abdomen and the fingers on the other. The uterus can be palpated with light pressure and careful movement of the hand cranially and caudally. Abnormalities of the uterus such as pyometra or endometrial carcinoma can also be detected by palpation. In such cases there may be a purulent or hemorrhagic discharge from the vagina.

The penis and prepuce of the buck can be inspected by pushing the penis out. Both testicles lie horizontal and cranial to the penis beneath the abdomen. The testicles descend from the age of 12 weeks, but the inguinal canal remains open during the entire life of the animal and sometimes the testicles pass back into the canal.

Guinea pig

After copulation a plug up to 3.75 cm long is formed in the vagina by coagulation of the ejaculate. It falls out of the vagina 1–2 days later.

The gender of guinea pigs is easily determined after the first day of life. In sows the anogenital area is Y-shaped and in males it is slit-shaped and the os penis is palpable. The penis can be exposed by pressing with the thumb cranial to the prepuce. In sows the vaginal opening is separate from the urethral opening. The vagina is closed by a membrane except during estrus and at the time of parturition. The anal–urethral distance is equal in boars and sows. Guinea pigs have paired uterine horns, a short uterine body, and a single cervix (uterus bicornis).

Pregnancy can be detected in guinea pigs beginning on the 16th day after breeding. By this time the ampullae have a diameter of 1 cm and can be palpated. After 23 days the diameter of the fetus is about 2 cm.

After the 30th day of pregnancy in the guinea pig a torsion of the uterus can occur. Pyometra also occurs in guinea pigs and tumors of the ovaries occur often.

Ten days before parturition the two halves of the pelvis begin to separate and by 47 hours before parturition the distance between the pubic bones is about 1.5 cm. During parturition this distance varies between 1.8 and 2.2 cm. If the sow is 7–8 months of age or older when she is bred for the first time, there are often problems. The symphysis widens less easily and fat can hinder the passage through the pelvic canal.

In boars the vesicular glands are very large. An inexperienced person seeing these 10-cm long and transparent organs at necropsy may mistake them for a uterus.

Chinchilla

In the breeding of chinchillas a harem system is used in which the individually-housed females wear a collar that prevents them from leaving their cages. The male wears no collar and via a passageway behind the cages can gain access to the individual females. Reproductive activity occurs mostly in the winter but also in other seasons. After copulation, the copulation plugs, about 2.5 cm long, can be found on the floor of the cages. There is an estrus following parturition and three litters per year are possible, but normally there are two. Usually two offspring are born but there can be up to five. If there is only one fetus, there are often problems in its delivery. Sometimes the fetus becomes mummified. Differentiating between the sexes is not easy. The clitoris is pointed and is situated ventrally in the vagina. It can be confused with a penis, especially because the male has no scrotum, the testicles being in the inguinal canal. The vagina is not very noticeable and except during estrus and parturition, it is closed off by a membrane. The most reliable method of determining the gender of chinchillas is to look at the distance between the anus and the genitalia. The

distance between the anus and the penis in the male is twice as great as that between the anus and the clitoris in the female. The female has a double cervix (cervix duplex). As in all rodents, the male has an os penis.

Hamster

Hamsters, like rabbits and chinchillas, have a double cervix. The day after ovulation (every fourth day) there is an excessive, opalescent, mucoid vaginal discharge, not to be confused with that of a bacterial infection of the genital tract. The pregnancy is extremely short and can be confirmed by palpation after 6–7 days. If pups are endangered in the first days of life, the doe can take up to 12 of them at the same time in her cheek pouches. However, the pups can also suffocate in the cheek pouches! Cannibalism of the pups by the doe can also occur if she is disturbed, especially during the first days postpartum. Determining the gender of the pups is done in the same way as described for the mouse.

Mouse

The period of heat in solitary does lasts 5–6 days. Does housed in the vicinity of a buck have a heat period of 4 days. This difference is caused by a pheromone from the buck. Large groups of does housed together go into anestrus (Whitten effect). If they are then housed with a buck, the estrous cycle resumes: almost half of the does are in estrus on the third day after introduction of a buck (synchronization method). Pairing is characterized by multiple copulations and one ejaculation. For 24 hours after copulation there is a copulation plug in the vagina. Ovulation is spontaneous and there is a postpartum estrus. If conception occurs during this estrus, implantation is retarded. The total duration of pregnancy can be up to 31 days. Some does become pseudopregnant if housed in groups (Lee-Boot effect). If a pregnant doe meets an unfamiliar buck between the first and fourth day of pregnancy, the pregnancy is blocked (pheromones). If she remains longer with the buck, a new ovulation and conception can occur (Bruce effect).

Determining the gender of mice is not difficult. The distance between the anus and urethra in bucks is twice that in does. In does the opening of the urethra is separate from that of the vagina. In juvenile does there is a membrane over the vagina.

Rat

The Bruce effect and the Whitten effect do not occur in rats, as they do in mice. Conception during the postpartum estrus causes, as in the mouse, retardation of implantation (up to 10 days, depending on the size of the uterus). After copulation there is a waxy copulation plug in the vagina. Sometimes the plugs are found in the cage. Pregnancy examination by palpation is possible from the eighth day after copulation. Determination of gender is done in the same way as in the mouse.

Gerbil

If a gerbil is bred during the postpartum estrus, implantation can be retarded and as a result pregnancy can be increased up to 42 days. Pseudopregnancy (16 days) also occurs in the gerbil. Determination of gender is the same as in the mouse.

Ferret

The reproductive season of the ferret lasts from March to August. The testicles of the hobs are then larger and an enormous swelling of the vulva occurs in the jills. The vulva swells up to a pale pink ball with a diameter of about 8 mm. For breeding it is best to place the jill in the cage of the hob. As in mink, copulation is a rather rough process. The hob grasps the jill by the skin of the neck and drags her around the cage. Actual copulation lasts from one-half to three hours. About one week later the vulva changes in appearance and shrinks.

Jills are more susceptible to diseases if not bred than if used for breeding. This is related to the fact that the jill remains in estrus during the entire season, until she is bred. This 'physiologic' process can lead to hyperestrogenism. The exposure to high concentrations of estrogens may lead to suppression of the bone marrow with signs including pale mucosae and petechia. In addition, bilateral symmetrical alopecia may develop (hairs in telophase!). Because the cervix remains open during estrus, there is a greater risk of metritis. In contrast to most other Mustelidae, there is no retardation of implantation in ferrets.

Jills in estrus but not yet bred should not be housed together, for playing may induce ovulation, leading to pseudopregnancy. Pseudopregnancy lasts as long as pregnancy, 41–43 days. Determination of the gender of ferrets is not difficult. Just as in the dog, the penis (with an os penis) is located ventrally. The distal end of the os penis is J-shaped and it can be caught when the animal passes through a small opening.

Mink

Mink reproduce once yearly, during the first 3½ weeks of March. They are monestrous (see also § 13.1.1). The actual duration of pregnancy is 30 days but the time between breeding and parturition can vary from 38 to 76 days, due to delayed implantation. The pups are born in May. Usually one male is kept with 5–10 females. The female must be placed with the male for breeding. Because it is not possible to determine whether a female is in estrus, she is put with the male once every four days until copulation occurs. If this does not succeed within a few weeks, the interval is shortened to 2 days. Copulation can last up to 14 hours

and is accompanied by screeching and fighting. Around the time of parturition mink must be left alone as much as possible to prevent the mother from eating the young.

29.3.7 Nervous system

A fracture or luxation of the lumbar vertebrae occurs occasionally in rabbits and the most obvious clinical sign is posterior paresis or paralysis. After inspection and palpation of the vertebral column, a neurological examination as described for the dog, performed within no more than 24 hours after the onset of paralysis, is essential for a correct prognosis. The absence of pain perception (tested by using forceps to pinch a toe) is a very bad prognostic sign. If there is pain perception, recovery is by no means excluded.

29.3.8 Eyes

There is often a tendency to think that disorders of the eyes in small mammals must have an infectious cause, but a well-performed examination, as described for the dog and cat, often reveals primary disorders of the eye.

An exceptional feature of the rat is the presence of Harder's gland, which under parasympathetic stimulation produces a secretion rich in lipids and porphyrins (protoporphyrin IX and coproporphyrin III). This gland is larger than the globe and is located medial to it. Under stress, in various infectious diseases, and in specific disorders there is increased tear production. The presence of the porphyrins gives these tears a red color and the dried tears can be seen around the eyes and the nose. Sometimes the entire head is colored red. This increased tear production, which is also sometimes observed in the gerbil, is called chromodacryorrhea. There is an orange-red fluorescence from the dried tears under ultraviolet light. Because of the red color, the excessive tear production is often thought to be more severe than it actually is.

29.3.9 Ears

Examination of the ears should be a part of the general examination in rabbits, rats, and ferrets (see § 29.3.2), because of the frequent occurrence of mite infestations, which can be detected by otoscopic examination. Purebred rabbits may have a tattoo in the pinna, right or left or both, depending on the country.

29.4 Notation

At the end of this chapter there is a form on which the owner can give the signs, past history, and living conditions. This forms the basis for additional questions to define the iatrotropic problem, which is placed on a form on which the results of the physical examination are also recorded.

29.5 Further examination

Many aspects of the further examination described for the dog and cat can also be carried out in the small mammals.

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30 Reptiles

I. Westerhof

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There are more than 7000 species of reptiles and they have been divided into three major orders: Testudines, (turtles, terrapins, tortoises), Squamata (lizards [Sauria] and snakes [Serpentes]), and Crocodylia. In terms of evolution, the testudines are the oldest reptiles and the snakes are the most recent.

Many problems in reptiles are caused by improper housing and/or malnutrition. Each species has specific requirements for husbandry, nutrition, and care. In order to give correct advice about the requirements of a reptile, identification of the species or family is essential. Because of the large number of reptile species this is not always easy, but determination tables can be very helpful.[1-3]

This chapter gives a global overview of the most commonly kept reptiles.

30.1 Taxonomy (Appendix 2)

The most striking characteristic of the order Chelonia (approximately 250 species) is the shell, with its shape, color, and size differing per species. Members of the order Serpentes (2500) are essentially legless and have an elongated body and a remarkable forked tongue. Members of the order Sauria (4450) have variably developed legs and include some snake-like lizards such as the slowworms (*Anguis fragilis*) that are legless and frequently mistaken for snakes (Fig. 30.1). Lizards generally have a mobile, protrusible, fleshy tongue, sometimes with a forked end.



Fig. 30.1 Slowworm (*Anguis fragilis*), of the family Anguidae, in its natural habitat, forests and meadows.

30.1.1 Chelonians

The common names of chelonians (Testudines) vary throughout the world and among languages. In the United Kingdom they are called terrapins (freshwater chelonians), tortoises (terrestrial chelonians), and turtles (marine chelonians). In the American literature all chelonians are referred to as turtles.

Chelonians are roughly divided into those living on land and those living in water. Terrestrial chelonians have feet with separate toes, whereas aquatic chelonians have flipper-like feet with webbed toes. All chelonians are oviparous (egg-laying).

More information on the chelonians seen most often in northwestern Europe is provided in Appendices 2.1 and 2.2.

30.1.2 Snakes

Snakes and lizards are classified together in the order Squamata. Snakes are placed in the suborder Serpentes. An overview of the snakes seen most often in veterinary practice in northwestern Europe is given in Appendix 2.3.

The classification is constantly being changed. The largest group of snakes is placed in the family Colubridae, which includes both poisonous (venomous) and nonpoisonous snakes.

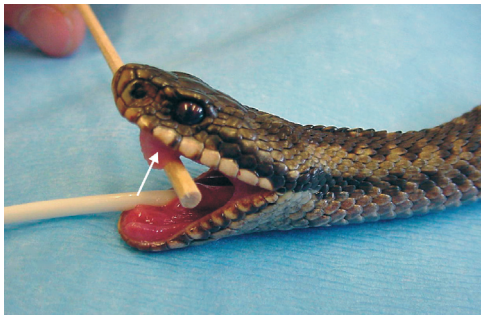


Fig. 30.2 Hollow fangs in the upper jaw of *Vipera berus*.

Poisonous snakes have venom glands in the upper jaw. The venom varies with the species, season, and age, and is transported from the venom glands through hollow fangs (Fig. 30.2). Some species do not have discrete venom glands but other oral toxic secretions. Well-known venomous snakes such as cobras and mambas *(Dendroaspis)* belong to the family Elapidae. Some Elapidae are able to spray their venom as an aerosol more than 2 meters into the face and eyes of their victim. Members of the family of the vipers (*Viperidae* and *Crotalidae*) can be recognized by the zigzag lines on the back, the large triangular head, and the large fangs.

Native snakes. Three species are native to northwestern Europe (Appendix 1.4).

30.1.3 Lizards

Appendix 2.5 gives an overview of the reptiles seen most frequently in veterinary practice in northwestern Europe. Iguanas are especially frequent. They are divided into three groups: Iguanidae (dominant group in the New World), Agamidae (dominant group in the Old World), and Chamaeleonidae (also in the Old World). The chameleon can be recognized by its long, retractable tongue.

The geckos belong to the suborder Gekkota and the family Gekkonidae, whose characteristic is the large adhesive lamellae or pads underneath the toes (Fig. 30.3). The eyes are usually covered by a transparent spectacle and are cleaned with the tongue. There are day-active or diurnal geckos (Phelsumas) and crepuscular or nocturnal geckos (most of the Gekkonidae).

The subfamily Eublepharidae, also called fat-tailed geckos, have freely-moveable eyelids and toes without lamellae. These sturdily-built geckos are *nocturnal* or *crepuscular.*

Reptiles in the suborder Platynota, such as the genus *Varanus* (monitors), have a forked tongue. The two venomous lizards are the Gila monsters, *Heloderma suspectum* and *Heloderma horridum*. Their venom

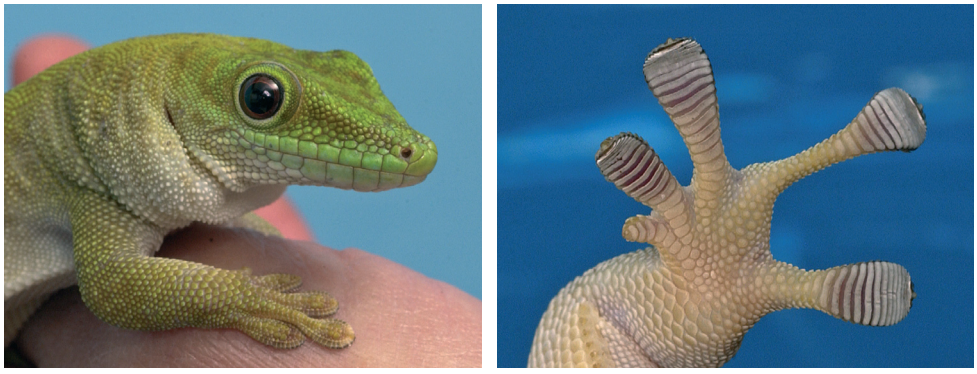


Fig. 30.3 *Phelsuma madagascariensis* with large adhesive lamellae under the toes.

glands are in the lower jaw and their fangs are not hollow but grooved. The venom reaches the teeth via a groove between the jaw and the lip and they must chew on their prey in order to inject the venom.

Some lizards are oviparous (*Varanus* spp, most of the Iguanidae, geckos, some of the chameleons).

Native lizards. Both the small lizard (*Lacerta vivipara)* and the sand lizard *(Lacerta agilis)* are native to northwestern Europe.

30.2 Laws and regulations

There is a multinational agreement concerning trade in endangered flora and fauna in order to protect endangered plants and animals throughout the world. This agreement was formed in 1973 and has been enforced since 1975 by the CITES regulations (Convention on International Trade in Endangered Species of wild fauna and flora). CITES regulations only apply to the international import and export of listed species. Legally imported species can be traded or transported within a country. Animals and plants listed in CITES are divided into three categories.

Appendix I lists the most protected category of endangered species for which trade will or may lead to extinction. Trade in living or dead animals, parts, or products of these animals is strictly regulated. Animals bred in captivity may be imported or exported with special permits.

Appendix II lists species that are not currently threatened by extinction but may be threatened if trade is not regulated.

Appendix III lists species protected in specific countries that are party to the global CITES agreement. All other countries are obliged to cooperate with them and to regulate international trade in these species.

The CITES regulations are subject to change and the latest developments can be found at: www.cites.org.

The European Union (EU) has set additional restrictions in Regulation EC 338/97 and Regulation EC 865/2006. These regulations are automatically applicable and harmonized in all Member States: http://eur-lex.europa.eu.

30.3 Signalment

Determination tables can be used if the species is unknown.[1-3]

30.3.1 Gender

Chelonians. There is sexual dimorphism in several species. In many species the female is larger than the male. In chelonians the male has a longer tail and the distance between the cloaca and the plastron is larger than in females. The plastron is concave in most males but flat in females. The iris is red in male terrapins and brown in females, and male terrapins have long nails on the toes of their front feet.

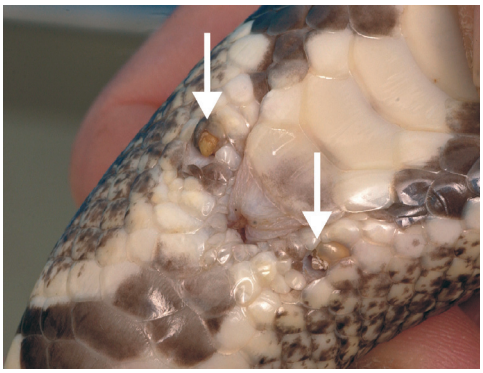


Fig. 30.4 *Python regius* with spurs on both sides of the cloaca.

Snakes. There is also sexual dimorphism in some snakes. Males of the family Boidae have more pronounced 'spurs' on the vestigial pelvis, on both sides of the cloaca (Fig. 30.4). In some snake species the base of the tail in males is relatively wide and straight, and thickened (hemipenal bulge) on the ventral side. Gender can be determined in snakes by inserting a lubricated, blunt-tipped sexing probe into the cloaca and advancing it *caudally*. The probe will pass deep in the hemipenal lumen in males, for a distance of 6–14 subcaudal scales (depending on the species), versus 2–6 scales in females (see the DVD). With some experience, probing can be performed safely. In neonatal colubrids it is possible to manually evert ('pop out') the hemipenes.

Lizard. There is sexual dimorphism in some adult lizards, such as iguanas and most of the geckos. Males of the suborder Iguania have pronounced preanal or femoral pores and a large tail base due to the hemipenes (Fig. 30.5). Spines, crests, dewlaps, and horns may be present and more prominent in males than in females.

30.3.2 Age

Age determination in reptiles is difficult because their growth is strongly dependent upon diet and husbandry. Lifespan also varies according to the species, husbandry, and management. Some chelonians such as terrapins live from 7 to 30 years and other species may live for up to 60 years or more. Many snakes, especially the large species, live 20 years or more. Lizards are also relatively long-lived: chameleons and anoles live 5–8 years, iguanas and skinks 10–20 years, and some geckos 20–40 years.[4,5]

More detailed information on longevity of reptiles can be found on the website Reptiles and Amphibians in Captivity: http://www.pondturtle.com/longev.html.

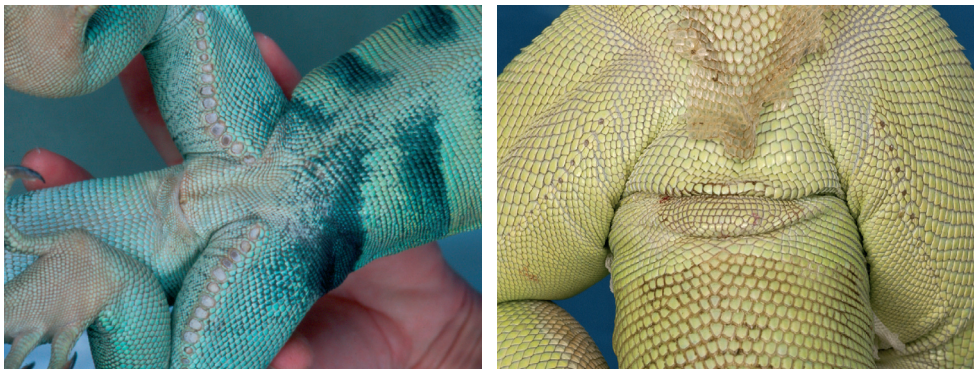


Fig. 30.5 Iguana with prominent preanal or femoral pores on the ventral aspect of the thigh. The pores are more pronounced in the male (left) than in the female (right).

30.4 History

The history comprises (1) the iatrotropic problem, (2) general information about the functioning of the animal, (3) past history, and (4) living conditions.

30.4.1 Iatrotropic problem

The history begins with the question: 'What is the problem?' Questions are then asked about its duration and progression. If the animal has been treated, information is obtained about the type of medication, route of administration, duration of treatment, and effect. Not uncommonly, it is found that the treatment was not prescribed by a veterinarian but obtained from a pet store or someone who keeps reptiles. It is also useful to inquire whether preventive treatment has been given (e.g., against parasites) and if so, what treatment, the route of administration, and the frequency.

30.4.2 Present functioning

Important here are questions about food intake, drinking, vomiting, and behavior. How is the respiration? Is the animal dyspneic? Are there abnormal respiratory sounds or coughing? What is the appearance of urine and feces and have they changed? How is the locomotion? Are there signs of neurological defects? Does the animal fall off its perch? What is the reproductive history? Are there skin lesions? Are there changes in body proportions or body parts, or other abnormal signs?

30.4.3 Past history

Has the animal been ill before? If so, what was the diagnosis? If the animal was treated, what was the treatment, who administered it, what was the duration, and what was the effect?

30.4.4 Living conditions

Questions about living conditions are concerned with the housing and feeding of the animal. How long has the animal been in the owner's possession? What was its origin? Was it captured in the wild or bred in captivity? Is it in contact with other animals? If so, with what species, for how long, and are there newly-introduced animals?

Snakes and chelonians are generally solitary animals that seek company only during the breeding season. Some species function well in groups but others may do better if housed alone or in pairs. Reptiles housed in small cages should be kept alone, but more than one animal may be housed in a large cage if they are closely watched. In general, reptiles from different geographic regions should not be held together because of the risk of transmitting diseases.

Many problems in reptiles are caused by improper housing, husbandry, and diet. Extensive questioning on these topics is very important.

Housing

Temperature. Reptiles are ectothermic: their body temperature depends on the environment. The **p**referred **o**ptimal body **t**emperature **r**ange or POTR is the temperature range in which the organ systems function most efficiently. On either side of the POTR is a narrow range of tolerable temperatures but temperatures beyond these will lead to stress and disease. For most reptiles the POTR is known and can be found in reference books.

In the wild, reptiles gravitate to an area having the temperature they need. In captivity, a temperature gradient must be provided to enable the animal to choose the temperature it prefers. It is therefore important to inquire about the temperature and the temperature gradient in the cage. It is also important to ask how the cage is heated. Are there basking areas, hot

spots, hot rocks, heating pads, incandescent bulbs, ceramic heaters, or other heat sources?

Heat sources should be placed out of the reach of the reptiles to avoid burning. The preferred temperature for most diurnal reptiles is 27–35°C, with a basking area that is above 40°C. Nocturnal reptiles prefer a temperature of 21–27°C, and with a warmer area that is 32–35°C (Appendix 3). A good rule is to provide a hot spot with a temperature near the upper end of the POTR. Nighttime temperatures should be slightly lower. Thermometers at various locations are used to monitor the temperature.

Temperate zone reptiles hibernate at temperatures of 5–15°C. Reptiles in cold climates hibernate at the lower end of this range. Subtropical reptiles may also hibernate but require some source of warmth, while tropical reptiles do not hibernate. Some snakes in desert areas have a 'summer rest' in order to escape the hottest temperatures.

Hibernating animals must be healthy and in a good condition. Those that are ill or weak are predisposed to problems after hibernation or death during hibernation. During hibernation there is a loss of approximately 1% of body weight each month. Temperatures below 0°C can lead to irreversible retinal degeneration and death.

Photoperiod. An appropriate photoperiod is important and both natural and artificial light are used to provide it, with the aid of timed switches. An inappropriate photoperiod and temperature fluctuations may result in reproductive failure. There is continuing discussion of what is the correct light quality and spectrum. Ultraviolet-B (UV-B) or light in the 290–320 nm range promotes the synthesis of the provitamin, D3, which is of great importance for calcium metabolism, especially in herbivorous and insectivorous reptiles. Incandescent and gas-discharge lamps do not emit UV-B but in the past decade more and more lamps designed for reptiles have been marketed. More research is needed concerning the UV-B requirement of various species.

Humidity. Most species do well at humidity levels of 50–70%, but desert species need lower humidity and jungle species need higher. Inadequate humidity may lead to skin problems and inadequate ecdysis.

Water. Turtles, snakes, and many lizards drink, sip, or lap water from bowls or saucers. Other lizards can drink dripping water or sprayed droplets. Many reptiles like to soak or bathe. This enhances water intake and stimulates excretion and shedding. Terrapins and tortoises are able to take up water via the cloaca. Large, shallow water bowls should be provided and should be cleaned regularly

Basic husbandry requirements. It is important to provide enough shelter and climbing facilities. Many different types of substrate can be used. What is important is that it can be cleaned easily and is pleasant for the reptile, does not cause ileus or obstipation if ingested, and does not cause skin irritation. Many oviparous snakes have special requirements for the substrate in order to deposit their eggs. The absence of a suitable place for their nest may lead to egg retention.

Hygiene. Reptiles have been shown to carry potential pathogens, such as *Salmonella* spp. Strict hygiene is important. No eating, drinking, or smoking is allowed during handling of the animals. Hands should be washed carefully with hot, soapy water after *every* contact with a reptile or its immediate environment. Water and food dishes should be cleaned in a location far away from the kitchen sink or the bathroom, using separate cleaning materials.

Feeding

The important questions for the history are: What and how much do you feed, how do you feed, and how frequently? Do you give supplements, and if so, what are they, how much, and how often? (Appendix 2).

Chelonians. Food-related problems are seen frequently in chelonians. Appropriate nutrition is essential for their growth, shell composition, and reproduction.

Terrestrial chelonians may be predominantly herbivorous or omnivorous. Herbivorous species can be fed high amounts of vegetable fiber such as dandelions, hand-picked weeds, grass, flowers, grass/hay pellets, and some vegetable greens. A vitamin-mineral supplement is given to insure adequate intake of calcium, iodine, vitamin D3, and vitamin A.

Omnivorous chelonians can be fed both plant and animal products. The ratio differs per species. They can be fed vegetables, flowers, fruits, and small live prey such as insects, snails, woodlice, and several worms such as tubifex and superworms (*Zophobas mori*). In addition, small amounts of meat, low-fat dog food, or pelletized food can be given (Fig. 30.6). In lieu



Fig. 30.6 A good varied diet for a box turtle (*Terrapene carolina*) includes greens, fruits, and a small amount of manufactured food.

of complete pellets or dog or cat food, a vitamin-mineral supplement is employed, but with the disadvantage of the risk of under- or overdosage.

In terrapins calcium deficiency and hypovitaminosis A can lead to shell abnormalities and swollen eyelids (Fig. 30.7). Inappropriate diets for insectivores and herbivores can lead to calcium and vitamin D deficiency, resulting in shell deformities, soft shells, poorly-calcified egg shells, and egg retention. Illness, poor husbandry, and inadequate diets can lead to anorexia and malnutrition. Pelletized food is available for several species, although more studies are needed in order to tailor composition to the species.

Snakes. Snakes are preferably fed intact prey, which is an adequate vitamin and mineral source. Snakes can eat very large prey due to the absence of a sternum and clavicle. Depending on the size of the snake, they can be fed rodents, rabbits, chickens, quail, or pigs. Injury to the snake can be prevented by feeding dead prey. If several snakes are housed together, they should be fed under supervision to avoid the risk that they eat each other. Some species such as kingsnakes can eat other snakes.

Snakes such as *Natrix* sp. and *Thamnophis* spp., are piscivorous. They feed on amphibians (frogs, salamanders), fish, worms, snails, etc. These and other aquatic carnivorous reptiles are susceptible to thiamine deficiency if fed thawed frozen fish, for the meat of several kinds of both saltwater fish and freshwater fish contains thiaminase (lists of thiaminase-free fish can be found on the internet). In frozen fish the amount of available thiamine is decreased and the activity of thiaminase is increased. To prevent thiamine deficiency, fresh fish are used or thiaminase is denatured by heating fish to 80°C for 5 minutes before freezing. Symptoms of thiamine deficiency include tremors, ataxia, and opisthotonos.

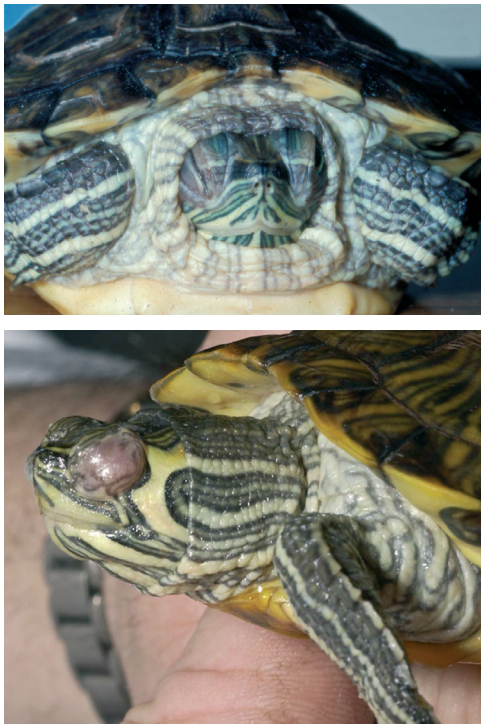


Fig. 30.7 Terrapins with hypovitaminosis A. The eyes are not visible because of the swollen eyelids.

Lizards. Lizards can be omnivorous, herbivorous, insectivorous, or carnivorous. Omnivorous lizards can be essentially herbivorous. As they age, lizards may change their diet: species such as the bearded dragon are carnivorous when young, then omnivorous, and finally herbivorous in old age.

Iguanas are omnivorous or herbivorous, depending on their age. They can be fed high-protein and high-fiber greens and vegetables, other plants, and fruits, with small amounts of insects, small prey, and/or pelletized food for iguanas.

Anoles, chameleons, geckos, water dragons, and skinks are insectivorous and feed on invertebrates. Some species may also eat small amounts of greens, leaves, or fruit. Invertebrates contain little calcium, except for snails with their shells, and earthworms. Diets low in calcium and/or vitamin D_3 or high in phosphorus, and/or the lack of UV-B may lead to nutritional secondary hyperparathyroidism (NSHP).

NSHP may develop in animals fed unsupplemented diets of insects alone or in lizards fed all-meat diets or neonatal prey. NSHP can also occur in herbivorous lizards fed only unsupplemented greens and vegetables or unsupplemented insects. Clinical signs of NSHP include tremors, pathological fractures, egg retention, and severe skeletal abnormalities (Fig. 30.8).

Most diets can be made complete by the addition of small amounts of commercial food or vitamin-mineral supplements. If insects are fed daily, they can be dusted with a vitamin-mineral supplement once or twice a



Fig. 30.8 Iguana with severe skeletal abnormalities. The severe lordosis is due to dislocation of vertebrae. The thickening of the jaws is due to fibrous osteodystrophy caused by nutritional secondary hyperparathyroidism.

week, although this may lead to either over- or underdosage. It is also possible to feed invertebrates a high-calcium diet that results in a high content of calcium in the gut (gut-loading).

It is challenging to devise a correct and complete diet for a reptile. Handbooks can be of help.[6,7] Variation in the diet depends on the climate, season, gender, age, and species. At the same time, the animals should be maintained in optimal environmental conditions.

30.5 Handling and restraint

Some of the handling procedures described here are shown on the DVD. As a rule, any feces or urine that is released during handling should be collected for further examination.

Chelonians. When handled chelonians can scratch, bite, urinate, and defecate. Terrapins can be restrained by placing one hand between the hind limbs, with the thumb on the carapace and the fingers on the plastron. The animal's head should be directed away from the handler and other persons.

Large terrestrial chelonians (>15 kg) can be placed on an upturned bucket to prevent their limbs from reaching the floor. Protective clothing should be worn for handling the large species. When a chelonian is turned over from side to side, there is a small risk of causing torsion of the intestines. To prevent this, the animal should be turned slowly and then returned to the upright position by reversing the direction of the rotation. Placing a gravid female in dorsal recumbency may cause displacement of the eggs into the bladder.

Long-necked turtles such as *Chelydra serpentina* and *Trionyx* spp. are able to turn their neck caudally over the carapace. To avoid being bitten, they are handled by grasping the caudal part of the carapace, with the plastron turned toward the handler. Snapping turtles can weigh up to 100 kg and can cause serious injury. Tortoises can usually be handled easily with one hand on each side of the shell between the front and rear limbs.[4] In some species, such as box turtles (*Terrapene* spp.), the plastron is joined flexibly to the carapace by connective tissue via which it can completely close the carapace, making clinical examination difficult or impossible (Fig. 30.9). To prevent this closure, an object or (in small animals) a finger can be inserted in the inguinal fossa cranial to the knee. In larger and stronger animals, this technique is not recommended and sedation may be necessary.



Fig. 30.9 Box turtles (*Terrapene carolina*): at the left with the shell completely closed and at the right with the shell open.

Snakes. Snakes can bite, strangle, defecate, urinate, and produce a foul-smelling secretion from their cloacal scent glands. Do not approach a snake from the front. A snake is handled by grasping it just behind the head and fixing the head between your thumb and forefinger. The firmer the grip, the stronger the snake's resistance. Aggressive snakes are restrained by securely grasping the head with the full hand. It is important to support the body of the snake so as to prevent thrashing which may result in dislocation or fracture of the neck or vertebral column. When a snake is presented in a bag, the head is identified and restrained before the bag is opened and after the bag is opened the head is restrained outside the bag with the other hand. Small strangling snakes tend to coil around the handler's arm, which is allowed. The head is fixed as described above. Snakes longer than 2.5 meters should be handled by two persons. A snake hook can also be used to lift or restrain a snake, but too much pressure on the neck may cause serious injuries to the head or spine. The head can be gently pinned to the floor until it is grasped by the handler. A snake loop can also be used to handle a snake. Finally, aggressive snakes can be sedated.

Venomous snakes require special handling techniques and antivenin should be available before handling is begun. Information on poisonous snakes can be obtained from the snake center 'Serpo' in Delft, NL (tel. +31.15.213.0334). This reptile zoo also has a website with 'What to do in case of a snake bite' (www.serpo.nl).

Lizards. Lizards range from tiny to huge. They can bite, defecate, and cause serious injury with their strong tail and long, sharp claws. A lizard should not be caught by the tail. Some species, including most of the Iguanidae, Geckonidae, and *Anolis* spp. have a preformed fracture line in the tail vertebrae which enables them to release the tail in order to escape from a predator.[8] Termed autotomy, this does not occur in Agamidae, Varanidae, or chameleons. Some lizards have very fragile skin, which can tear easily. Tiny lizards can be restrained manually by gently fixing the head between the thumb and index finger, holding the rest of the body in the palm.



Fig. 30.10 Chameleon resting on a branch.

Large lizards are fixed by grasping just behind the head with one hand, the other hand drawing the hind limbs caudally parallel to the tail. Certain species such as the green iguana have a very strong, whip-like tail, which should be secured at all times. It is sometimes helpful to place a towel over the animal and then grasp the head. The animal can also be wrapped in a towel or captured with gloves. Sometimes sedation is necessary.

If metabolic bone disease is suspected, careful handling is indicated because of the risk of fractures. Animals with active ovarian follicles should also be handled with great care to prevent rupture of the follicles.

Chameleons are very docile and can be handled with little restraint. They appear to be more relaxed if they can grasp something, such as a branch (Fig. 30.10).

30.6 Physical examination

Physical examination of reptiles does not proceed according to organ systems but topographically, from cranial to caudal.

30.6.1 General impression

The general impression is formed by looking at and listening to the patient from a slight distance. Look for abnormalities that stand out.

Level of consciousness, behavior, posture, and locomotion

Reptiles may be presented for examination in small cages, or snakes and lizards may be in a sack. If observation is not possible, the animal can be placed in a temporary observation cage.

Chelonians. Some chelonians will not move, while others run around or swim. Terrapins are normally more active than terrestrial species. The box turtle is able to close its carapace, which prevents formation of the general impression (Fig. 30.9). Most healthy chelonians are able to lift the head and look around. Their locomotion is symmetrical and some species are able to lift the body off the ground when they move. In some species the legs are involved in respiration, best observed when the animal is at rest.

Terrapins can be observed well in an aquarium (Fig. 30.11). The position of the animal in the water (normally straight) is of importance. Floating abnormally may suggest respiratory disease, intestinal disease, or a coelomic disorder. Take care that the animal does not drown.

Snake. Much information can be gained by observing the position of the snake in the cage. Behavior differs among the species and what is normal for one species can be very abnormal for another (Fig. 30.12). For example, the ball python *Python regius* tends to roll up into a ball. A healthy snake will carry its head and flick its tongue in and out in order to explore the surroundings (see the DVD).

A healthy snake placed in dorsal recumbency shows a normal righting reflex by turning the head first. A healthy snake held by the middle of its body with its head hanging down should be able to raise its head up level.



Fig. 30.11 A normally floating red-eared slider (*Trachemys elegans*).



Fig. 30.12 *Chondropython viridis* (family Boidae) in its species-specific posture.

Lizard. Behavior, posture, and locomotion vary from species to species. Small lizards tend to hide and are normally very active. Others, such as the chameleon, can remain immoveable for a long time (Fig. 30.10). Several species, such as among the Iguanidae and Varanidae, use the tongue as an organ of both taste and smell. Some species use the tongue to impress or to threat.

30.6.2 Inspection from a distance

Look systematically for signs of illness, from cranial to caudal. Inspection of the head starts with the eyes, nasal openings (nares), beak, external ear (if present), and skin. The eyes are normally open. In terrapins hypovitaminosis A may cause swollen eyelids. The nares should be open and clean. If there is a discharge from one or both nasal openings, take note of its appearance. The beak is normally closed. In snakes observe the flicking tongue. Aggressive animals open their beaks to threaten, giving the clinician a view of the mouth. In chelonians and lizards the tympanic membrane is covered with skin.

In chelonians with otitis media the tympanic membrane is swollen. Snakes have no tympanic membrane or middle ear but they have a slit-shaped inner ear which enables them to hear low-frequency sounds.[9] During inspection of the skin of the head and neck, look for lesions, swellings, hemorrhages, parasites, abnormal shedding, and other abnormalities.

In chelonians all parts of the shell are examined with regard to shape, scute quality, seams between the scutes, shedding, color, ulceration or other lesions, exudate, and other abnormalities. The dome of the shell is the carapace and the ventral part is the plastron. They are joined by the bridge.

In snakes and lizards the skin is examined for the presence of lesions, hemorrhages, discolorations, swellings, parasites, and other abnormalities. Snakes shed the skin frequently, depending on the species, age, nutritional condition, reproduction, illness, environmental influences such as temperature and humidity, and many other factors.

During shedding of the skin, the cells of the germinal layer multiply to form a new epidermal layer. This takes 5–7 days and the color of the skin becomes dull blue. The eyelids of the snake are fused to form a protective spectacle (eye cap or brille) over the cornea. These spectacles are also shed and during shedding the epithelium of the spectacles becomes cloudy for 3–4 days. An enzyme-containing lymph fluid accumulates between the old and new skin layers. Just before shedding occurs, the spectacles and the skin become clear. Then shedding occurs within 3–4 days (Fig. 30.13).[10] The tongue also sheds its surface layer regularly. A healthy snake sheds the skin in one piece.

Most lizards shed their skin in several pieces.

Legs. Inspection is from proximal to distal. The skin of healthy animals is free of lesions, hemorrhages, swellings, parasites, or other abnormalities. Most chelonians and lizards are able to bear their weight on their legs (Fig. 30.14). Pathological fractures and arthritis occur frequently in iguanas, resulting in abnormal positioning of the leg, inability to bear weight, or swollen joints.

Most chelonians have short nails on their claws but male terrapins have long nails on their front claws.

Tail. The shape and position of the tail varies among species. Some lizards are able to discard the tail (autotomy). In most cases the tail eventually regenerates, often with a different appearance. If autotomy is incomplete, two new tails can appear. Abscesses, fractures, or necrosis may also occur.

30.6.3 Examination of the restrained animal

Before handling the animal, the examiner should make a plan based on the findings obtained from the history, general impression, and inspection from a distance. All equipment needed for further examination is placed within easy reach. Physical examination should be thorough and systematic, from cranial to caudal.

General examination includes inspection and palpation. Excreta or other material produced during the examination should be collected for further examination.

Head. Inspection of the head is undertaken in the same manner as inspection at a distance. It is necessary to restrain the head in order to palpate it and collect material for further examination. The head of chelonians is restrained by grasping from above or below with the thumb and forefinger, just behind the jaws (Fig. 30.15). The head can be brought forward by constant gentle traction.

If the animal has retracted its head, pushing the hind legs inside the shell may cause the head to reappear. Sometimes the head can be extracted by allowing the animal to bite an object. Forceps can be of help but can also cause injury. Blunt forceps can be placed behind the beak and then gentle traction can be applied. If all of these attempts fail, the animal should be allowed to rest and attempts resumed later. Eventually the animal can be sedated.

The head of snakes and lizards is fixed with the thumb and forefinger just behind the jaws (see the DVD).

Eyes. Chelonians have well-developed eyes and usually a third eyelid. As described above, the eyelids of snakes

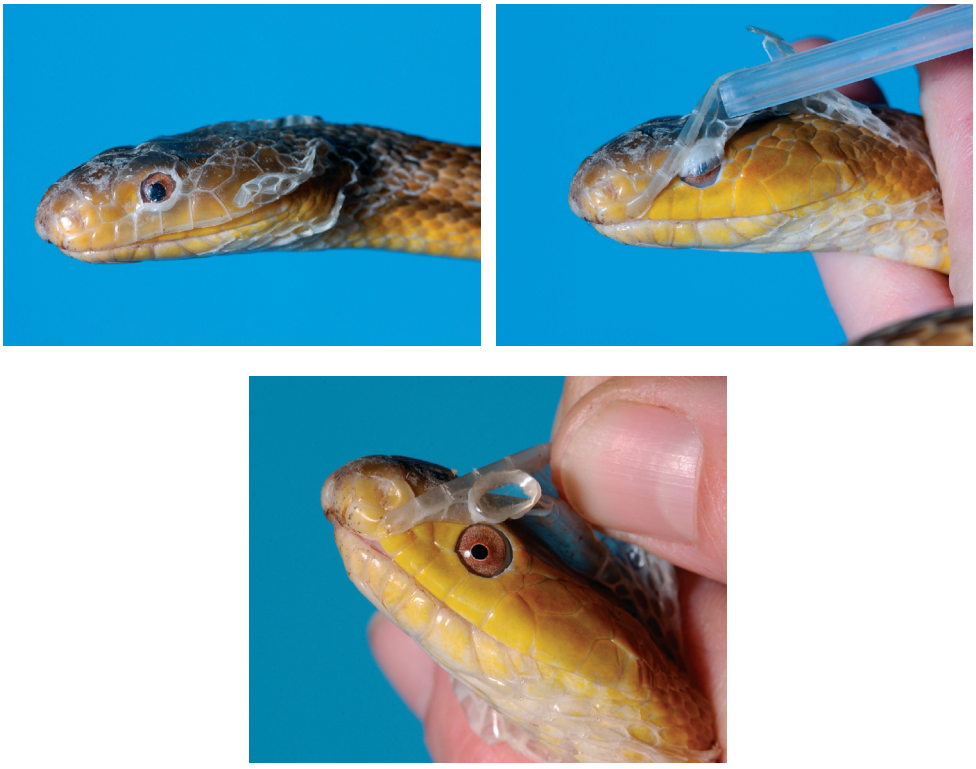


Fig. 30.13 A shedding snake. The eyelids of a snake are fused to form transparent spectacles (eye cap or brille). The spectacles are also shed. Before shedding, the skin has a dull blue appearance and the spectacles become cloudy. After several days the skin and spectacles clear up and then shedding occurs.

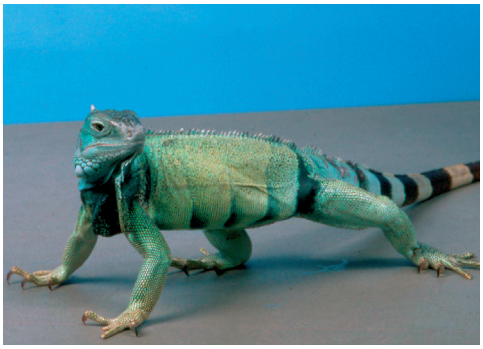


Fig. 30.14 A healthy iguana, able to lift its body and the first part of its tail off the ground.

are fused to form spectacles. Most lizards have eyelids and a nictitating membrane, except for some Geckonidae and skinks (*Ablepharus* sp.). In some of these species the eyelids are fused, as in snakes. Further inspection of the eye is similar to that in the dog and cat. However, as in birds, the reptilian iris contains striated muscles and therefore the pupillary light reflex is under the influence of the voluntary nervous system (see also § 28.6.3). Several species have a parietal eye ('third eye' or extraocular photoreceptor) located on the dorsal midline of the head, beneath the skin. It consists of a degenerate eye containing a lens and a retina, and it connects with the pineal gland. It is thought to play a role in thermoregulation and in reproduction.[11]

Nose. The nasal openings (nares) should be clean and dry. They can be enlarged in chronic infection. Some herbivores, such as iguanas, have nasal salt glands which excrete salt when plasma osmolality is elevated (see § 28.3.4). The animals may sneeze, producing a clear fluid which dries to a white powder of salt crystals. This should not be mistaken for a respiratory infection.

Beak. The beak of reptiles is normally closed. Malformations, softening, and compressibility of the lower jaw may indicate nutritional secondary hyperparathyroidism (NSHP) due to dietary and/or husbandry mismanagement. Affected lizards may be unable to close the beak (Figs 30.8 and 30.16). There are also other causes of beak abnormalities. The beak is palpated to detect possible flexibility and other abnormalities.

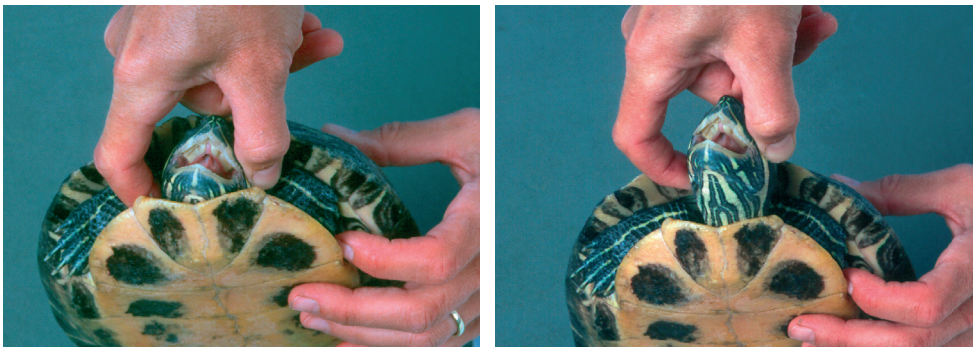


Fig. 30.15 Fixing the head of a terrapin. Left: the head is fixed from above by the thumb and forefinger, just behind the jaws. Right: the head is retracted by constant gentle traction.

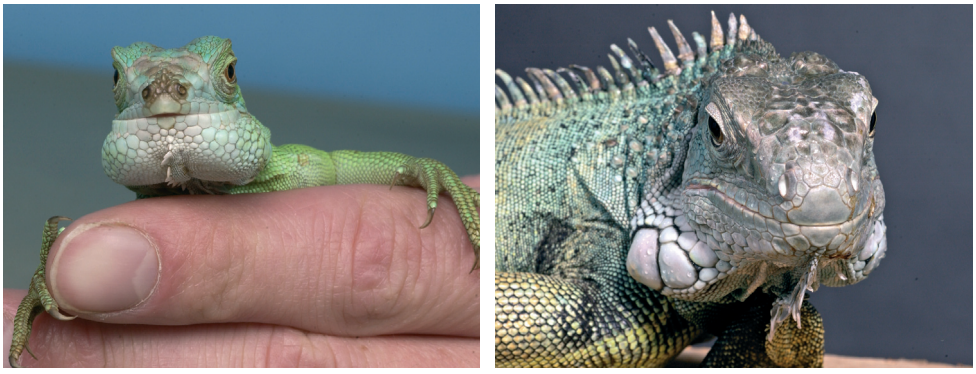


Fig. 30.16 Left: Young iguana with nutritional secondary hyperparathyroidism (NSHP). The enormous swelling of the lower jaw is the result of fibrous osteodystrophy. Right: head of a healthy iguana.

Some snake species (some of the Boidae, Viperidae, and Crotalidae) possess specialized receptors (pits) which are very sensitive to heat and infrared radiation. This organ enables the snake to sense warm-blooded prey, even in the dark, and to navigate. They can detect a temperature variation of as little as 0.003°C. In boas and pythons these slit-like openings are located on the upper and/or lower labial scales (labial pits). In vipers the pits are located between the nostril and the eye (facial pits). Look for parasites, inflammation, and other abnormalities in and around the pits (Fig. 30.17).[12]

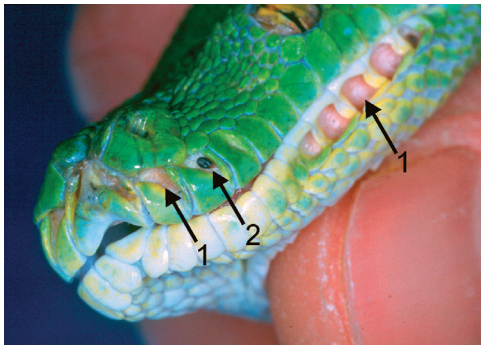


Fig. 30.17 Some snake species possess specialized organs (pits) sensitive to heat and infrared radiation. In this snake (*Corallus caninus*) the slit-like openings of labial pits are located on the upper and lower labial scales (arrow 1). Arrow 2 indicates the presence of a snake mite (*Ophionyssus* sp.)

Mouth. Some reptiles open the mouth spontaneously to threaten and this may allow the mouth to be inspected. If it is necessary to keep the mouth open, a mouth speculum or spatula can be placed in the beak. Sometimes the beak can be held open by placing a thumb and forefinger in the angle of the jaw (Fig. 30.18). This technique is not without risk in aggressive chelonians. In docile animals the mouth can be kept open with an index finger or with the tip of a blunt mosquito forceps laid across the lower jaw. Chelonians have a short, fleshy, pinkish tongue. The narrow openings of the eustachian tubes may be visible inside the pharynx just caudal to the jaw. The glottis is visible at the back of the tongue. Inspection of the palate reveals the choanae.



Fig. 30.18 The beak is opened by pressing with the thumb and forefinger and then a mouth speculum or spatula is inserted.

The mouth is inspected for color, moistness of the mucous membranes and tongue, and for hemorrhage, ulceration, inflammation, caseous lesions, diptheroid membranes, signs of gout, discharge in the glottis or choanae, foreign bodies, food, or other abnormalities. Gentle digital pressure on the choanae may expel material present in the choanae and nasal cavity through the nares.

Snakes have no mandibular symphysis and thus the jaw bones can move apart and forward or backward. This enables snakes to swallow large prey. The head of the snake is restrained between the thumb and index finger, or between the thumb and middle finger with the index finger on top of the head. The absence of a mandibular symphysis allows the beak to be opened by placing a metal or plastic spatula in this fossa and then turning it 90° until it is positioned in the angle of the jaw.

The number of teeth varies among species. Most snakes have six rows of teeth: one row on each lower jaw and two rows on each maxillary and palatine or pterygoid bone of the upper jaw. The slender, forked tongue lies in a sheath beneath the glottis and rostral trachea. It functions in olfaction, taste, and touch. Sense particles are collected on the tongue from the environment. The fork is then inserted into the vomeronasal pits or Jacobson's organ located in the rostral part of the roof of the mouth. This highly sensitive and specialized organ is important in localizing prey, mating, and aggression. The information is transported via olfactory nerves to the brain. Loss of the tongue may lead to anorexia. The vomeronasal organ is well developed in snakes and most lizards. It is modified in chelonians and absent in adult crocodiles.[13-15]

Lizards open the mouth spontaneously or it can be opened by pinching and lifting the nose. It may also be opened by pulling on the fold of skin beneath the chin (dewlap). If necessary, a speculum can be placed in the mouth to keep it open. Take care not to break any teeth. Sedation may be needed. The tongue of a lizard may be short and fleshy (iguanas), mobile (leopard gecko), forked (Varanidae), or projectable (chameleons). In the iguana the end of the tongue and the glottis are pigmented. The tongue is used for taste, olfaction, and feeding. The glottis is located at the base of the tongue. Inflammation of the mucous membranes can cause malformation of the jaw. Jacobson's organ is located in the roof of the mouth. The mouth is inspected for color, moistness of the mucous membranes, hemorrhage, ulceration, necrosis, caseous lesions, foreign bodies, discharge, and other abnormalities. Gentle digital pressure on the choanae may expel material from the choanae and nasal cavity via the nares.

Ear canal. The ear opening or tympanic scales should be inspected closely for signs of swelling or other abnormalities. They can be palpated if necessary. Most lizards have a transparent tympanic membrane (Fig. 30.19).

Neck. The neck of chelonians and lizards is inspected and palpated for lesions, hemorrhages, swellings, parasites, and other abnormalities. Some gecko species (*Phelsuma* spp.) store calcium in the endolymphatic sacs, which may be visible as white swellings on either side of the neck.

Shell. All parts of the shell are closely inspected with regard to shape, scute quality, seams between the scutes, shedding, color, ulceration, exudate, trauma, inflammation, and growth abnormalities. With the exception of soft-shelled turtles (*Trionyx* spp.), most species have a firm, noncompressible shell. Percussion may provide some information.

Integument, legs, tail. The skin of the entire body of snakes and lizards and that of the head and legs of chelonians is examined from cranial to caudal and from dorsal to ventral for lesions, hemorrhage, discolorations, swellings, parasites, shedding, and other

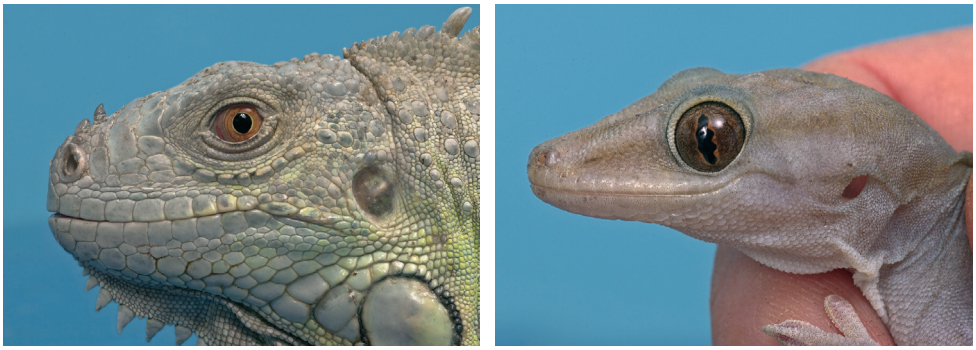


Fig. 30.19 Left: The opening of the ear canal of the iguana is covered by a thin, transparent membrane. Right: In some lizard species (*Gecko auratus*) the opening is uncovered and clearly visible.

abnormalities. Following inspection, the head and body are palpated from cranial to caudal.

In snakes the musculature of the back may reflect the nutritional condition. Some snake species (e.g., some of the Boidae) have retained pelvic vestiges, also called spurs, on either side of the cloaca (Fig. 30.4). The spurs are used during courtship and mating and are more pronounced in male snakes than in females.

Some species possess cloacal scent glands (or anal glands). These glands produce a foul-smelling material to mark their territory and to repel predators. It may be released during handling and should not be confused with inflammatory exudate.

Many lizards, such as Iguanidae and Agamidae, have femoral pores on the ventral aspect of the thigh (Fig. 30.5). Several gecko species also have precloacal pores which lie in a V-shaped row anterior to the cloaca. These pores are more pronounced in males than in females.

The muscles of the legs of chelonians and lizards and those of the tail of lizards also may reflect the animal's nutritional condition. Following inspection of the stance of the legs of chelonians and lizards, the animal is inspected and palpated from proximal to distal for abnormalities of the skin, toes, and nails, and to detect any soft tissue swellings, fractures, or swollen joints. The tail is inspected and palpated to evaluate its position, shape, and length, and to detect any skin abnormalities, wounds, or fractures.

Cloaca. The cloaca is examined with regard to its shape and content, and for possible swelling, prolapse, an egg, or other abnormalities. Prolapse of the penis (chelonians) or the hemipenes (snakes and lizards) and part of the cloaca can be either physiological or pathological. Prolapse of the shell gland, colon, or bladder (chelonians and most lizards) is pathological. After the cloaca is inspected it can be palpated and, if the animal is large enough, it can be explored digitally.

Coelomic body cavity. A healthy reptile usually has a supple abdomen. To palpate the abdomen of chelonians the index fingers are placed in the prefemoral fossa of both sides. Eggs, cystic calculi, or other masses may be palpated by moving the animal from side to side. Snakes are palpated on the ventral side between the ribs from cranial to caudal, starting just behind the head. The coelomic body cavity of lizards can be palpated gently from ventral or from lateral, depending on the size of the animal.

Masses that may be encountered during palpation include food, fecal material, fat bodies, retained eggs, fecoliths, enlarged organs (e.g., kidneys), or large ovarian follicles.

30.7 Fecal analysis

Reptilian feces are normally mixed with urates. The feces should be at body temperature for microscopic examination. They are collected with a lubricated glass probe inserted gently into the cloaca (Fig. 30.20). Defecation is stimulated by gently turning the probe. Sometimes only urates or urine is obtained, but this material should also be examined microscopically.



Fig. 30.20 Feces are collected from a snake by inserting a lubricated glass probe into the cloaca. Defecation is stimulated by gently turning the probe.

If no feces are obtained, cloacal washing can be used. Lukewarm saline (10 ml/kg body weight) is introduced into the cloaca and then retrieved with a syringe. Some reptiles defecate when placed in a warm, shallow bath. A direct smear of the feces is examined for flagellates and parasite ova and then fecal flotation is performed to detect other parasites.

After physical examination, every patient should be weighed accurately and its length also measured. Recording of all information is of great importance.

30.8 Further examination

Possible additional diagnostic procedures for reptiles include bacteriology, mycology, cytology, histology, hematology, biochemistry, serology, diagnostic imaging (radiology, CT, MRI), endoscopy, ultrasound, and ECG. Reference values are available for some species, but they are lacking for many. Results of laboratory examinations depend upon the species and are influenced by the environment, season, age, nutrition, and hibernation. More detailed information is available in recent textbooks.[6,7]

Blood collection

Lithium heparin is used as the anticoagulant for reptile blood because EDTA can cause hemolysis. At several possible sites of blood collection there is a risk of contamination with lymph. The skin of the site of blood collection should always be disinfected (see also § 25.2.4).

Chelonians. Blood can be collected from the right jugular vein. This vein is very superficial, lying on the right side of the neck in a line between the tympanic membrane to the base of the neck. The neck is fully extended and the needle is inserted into the vein from cranial to caudal (Fig. 30.21). Pressure should be applied over the site after withdrawing the needle, to prevent a hematoma.

Blood can also be collected from the dorsal coccygeal vein, which lies quite superficially in the midline of the tail. The disadvantage of this site is the risk of unpredictable dilution of the sample with lymph. The needle is inserted in the midline as far cranially as possible, at an angle of 45°. It is then moved slightly cranially and caudally until blood is obtained. If a vertebra is encountered, the needle is withdrawn and reinserted at a different angle and/or a different site.

The subcarapacial (subvertebral) venous sinus is a good site for venipuncture, with the neck extended or flexed. The sinus is in the dorsum of the neck, just under the carapace and caudal to the nuchal scute (Fig. 30.22). The needle is bent slightly and then inserted at a slight upward angle in the caudal direction, with gentle negative pressure until the sinus is encountered. The needle may enter a lymphatic, which lies just cranial to the venous plexus.[16]



Fig. 30.21 Collection of blood from the right jugular vein of a terrapin. The neck is fully extended and the needle is inserted into the vein from cranial to caudal.



Fig. 30.22 Collecting blood from the subcarapacial venous sinus in a terrapin.

An alternative but less favorable site for collecting blood is the cephalic vein (Fig. 30.23). When the front leg is extended, a tendon can be palpated on the caudal aspect of the antebrachiohumeral joint. The cephalic vein is between the joint and the tendon. The needle is inserted in the proximal direction, caudal or ventral to this tendon.

Another less favorable site is the femoral vein. It is located on the medial side of the femur and may be difficult to find. The animal is positioned in dorsal recumbency and the hind limb is extended and pulled



Fig. 30.23 Collecting blood from the cephalic vein. The front leg is extended and the needle is inserted at the level of the elbow in the proximal direction. The head of the terrapin is on the right in this picture.



Fig. 30.24 For blood collection from the heart, the snake is positioned in dorsal recumbency. The heart is immobilized between the thumb and forefinger and the needle is inserted into the heart at an angle of 45°.

backwards. The needle is inserted proximal to the knee in the proximal direction.

Snake. Depending on the size of the snake, blood can be collected from the heart, the ventral tail vein, and the palate-pterygoid veins. Cardiocentesis is a relatively simple procedure with little risk. The heart is located at approximately one-third the distance from the snout to the tail. The snake can be sedated if its condition allows. With the snake in dorsal recumbency, its heart is immobilized between the thumb and forefinger. The skin is disinfected and the needle is inserted at an angle of 45° in the craniodorsal direction into the ventricle. Digital pressure is applied over the site for 30–60 seconds (Fig. 30.24).

For collection of blood from the ventral tail vein, the snake is positioned in dorsal recumbency. The vein is located in the midline caudal to the cloaca, which is approximately halfway to the tip of the tail. The needle is inserted in the midline at an angle of 45° in the craniodorsal direction. Be aware of the hemipenes (up to 14–16 subcaudals downwards). Lymphatic contamination is possible.

The palate-pterygoid veins can be seen in large snakes when the mouth is opened. They are in the roof of the mouth on each side of the tongue. Sedation is usually necessary.

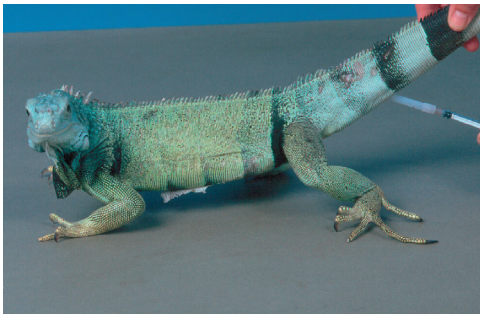


Fig. 30.25 Collecting blood from the ventral tail vein of an iguana.

Lizards. The best site for collecting blood in lizards is the ventral caudal tail vein. Large lizards can be positioned in dorsal or ventral recumbency. If in ventral recumbency, the tail is turned upwards. The needle is inserted in the ventral midline at a point between 1/5 and 4/5 of the distance to the tip of the tail. The needle is inserted at an angle of 45–90° in the craniodorsal direction, with slight negative pressure until blood appears in the syringe (Fig. 30.25). Small lizards should be sedated, to prevent tail autotomy.

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Appendix 1

Guidelines for housing of rats, gerbils, hamsters, guinea pigs, rabbits, and ferrets as experimental animals

Source: Preliminary recommendation of the European Council ETS 123: GT 123(2000) 57.

Table App 1A Rats

	body weight (g)	minimum floor surface (cm^2)	minimum cage height (cm)	floor surface per animal (cm^2)
in stock and during procedures*	=200	800	18	200
	201–300	800	18	250
	301–400	800	18	350
	401–600	800	18	450
	>600	1500	18	600
during breeding		800 female with litter for each additional adult add 400 cm^2	18	
stock with breeder cage size 1500 cm^2	50	1500	18	100
	51–100	1500	18	125
	101–150	1500	18	150
	151–200	1500	18	175
stock with breeder cage size 2500 cm^2	100	2500	18	100
	101–150	2500	18	125
	151–200	2500	18	150

*In lifetime studies social housing is required. It may be difficult to anticipate animal density at the end of a study and hence the guidelines may be exceeded in some circumstances. In such situations maintenance of a stable social structure should be given high priority.

Table App 1B Gerbils

	body weight (g)	minimum floor surface (cm^2)	minimum cage height (cm)	floor surface per animal (cm^2)
in stock and during procedures	40	1200	18	150
	>40	1200	18	250
during breeding		1200 monogamous pair or trio with young	18	

Table App 1C Hamsters

	body weight (g)	minimum floor surface (cm^2)	minimum cage height (cm)	floor surface per animal (cm^2)
in stock and procedures	60	800	14	200
	>100	800	14	250
during breeding		800 monogamous pair or female with young	14	
stock with breeder*	<60	1500	14	100

*For a short period after weaning hamsters may be kept in this high density, provided there is sufficient room and the cage is adequately enriched. There may be no evidence of harm to health and/or welfare.

Table App 1D Guinea pigs

	body weight (g)	minimum floor surface (cm^2)	minimum cage height (cm)	floor surface per animal (cm^2)
in stock and during procedures	200	1800	23	200
	201–300	1800	23	350
	301–450	1800	23	500
	451–700	2500	23	700
	>700	2500	23	900
during breeding		2500 pair with young for each breeding sow 1000 cm^2 extra	23	

Table App 1E Rabbits

Older than 10 weeks

maximal body weight in cage (kg)	minimum floor surface for 1–2 socially harmonious animals (cm^2)	minimum cage height (cm)
<3	3500	45
3–5	4200	45
>5	5400	60

doe with young

doe weight (kg)	minimum floor surface (cm^2)	extra for nest boxes (cm^2)	minimum height (cm)
<3	3500	1000	45
3–5	4200	1200	45
>5	5400	1400	60

Less than 10 weeks

age	minimum floor surface (cm^2)	maximal number of animals on minimum surface	per animal extra (cm^2)	minimum height (cm)
weaning to 7 weeks	4000	5	800	40
8–10 weeks	4000	3	1200	40

Table App 1F Rabbit

Seats (planks) for rabbits

age (weeks)	*body weight maximal (kg)*	*surface (cm × cm)*	*height above cage floor (cm)*
<10	-	55×25	-
>10	<3	55×25	25
	3–5	55×30	25
	>5	60×35	30

Table App 1G Ferret	
individual housing	4500 cm^2
housing in groups <600 g	1500 cm^2 per animal
housing in groups >600 g	3000 cm^2 per animal
adult hob	6000 cm^2 per animal
jill with pups	5400 cm^2

Appendix 2 Classification of reptiles (ref: Animal Diversity Web)

Class : Reptilia

Order: Testudines (chelonians) approx. 254 species

Family: Chelidae (snake-neck turtles)
Family: Cheloniidae (sea turtles)
Family: Cheydridae (snapping turtle)
Family: Carettochelyidae (New Guinea soft-shelled turtles)
Family: Dermatemydidae (Central American river turtles)
Family: Dermochelyidae (leatherback turtles)
Family: Emydidae (freshwater turtles and box turtles)
Family: Kinosternidae (mud turtles)
Family: Pelomedusidae (helmeted side-necks)
Family: Testudinidae (tortoises)
Family: Trionychidae (soft-shell turtles)

Order: Crocodilia (crocodiles, caimans, alligators) approx. 27 species

Family: Crocodylidae (crocodiles and family)
Subfamily: Alligatoridae (alligators and caimans)
Subfamily: Crocodylinae (crocodiles)
Subfamily: Gavialinae (gavialis)

Order: Squamata (lizards and snakes)

Suborder: Sauria (lizards) approx. 3900 species
Infraorder: Diploglossa
Family: Anguidae (slow worms and alligator lizards)
Family: Anniellidae (American legless lizards)
Family: Xenosauridae (knob-scale lizards)
Infraorder: Gekkota (geckos)
Family: Dibamidae (dibamids)
Family: Gekkonidae (geckos)
Family: Pygopodidae (scaley-foot lizards)
Infraorder: Iguania
Family: Agamidae (agamas)
Family: Chamaeleonidae (chameleons)
Family: Corytophanidae (helmeted iguanas or basiliscus)
Family: Crotaphytidae (collared lizards)
Family: Hoplocercidae (prickle-tail iguanas)
Family: Iguanidae (iguanas)
Family: Opluridae (Madagascan swifts)
Family: Phrynosomatidae (horned lizards)
Family: Polychrotidae (anolisamilie: Tropiduridae (lava lizards)

Infraorder: Platynota
Family: Helodermatidae (Gila monsters or beaded lizards)
Family: Lanthanotidae (earless monitors)
Family: Varanidae (monitors)

Infraorder: Scincomorpha
Family: Cordylidae (girdle-tailed lizards)
Family: Gerrhosauridae (plated lizards)
Family: Gymnophthalmidae (spectacled tegus)
Family: Lacertidae (green lizards)
Family: Scincidae (skinks)
Family: Teiidae (teius lizards)
Family: Xantusiidae (night lizards)

Suborder: Amphisbaenia approx. 140 species
Family: Amphisbaenidae (amphisbaenia)
Family: Bipedidae (two-legged worm lizards)
Family: Rhineuridae (Florida worm lizards)
Family: Trogonophidae (snake lizards)

Suborder: Serpentes (snakes) approx. 2400 species
Infraorder: Henophidia
Family: Aniliidae (pipe snakes)
Family: Anomochilidae (dwarf pipe snakes)
Family: Boidae (giant snakes)
Family: Uropeltidae (shield-tailed snakes)
Family: Xenopeltidae (sunbeam snakes)
Infraorder: Typhlopoidea (blind worm snakes)
Family: Leptotyphlopidae (slender blind snakes) 78 species
Family: Typhlopidae (common blind worm snakes) 180 species
Family: Anomalepidae (American blind snakes) 20 species
Infraorder: Xenophidia
Family: Acrochordidae (file snakes)
Family: Atractaspididae (burrowing vipers, mole vipers)
Family: Colubridae (colubrids or typical snakes)
Family: Elapidae (cobras)
Family: Hydrophiidae (sea snakes)
Family: Viperidae (true vipers)
Subfamily: Crotalidae (pit vipers)

Order: Rhynchocephalia (tuataras) 1 species

Family: Sphenodontidae (tuataras)

Appendix 2.1 Some data on the most commonly kept tortoises

	Testudo hermanni	**Testudo graeca**	**Chelonoidis carbonaria**	**Geochelone pardalis**
Taxonomy (family)	Testudinidae	Testudinidae	Testudinidae	Testudinidae
Origin	southern Europe	southern Spain to northern Africa, Balkans	South America	central and southern Africa, southern Asia
Biotope	moderate climate	moderate climate	tropical forest	dry area
Nutrition	herbivore/omnivore	herbivore/omnivore	omnivore	herbivore/omnivore
Special characteristics	nail on tip of tail carapax up to 20 cm	spurs on thighs carapax up to 20 cm	American giant tortoise has carapax up to 50 cm	carapax up to 70 cm
Related species	*T. graeca* *T. marginata* *T. horsfieldi* *T. kleinmanni*	*T. hermanni* *T. marginata* *T. horsfieldi* *T. kleinmanni*	*C. denticulata* *C. elephantopus*	*G. sulcata* *G. elegans*

Appendix 2.2 Some data on the most commonly kept terrapins

	Chrysemys scripta elegans	**Trionyx**	**Terrapene carolina**	**Chelydra serpentina**
Taxonomy (family)	Emydidae	Trionychidae	Emydidae	Cheydridae
Origin	North and South America	North America, Africa, Asia, Indonesia, Australia	North America	Canada to South America
Biotope	marsh, rivers	marsh, rivers, ponds	open woods close to water	hides in soft ground, active in twilight and night
Nutrition	omnivore	carnivore	carnivore/omnivore	carnivore (feeds on invertebrates and reptiles)
Special characteristics	red spot on cheek, likes basking in sun carapax 20–40 cm	proboscidal nose, compressible shield carapax up to 90 cm	can close shield completely carapax up to 18 cm	small abdominal shield, long neck, large head, strong mouth carapax up to 70 cm
Related species	*C. decorata* *C. concinna* *C. picta picta*	*T. cartilagineus* *T. ferox* *T. triunguis*	*T. ornata* *T. coahuila* *T. nelsoni*	*Macroclemys temminckii*

Appendix 2.3 Some data on the most commonly kept snakes

	Boa constrictor	**Python molurus**	**Elaphe guttata**	**Thamnophis sirtalis sirtalis**
Taxonomy (family)	Boidae	Boidae	Colubridae	Colubridae
Origin	southern Central America	Africa, southeast Asia, Australia	southeastern Central America	northern Central America
Biotope	dry area, woods	woods, swamp	wet fields, woods	all habitats
Reproduction	viviparous	oviparous	oviparous	viviparous
Nutrition	prey	mammals, birds	small mammals	fish
Special characteristics	constrictor, 2.5–4 m	constrictor, up to 8 m	popular terrarium snake, constrictor, 60 cm to 2 m	30–60 cm
Related species	*Boa constrictor occidentalis*	*P. regius* *P. reticularis*	*E. obsoleta* *E. schrenki* *E. rufodorsata* (fish-eater, viviparous)	*T. sirtalis tetrataenia* *T. elegans elegans* *T. sirtalis concinnus*

Appendix 2.4 Some data on snakes occurring in northwestern Europe

	Natrix natrix	**Coronella austriaca**	**Vipera berus**
Taxonomy (family)	Colubridae	Colubridae	Viperidae
Origin	Europe, northwest Africa, Asia	Europe, northwest Africa, western Asia	Europe, western Asia
Biotope	moist, sunny spots close to water	heath, grassy plains	hedgerows, undergrowth, heath
Reproduction	oviparous	viviparous	viviparous
Nutrition	frogs, fish	lizards, small mammals, birds, mice	small mammals
Special characteristics	can appear to be dead, fair spot behind head 80–150 cm	grayish-red snake 70 cm	zigzag stripe on back, vertical pupil 50–80 cm
Related species	*N. natrix helvetica* *N. tesselata*	*C. girondica* (oviparous)	*V. kaznakovi* *V. ursinii*

Appendix 2.5 Some data on the most commonly kept lizards

	Iguana iguana	**Agama**	**Gekko gecko**	**Skink**
Taxonomy (family)	Iguanidae	Agamidae	Gekkonidae	Scincidae
Origin	central Mexico, South America	Africa (*Agama, Uromastyx*), southwest-central Asia (*Phrynocephalus*) Australia (*Amphibolorus*, etc.)	southeast Asia, Indonesia, Australia, Korea, Japan	southeast Asia, Australia, Africa
Biotope	rain forest, close to water	tropical rain forest, mountains, steppe, desert	in trees, tropical rain forest to savanna, steppe, close to water	tropical areas, ground, sometimes digs
Reproduction	oviparous	oviparous	most oviparous, but ovoviviparous in New Zealand	ovoviviparous, some viviparous, some oviparous with very short incubation period
Nutrition	omnivorous/herbivorous	insects	insects, small vertebrates, some plants	insects, some eat plants
Related species	*I. delicatissima*	*Draco, Hydrosauru* and many others	*G. japonicus* *G. smaragdinus* *G. monarchus* *G. vittatus*	Subfamily: Tiliquinae Scincinae Lygosomina
Special characteristics	long tail, good swimmers, enjoy basking in sun, femoral pores, spines, throat or skin flaps and other decorations, up to 2 meters	can change colors, fleshy tongue, spines, throat or skin flaps and other decorations, up to 40 cm	vertical-slit pupil, setae on feet, preanal pores, 5–35 cm	cylindrical body, short rudimentary feet, short neck, 10–65 cm

Appendix 3 Basic husbandry requirements for reptiles (I)

Terrarium	
Location	Preferably a quiet place, not by a sunny window.
Cage size	**Snakes:** terrarium diagonal at least equal to the length of the snake and for each additional snake increase the diagonal by one-half the width. **Lizards:** terrarium length 1.5–2× the length of the animal, width 1x the length of the animal, and for each additional animal increase the length and width by 30%. **Tortoises:** terrarium length and width 4× the length of the carapace, and for each additional animal increase the length and width by 1× the length of the carapace. **Terrapins:** terrarium length and width 6× the length of the carapace and for each additional animal increase the length and width by 1.5× the length of the carapace. Note: for animals that live in trees the height of the terrarium should be at least equal to its length.
Heating	Heating lamp or pads, basking area, with a temperature gradient in the terrarium, and no possibility of contact between the animal and the lamp.
Housing	Simple, with non-slip and easily cleaned floor, some branches or stones, and at least one hiding place. The terrarium should be closed with an opening in the top for ventilation. For tortoises from subtropical and temperate areas the top can be open. For some species it is preferable to have one animal per terrarium, but tortoises can get along well in groups.
Temperature of the terrarium	
Equatorial	28–33°C in daytime, 25–29°C at night (**A**)
Tropical	24–30°C in daytime, 20–25°C at night (**B**)
Subtropical	summer: 20–27°C in daytime, 15–21°C at night winter: 10–16°C in daytime, 5–12°C at night (**C**)
Temperate	summer: 16–23°C in daytime, 10–16°C at night winter: 4–9°C in daytime, 2–5°C at night. These animals hibernate. (**D**)
Desert	30–40°C in daytime, 8–12°C at night (**E**)
Humidity	
Dry	relative humidity 20–40% (**F**)
Normal	relative humidity 40–70% (**G**)
Humid	relative humidity 70–100% (**H**)
Photoperiod	
	The normal variation of the photoperiod in northwestern Europe is not a problem for reptiles.
Nutrition	
	Nutrition differs according to species, age, and size of the animal (Appendix 4). Key: mammals (**I**), birds (**J**), reptiles (**K**), amphibians (**L**), fish (**M**), crustaceans (**N**), insects (**O**), snails (**P**), spiders (**Q**), fruits (**R**), vegetables (**S**), flowers (**T**), boiled eggs (**U**), dog food or pellets (**V**).
	Note: to prevent nutritional deficiencies many herbivores and insectivores are fed small amounts of commercial pellets or vitamin/mineral supplements.

Appendix 4 Basic husbandry requirements for reptiles (II)

		temp.	humid.	food
Snakes				
Boa	*Boa constrictor* sp.	A,B	F,G	I,J
Python	*Python, Morelia, Liasis* spp.	A,B	F,G	I,J
Tree python	*Chondropython* sp.	A	H	I,J
Other boas		A,B	F,G	I,J
Rat snake	*Elaphe* sp.	C,D	G	I,J,U
Anaconda	*Eunectes* sp.	A,B	H	I,J,K
Cobra	*Naja, Ophiophagus* spp.	B,C	G	I,J,K
Egg-eating snake	*Dasypeltis scabra*	B,C	G	I,U
Garter snake	*Thamnophis* sp.	D	G	I,K,L,M
Ring snake	*Natrix, Nerodia* spp.	D	G	L,M
King snake	*Lampropeltis* sp.	C,D	G	I,J,K
Adder	*Vipera, Cerastes, Bothrops* spp.	C,D	G	I,J,K
Lizards				
Agame	*Agama* sp.	A,B	G,H	I,O
Anole	*Anolis* sp.	B	G,H	O
Basilisk	*Basiliscus* sp.	B	H	I,O
Chameleon	*Brooksia, Chamaeleo* spp.	A–C	G,H	O,I
Gecko	several species	A,B,C,D	G,H	I,O,K,J
Day gecko	*Phelsuma* sp.	B	G,H	O,R
Iguana*	*Iguana iguana*	B	G	I,J,O,P,R,S,T,V
Monitor*	*Varanus* sp.	A,B,C	G,H	I,J,K,L,M,N,O,P,Q,U,V
Skink	*Scincus, Chalcides* spp.	B	G	I,J,O,P,Q,S,T,U,V
Tortoises				
European tortoise	*Testudo hermanni, Testudo graeca*	C,D	G	R,S,T,V
Radiated tortoise	*Asterochelys*	B	G	R,S,T,V
American giant tortoise	*Chelonoides carbonaria*	B	G,H	R,S,T,V
Box turtle	*Terrapene* sp.	B,C	H	M,O,P,R,S,T,V
Terrapins				
Painted turtle	*Chrysemys scripta elegans*	A,B	H	L,M,N,O,P,U,V,S
Map turtle	*Graptemys* sp.	B,C	H	L,M,N,O,P,U,V,S
Crocodiles				
Mississippi alligator	*Alligator mississippiensis*	B	H	Z,J,K,L,M,V
Caiman	*Caiman* sp.	A,B	H	Z,J,K,L,M,V
Crocodile	*Crocodylus* sp.	A,B	H	Z,J,K,L,M,V
Gavial	*Gavialis gangeticus*	A,B	H	M,V,J,L

*The nutrition of iguanas and varanes varies considerably with age. In general, young animals eat more insects than do adults.
Source: Chris van Kalken.

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