Self-Assessment Color Review

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Small Animal Emergency and Critical Care Medicine

2nd Edition

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Preface

When seconds count . . . will you be ready?

Sit down, buckle up, and get ready for the ride of your life! The ups and downs of emergency and critical care are like the ultimate high-speed roller coaster ride. The difference between life and death may be your ability to intervene with speed, efficiency, and skill. Every organ in the body can play a role in the survival or demise of the critical patient. There is no time to lose and little margin for error.

This second edition of *Small Animal Emergency and Critical Care Medicine* provides an excellent and fun method for sharpening your skills and expanding your knowledge base in this exciting specialty. Whether you are a seasoned veterinary practitioner, emergency clinician or specialist, veterinary student, intern or resident, or veterinary technician, you will discover important information that can help you save a life. The experience and expertise of the authors (more than 40 years in the specialty, more than 100,000 emergency/critical care patients) provide an insight into important yet practical examples of critical patient care.

This book is a treasure chest of practice tips, guidelines, treatment strategies, and pearls brought to you through cases, questions, and answers. We encourage you, the reader, to work alone, or with a group of colleagues, to expand and test your knowledge and skills. It is best to read the question and propose your answer before reading our recommendations. Do not hesitate to write in the margins and make notes to assist you when you revisit cases a second or third time. We have given you what we believe to be our best answer but readily acknowledge that there are many ways to perform a procedure or treat a patient. It is our hope that you will incorporate your own experiences and training into the information from these cases and create a knowledge base that is ideal for you.

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Andrew Linklater

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Rebecca Kirby
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Andrew Linklater

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Broad classification of cases

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Abbreviations

ABP	arterial blood pressure
ACEI	angiotensin-converting enzyme inhibitor
ACT	activated clotting time
ACTH	adrenocorticotropic hormone
ACVIM	American College of Veterinary Internal Medicine
ADH	antidiuretic hormone
AKI	acute kidney injury
ALP	alkaline phosphatase
ALT	alanine aminotransferase
aPTT	activated partial thromboplastin time
BP	blood pressure
bpm	beats per minute/breaths per minute
BCS	body condition score
BUN	blood urea nitrogen
CBC	complete blood count
CHF	congestive heart failure
CN	cranial nerve
CNS	central nervous system
COP	colloid osmotic pressure
CPR	cardiopulmonary resuscitation
CRH	corticotropin-releasing hormone
CRI	constant rate infusion
CRT	capillary refill time
CSF	cerebrospinal fluid
CVP	central venous pressure
DIC	disseminated intravascular coagulation
DLH	domestic longhaired (cat)
DSH	domestic shorthaired (cat)
ECG	electrocardiogram
ET	endotracheal tube
$ETCO_2$	end-tidal CO_2
FAST	focused assessment with sonography for trauma (scan)
FB	foreign body
FeLV	feline leukemia virus
FiO_2	fraction of inspired oxygen
FIP	feline infectious peritonitis
FIV	feline immunodeficiency virus
GA	general anesthesia
GDV	gastric dilatation/volvulus
GFR	glomerular filtration rate
GI	gastrointestinal
Hct	hematocrit
HES	hydroxyethyl starch
HP	hydrostatic pressure
HR	heart rate
ICP	intracranial pressure
ICU	intensive care unit
IM	intramuscular/intramuscularly
IV	intravenous/intravenously
IVC	intravenous catheter
LRS	lactated Ringer's solution
MAP	mean arterial pressure
MM	mucous membranes
MODS	multiple organ dysfunction syndrome
NCC	nucleated cell count
NPO	nil per os
NSAID	non-steroidal anti-inflammatory drug
OD	oculus dexter (right eye)
OS	oculus sinister (left eye)
OU	oculus uterque (both eyes)
PCR	polymerase chain reaction
PCV	packed cell volume
PEEP	positive end-expiratory pressure
PIVKA	proteins induced by vitamin K antagonism or absence (test)
PLR	pupillary light reflex
PMN	polymorphonuclear leukocyte
PO	per os/orally
pRBC	packed red blood cell
PT	prothrombin time
PU/PD	polyuria/polydipsia
RBC	red blood cell
RER	resting energy requirement
RR	respiratory rate
SABP	systolic arterial blood pressure
SAP	systemic arterial pressure
SC	subcutaneous/subcutaneously
SG	specific gravity
SIRS	systemic inflammatory response syndrome
T	temperature
TP	total protein
TPR	temperature, pulse, respiration
TS	total solids
UPC	urine protein:creatinine (ratio)
V/Q	ventilation/perfusion
WBC	white blood cell

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How to have the ultimate case-based learning experience: recommendations for the reader

The authors have written the questions and answers that accompany these cases with only one goal in mind: to give you, the reader, the most valuable and enjoyable learning experience possible. To achieve this goal we have listed below our recommendations for how you can best benefit from this book.

1. The questions are meant to be read and your best answer recorded before you review our prepared answers to the questions. There is a table of normal laboratory values at the front of the book. Both American and the International System of Units (SI) values are provided, together with the relevant conversion factors. All ECGs are run at a paper speed of 25 mm/sec, with an amplitude of 1 mV/cm unless otherwise stated.
2. While most of the cases in the book are placed in random order, the first section of the book is specifically sequenced. This section presents details pertaining to our 'Back to the Basics' approach to patient assessment, organized steps to interpret data or create a resuscitation plan, physiology important to patient survival, and the essential Rule of 20 for monitoring the critical patient. Work through this section first for the best learning experience.
3. Take the time to use the guidelines presented in the first section on the cases that follow – even when not specifically requested. This includes:
   - Creating a problems list in order of priority;
   - Using the steps provided to create your fluid resuscitation plan and to interpret an ECG or blood gas;
   - Assessing the cause and effect of a problem on the patient; and
   - Considering the pros and cons of doing a procedure or giving a medication.

   While these tasks might appear daunting at first, they provide an organized and educated approach to patients and their data. Repetition is the key to learning!
4. Make notes and checklists from the information you gain as you work through the cases. We guarantee that this information will be useful when managing the cases in this book as well as many of the patients in your clinic.
5. We encourage you to explore the suggested Further reading list, which includes physiology, internal medicine, surgery, clinical pathology, imaging, and emergency/critical care texts, in order to further expand your knowledge base and options for patient management.
6. There has been controversy regarding the use of hydroxyethyl starch (HES) products in septic humans. The authors have used either hetastarch or tetrastarch for more than 20 years in over 20,000 dogs and cats. We have not seen the complications reported in humans in either the dog or the cat. However, the authors recommend using HES conservatively in small animals with kidney failure or coagulopathies until further studies have been completed in these species.

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Laboratory values: normal ranges and Old unit/SI unit conversion factors

Test	Old (US) units	Conversion: multiply by	SI units
Prothrombin time (PT)	11–17 seconds	n/a	11–17 seconds
Activated partial thromboplastin time (aPTT)	72–102 seconds	n/a	72–102 seconds
Packed cell volume (PCV) canine	37–55%	0.01	0.37–0.55 l/l
Packed cell volume (PCV) feline	24–45%	0.01	0.24–0.45 l/l
Total solids (TS) canine	5.8–7.2 g/dl	10	58–72 g/l
Total solids (TS) feline	5.7–7.5 g/dl	10	57–75 g/l
White blood cell count (WBC)	6,000–17,000/µl	0.001	6–17 × 10^9/l
Segmented neutrophils	3,230–10,850/µl	0.001	3.23–10.85 × 10^9/l
Monocytes	0–430/µl	0.001	0–0.43 × 10^9/l
Lymphocytes	530–3,440/µl	0.001	0.53–3.44 × 10^9/l
Eosinophils	0–1,820/µl	0.001	0–1.82 × 10^9/l
Basophils	10–540/µl	0.001	0.01–0.54 × 10^9/l
Platelet count	200,000–500,000/µl	0.001	200–500 × 10^9/l
Hematocrit (Hct)	37–55%	0.01	0.37–0.55 volume fraction
Mean corpuscular volume (MCV)	60–72 fl	n/a	60–72 fl
Mean corpuscular hemoglobin concentration (MCHC)	32.0–38.5 g/dl	10	320–385 g/l
Blood urea nitrogen (BUN)	9.0–29.0 mg/dl	0.357	3.2–10.4 mmol/l
Creatinine	0.4–1.4 mg/dl	88.4	35.4–123.8 µmol/l
Phosphorus	1.9–5.0 mg/dl	0.323	0.6–1.6 mmol/l
Calcium	9.0–12.2 mg/dl	0.25	2.25–3.05 mmol/l

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Total protein	5.5–7.6 g/dl	10	55–76 g/l
Albumin	2.5–4.0 g/dl	10	25–40 g/l
Globulin	2.0–3.6 g/dl	10	20–36 g/l
Glucose	75–125 mg/dl	0.0555	4.16–6.94 mmol/l
Cholesterol	120–310 mg/dl	0.0259	3.1–8.0 mmol/l
Alanine aminotransferase (ALT, SGPT)	0–120 U/l	1	0–120 U/l
Aspartate aminotransferase (AST, SGOT)	0–60 U/l	1	0–60 U/l
Alkaline phosphatase (ALP, SAP)	0–140 U/l	1	0–140 U/l
Gamma glutamyltransferase (GGT)	0–14 U/l	1	0–14 U/l
Total bilirubin	0–0.5 mg/dl	17.1	0–8.55 µmol/l
Amylase	100–1,500 U/l	1	100–1,500 U/l
Lipase	0–225 U/l	1	0–225 U/l
Magnesium	1.5–2.4 mg/dl	0.4114	0.62–0.98 mmol/l
Triglycerides	30–130 mg/dl	0.0113	0.34–1.47 mmol/l
Sodium	140–151 mEq/l	1	140–151 mmol/l
Potassium	3.5–5.0 mEq/l	1	3.5–5.0 mmol/l
Chloride	106–127 mEq/l	1	106–127 mmol/l
Ionized calcium	4.5–5.7 mg/dl	0.25	1.13–1.42 mmol/l
Anion gap	5–22 mEq/l	1	5–22 mmol/l
pH	7.36–7.46	n/a	7.36–7.46
$PvCO_2$	30–47 mmHg	0.1333	4–6.3 kPa
Bicarbonate (HCO_3)	16–28 mEq/l	1	16–28 mmol/l
Lactate	5.4–27 mg/dl	0.111	0.6–3 mmol/l

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1 On a slow night at the veterinary emergency room the following animals arrive within 5–10 minutes of one another (**1**).

1. 3-year-old male neutered cat straining to urinate for the past 4–5 hours. He has a small but inexpressible bladder, is alert, and is uncomfortable with a normal TPR.
2. 14-year-old female spayed cat having difficulty breathing for the past 2 days. She has dull lung sounds, an asynchronous respiratory pattern, is open-mouth breathing, and has a murmur. Gums are slightly cyanotic in color.
3. 8-year-old small Terrier-cross that was bitten by a larger dog on the right front paw, which he is holding up. Cardiovascular status is stable.
4. 11-year-old Labrador-cross that has collapsed, has a distended abdomen, HR of 190 bpm, and pale gum color.
5. 12-year-old male neutered beagle that has been seizuring for the past hour and has a temperature of 42.8°C (109°F).

i. Put the patients in order of priority for medical therapy.
ii. What is your immediate emergency stabilization plan for each patient?

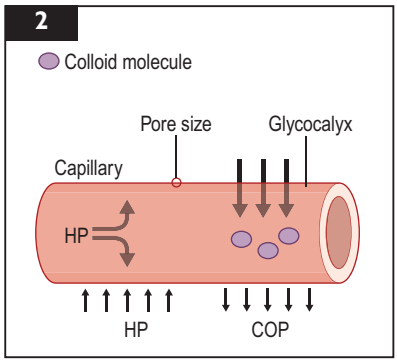
2 i. In what structure of the cardiovascular system does the majority of fluid, electrolyte, gas, and nutrient exchange occur?
ii. What is the composition of this structure?
iii. Explain the forces driving fluids and substances in and out of this structure.

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Answers: 1, 2

1 i. Patients 2, 5, and 4 may be equally critical, then patient 1, then patient 3.
ii. Patient 2 is placed in an oxygen-rich environment and given a mild sedative such as butorphanol IV/IM. Patient 5 has an IVC placed, is given a benzodiazepine with IV fluid administration, has external cooling techniques initiated, and a laboratory emergency database checked. Patient 4 has an IVC placed and is started on low-volume resuscitation and an emergency laboratory database evaluated. Patients 1 and 3 are given analgesic medication pending stabilization of the other patients. Following this, patient 2 has an IVC placed, thoracocentesis is performed with oxygen support, and placed into the oxygen-rich environment. Patient 1 has an emergency laboratory database checked for hyperkalemia, and patient 3 a bandage placed. Following stabilization of patients 5 and 4, patient 1 is unblocked.

2 i. The capillary structure.
ii. The capillary is composed of a thin single layer of endothelial cells resting on a bed of collagen and/or fibrin. There is an endothelial glycocalyx matrix resting on the endothelial cells within the intravascular space (**2**).
iii. Starling's forces, including capillary pore size, direct fluid movement into and out of capillaries. Intravascular hydrostatic pressure (HP) from cardiac output (intravascular volume, contractility, HR) and BP (systemic vascular resistance and cardiac output) are the main forces driving fluid and molecules out of the capillary. The intravascular COP (large molecules trapped in capillary lumen) and the endothelial glycocalyx matrix create an osmotic gradient towards the intravascular space and favor fluid retention within the capillary. The intravascular forces are opposed by HP and COP of the interstitial tissues and the reflection coefficient of the capillary endothelium.



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3 Match the stages of shock (compensatory, early decompensatory, late decompensatory) with the typical physical peripheral perfusion parameters of the dog (parameters can be used more than once):

- Tachycardia, normal HR, bradycardia.
- Bright pink/red MM, pale MM, white MM.
- CRT = <1 sec, CRT = >2 sec.
- Bounding femoral pulses, weak femoral pulses, absent femoral pulses.
- Normal BP, elevated BP, decreased BP.

4 Answer the following questions regarding the creation of a fluid resuscitation plan.

i. Put the clinical parameters below under the heading that they reflect: either perfusion (intravascular) or hydration (interstitial/intracellular):
HR; MM moisture; skin turgor; pulses; CRT; eye position in the orbit; MM color; CVP; PCV/TS; BP, body weight.

ii. Complete the following chart regarding the signs seen in the different stages of hypovolemic shock.

Stage of shock		**HR**	**MM color**	**CRT**	**Pulses**
Compensatory (not in cats)					
Early decompensatory	Dog				
	Cat				
Late decompensatory (hypothermia)					

iii. Briefly explain the mechanism of cardiogenic shock, distributive shock, and obstructive shock, and give an example of a cause of each.

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Answers: 3, 4

3 Compensatory stage: tachycardia; bright pink/red MM; CRT = <1 sec; bounding femoral pulses; normal, elevated or decreased BP.
Early decompensatory stage: tachycardia; pale MM; CRT = >2 sec; weak femoral pulses; normal or decreased BP.
Late decompensatory stage: bradycardia or normal HR; pale or white MM; CRT = >2 sec; absent femoral pulses; decreased BP.

4 i. Perfusion: HR, pulses, CRT, MM color, BP, CVP. Hydration: MM moisture, skin turgor, eye position in orbit, body weight, PCV/TS.
ii.

Stage of shock		HR	MM color	CRT	Pulses
Compensatory (not in cats)		↑	Red	<1 sec	Bounding
Early decompensatory	Dog	↑	Pale	>2 sec	Weak
	Cat	N or ↓	Pale	>2 sec	Weak
Late decompensatory (hypothermia)		N or ↓	White	Absent	Absent

iii. Cardiogenic shock has poor cardiac output because of poor cardiac performance. The baroreceptors are not stretched and vasoconstriction occurs peripherally. This increases afterload and worsens cardiac output. Further vasoconstriction and aggressive fluid resuscitation will worsen the status. Example: CHF from dilated cardiomyopathy.

Distributive shock occurs when blood is redistributed to the periphery, primarily due to peripheral vasodilation, rather than to the core circulation typical of the hypovolemic shock process. Example: septic shock.

Obstructive shock occurs when there is obstruction to venous return back to the heart. This reduces cardiac filling and, subsequently, cardiac output. The baroreceptors initiate vasoconstriction, which can further impede flow. Example: vena caval syndrome with heartworm disease.

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5 These four steps (**5**) are followed when creating the Fluid Resuscitation Plan for a patient:

5

4-Step Fluid Resuscitation Plan

Step 1 – Determine where the fluid deficit is – perfusion vs. hydration
Step 2 – Select the specific fluid(s) – crystalloid, colloid or both
Step 3 – Select resuscitation end-points – high end or low end
Step 4 – Select resuscitation technique to reach desired end-points – large volume or small volume

i. Describe the factors contributing to decision making in step 1.
ii. Describe the factors contributing to decision making in step 2.
iii. Describe the factors contributing to decision making in step 3.
iv. Describe the factors contributing to decision making in step 4.

6 An 8-month-old mixed-breed female neutered dog weighing 15 kg was last normal 12 hours ago. She presents for acute vomiting (4 times, white liquid) and bloody, watery, fetid diarrhea. T = 39.4°C (103°F); HR = 180 bpm; RR = 48 bpm; CRT = <1 sec; MM brick red; femoral pulse bounding and synchronous with heart. The dog has very dry MM and corneas. Skin turgor and eye position are normal. PCV = 0.44 l/l (44%); total solids = 52 g/l (5.2 g/dl); blood glucose = 2.8 mmol/l (50 mg/dl); Doppler systolic indirect BP = 140 mmHg.
i. What is the dog's perfusion status?
ii. What is happening within the cardiovascular system to result in this dog's peripheral physical perfusion parameters?
iii. Is this dog in shock? Explain the BP value in your answer.
iv. What is the dog's hydration status? Justify your answer.

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Answers: 5, 6

5 i. Perfusion reflects intravascular volume and cardiac function, demonstrated by HR, BP, MM color, pulse intensity, CRT, and rectal temperature. Hydration reflects interstitial and intracellular fluid content, demonstrated by MM and corneal moisture, skin turgor, and eye position in the skull. Perfusion deficits (not due to heart failure) typically result in concurrent hydration deficits.
ii. Perfusion deficits not due to heart failure can be resuscitated with colloids and crystalloids together. Hydration deficits are corrected with crystalloids. Congestive heart failure is treated by addressing heart failure and giving crystalloid support as needed. Blood products are chosen during resuscitation of severe anemia (whole blood, pRBCs, Oxyglobin®) or coagulopathy (whole blood, plasma) with crystalloids. Perfusion deficits treated with crystalloids alone can have interstitial edema as a significant complication.
iii. Low end goals are used in post trauma, heart failure, brain or lung edema/hemorrhage, oliguria, or coagulopathy. High end goals are used in all other situations, especially SIRS diseases or when systemic vasodilation is present (anaphylaxis, hypoadrenocorticism, sepsis).
iv. Titration of small volumes of fluids (initial 10 ml/kg crystalloids and simultaneous 5 ml/kg colloid increments) is done any time low end goals are targeted and in all cats for either low or high end goals. This technique avoids rapid, severe increase in intravascular HP. Large volume infusion (crystalloids [20–50 ml/kg] and colloids [HES: 15–20 ml/kg; Oxyglobin®: 5 ml/kg]) is utilized in dogs when high end goals are targeted.

6 i. Hyperdynamic perfusion (compensatory shock).
ii. IV volume deficit is detected by decreased stretch of the baroreceptors resulting in decreased inhibition of the central sympathetic center; this results in an increased sympathetic cardiovascular response (tachycardia, increased contractility, mild vasoconstriction) and subsequent signs of hyperdynamic (compensatory) stage of shock.
iii. Yes, it is in the earliest 'compensatory' stage of shock. Although the systolic BP alone is within normal limits for the dog, it is only because of the tachycardia and other sympathetic responses perpetuated by the baroreceptor stimulation to bring the BP within a normal range. This process is utilizing high amounts of energy and requires IV volume replacement to stretch the baroreceptors and eliminate the need for the sympathetic response.
iv. The dog is 4–5% dehydrated based on the very dry MM and corneas with a normal skin turgor and eye position.

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7 An 8-year-old male neutered cat weighing 5 kg presented for 4 weeks of progressive anorexia and weight loss. Physical examination: T = 38.3°C (101°F); HR = 180 bpm; RR = 24 bpm; CRT = 1.5 sec; MM dry pink; skin tenting at nape of neck; eyes sunken in the orbit. The femoral pulses were strong and synchronous with the heart. There was a large mass palpable in the mid-abdominal region. Doppler systolic BP = 100 mmHg.
i. What is the cat's perfusion status? Justify your answer.
ii. What is the cat's hydration status? Justify your answer.
iii. Which fluid space is affected with poor perfusion and which space is affected with dehydration?

8 Hydration status is a reflection of interstitial and intracellular fluid balance.
i. Complete the following chart noting a change of one or more of the appropriate clinical signs. Choices include: MM moisture, skin turgor, PCV/TS, corneal moisture, position of eye globe within orbits, and perfusion status.

Estimated % dehydration	Clinical signs
4–6	
6–8	
8–10	
10–12	
>12	

ii. Give two clinical situations when the assessment of skin turgor and/or position of the eye globe within the orbits may not provide an accurate assessment of hydration status.

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Answers: 7, 8

7 i. The cat's perfusion appears adequate with normal peripheral physical perfusion parameters: normal body temperature, HR, pulse intensity, BP, and CRT, with pink gum color.
ii. The cat is approximately 8–10% dehydrated with dry gums, tenting of the skin, and sunken eyes in the orbit.
iii. Intravascular volume deficits are reflected as hyper- or hypodynamic perfusion parameters, detected on physical examination by the patient's perfusion parameters, which include body temperature, HR, pulse intensity, CRT, MM color, and BP. Dehydration is a reflection of fluid deficit in the interstitial and intracellular fluid spaces, reflected by MM dryness, skin turgor, corneal moisture, and eye position within the orbit.

8 i.

Estimated % dehydration	Clinical signs
4–6	Dry MM
6–8	Dry MM, loss of skin moisture, increase in PCV/TS
8–10	Dry MM, loss of skin moisture, increase in PCV/TS, retracted globes within orbits
10–12	Dry MM, loss of skin moisture, increase in PCV/TS, retracted globes within orbits, dull corneas
>12	Dry MM, loss of skin moisture, increase in PCV/TS, retracted globes within orbits, signs of perfusion deficits

ii. (1) A rapid loss of interstitial fluid into a third-body fluid space, such as the GI tract in acute parvovirus infection or hemorrhagic gastroenteritis, results in water moving from the blood vessel into the interstitium (Starling's forces have a higher intravascular HP and interstitial COP). This can minimize the change in skin turgor typical of the clinical signs of dehydration, requiring an estimation of dehydration higher than that assigned based on skin turgor changes. (2) A situation involving animals with chronic weight loss or elderly animals who have lost skin and subcutaneous elastin, allowing tenting of the skin during normal hydration. In addition, the animal may have metabolized the fat pads around the eyes, with resultant retraction of the globes within the orbit. This situation leads to an overestimation of dehydration. Retrobulbar/ocular disease could also affect eye position.

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9 i. Why would interstitial dehydration be reflected by a change in the PCV/TS (which is intravascular)?
ii. Recommendations for time to accomplish rehydration can range from 1 hour to 24 hours. Provide at least five patient variables that will affect your decision for rapid (1–4 hours), moderate (4–6 hours), or slow (12–24 hours) rehydration rates.
iii. Your patient is 15 kg and 8% dehydrated. You have decided to rehydrate over 6 hours. Show your calculation for the amount of fluids to give each hour for the 6 hours of rehydration.

10 i. Define crystalloid and give some examples of crystalloid fluids (**10**).
ii. What do the following mean when referring to crystalloids: (a) buffered; (b) balanced; (c) isotonic; (d) replacement; (e) maintenance. Give an example of a fluid that has each of these properties.
iii. Provide some clinical situations for normal saline (0.9% NaCl) as the initial crystalloid, and explain why.
iv. What are the pros and cons of using 5% dextrose in water as a resuscitation crystalloid?



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Answers: 9, 10

9 i. When water is lost from the interstitium, the interstitial COP becomes elevated and the interstitial HP is reduced. Water and electrolytes move from the intravascular space into the interstitium. This results in a rise in PCV/TS.
ii. Rate of fluid loss (fast loss, rapid replacement; slow loss, slower replacement); ongoing fluid loss requires faster fluid replacement; electrolyte alterations, heart function, pending procedures, renal function, capillary integrity, internal hemorrhage, and lung or brain edema may warrant moderate rates.
iii. 0.08 × 15 kg = 1.2 liters divided over 6 hours = 200 ml/hr for rehydration, plus maintenance. There are several recommendations for calculating maintenance fluids: (1) based on metabolic rate: (30 × kg body weight) + 70 = (30 × 15) + 70 divided by 24 = 21.6 ml/hr; or (2) estimations of: 50 ml/kg/24 hours = 50 × 15 divided by 24 = 31.2 ml/hr. This patient would receive (when using crystalloids alone) 200 ml (rehydration) + 22–31 (maintenance) = 222–231 ml for the first 6 hours. Administered enteral fluids and CRI of drugs and/or colloids would reduce the hourly volume of crystalloid proportionately. The patient should be reassessed hourly and the rate and volume adjusted as needed.

10 i. A crystalloid is a water-based solution containing small molecular weight molecules, freely permeable across the normal capillary membrane. They are used primarily to rehydrate interstitial and intracellular spaces (e.g. LRS, Ringer's, Normosol-R®, Plasmalyte-A®, normal saline, hypertonic saline, 5% dextrose in water).
ii. (a) 'Buffered' means the pH is close to the normal pH of the blood (7.4) due to the metabolism of an added buffer such as lactate, gluconate, or acetate (i.e. LRS, Normosol-R, Plasmalyte-A).
(b) 'Balanced' fluids contain electrolytes in addition to Na and Cl (e.g. K, Mg, and Ca).
(c) 'Isotonic' fluid administration IV does not result in an osmotic shift of fluid out of the RBCs. Sodium is the primary osmotic molecule and the concentration of sodium can be similar to (isotonic), higher (hypertonic), or lower (hypotonic) than the normal plasma. Examples: LRS, Ringer's, Normosol-R®, Plasmalyte-A®, normal saline.
(d) 'Replacement' fluid has an electrolyte composition similar to normal plasma. Examples: Normosol-R, Plasmylyte-A, LRS.
(e) Maintenance fluid is meant to replace water and electrolytes lost from the plasma during a normal metabolic state. Lower sodium and higher potassium concentrations than replacement fluids are common. Dextrose can be added to hypotonic (low sodium) fluids to prevent fluid shifts. Examples: Normosol-M®, Procalamine®, FreAmine®.
iii. *Hypernatremia* – higher sodium concentration in 0.9% NaCl reduces rapid fluid shifts into or out of the cells during treatment.
Hypercalcemia – promotes calciuresis.
Hypochloremic metabolic alkalosis – higher chloride concentration needed to correct alkalosis.
Metabolic alkalosis – 0.9% NaCl has an acidic pH.
iv. There are no pros. 5% dextrose in water should not be used as a resuscitation crystalloid. Once the glucose is utilized, free water remains, allowing significant cell swelling and, potentially, organ dysfunction or failure.

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11 i. Define colloid and give some examples of colloid fluids.
ii. What determines the osmotic effect and half-life of the colloid solution?
iii. What do the terms natural and synthetic mean when referring to colloids?
iv. What do each of these numbers mean – 6% HES 650/0.7 – when describing HES?
v. What are the differences between (a) hetastarch, (b) tetrastarch, and (c) pentastarch? Give examples of each type.

12 i. How do HES colloids affect coagulation?
ii. What are the pros and cons of using an HES colloid in the following cases:

- A 6-year-old intact male Labrador Retriever presents with severe anemia and compensatory shock 24 hours after ingesting an anticoagulant rodenticide. PCV = 0.15 l/l (15%); TS = 45 g/l (4.5 g/dl).
- An 11-year-old cat presents with vomiting and abdominal pain after eating bacon grease. The cat is in early decompensatory shock with a diagnosis of pancreatitis. PCV = 0.5 l/l (50%); TS = 54 g/l (5.4 g/dl).
- A 14-year-old mixed-breed dog presents for surgical removal of a mass in a single liver lobe. The perfusion is adequate prior to induction. PCV = 0.38 l/l (38%); TS = 79 g/l (7.9 g/dl).

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Answers: 11, 12

11 i. A colloid is a crystalloid-based solution containing large molecular weight particles too large to pass freely across the normal capillary membrane. They expand the intravascular space. Examples include: albumin solutions, HES, hemoglobin-based oxygen carrier solutions.
ii. The difference in macromolecular structure and weight dictates the colloid osmotic effect, method of excretion, and half-life of the colloid solution. The more colloid molecules per unit volume and higher degree of substitution, the greater the plasma volume expansion. The concentration of the solution (6% vs. 10%) also affects colloidal osmotic effect per unit volume.
iii. Natural refers to solutions that contain naturally produced proteins such as albumin (whole blood, plasma, canine albumin) or hemoglobin (polymerized bovine hemoglobin [Oxyglobin®]). Synthetic refers to solutions that contain synthetically derived colloid particles (e.g. hydroxyethyl starches).
iv. 6% is the concentration (6 g/100 ml); 650 is the weight-averaged molecular weight (M_w) (sum of the number of molecules at each weight divided by the total of all molecules) and is expressed in kilodaltons. 0.7 is the degree of substitution and gives the name 'heta' to the solution.
v. (a) Hetastarch: 0.7 degree substitution (in saline: Hespan® M_w of 450 kD; in LRS: Hextend® M_w of 670 kD). (b) Tetrastarch (Volvulen®, Vetstarch® M_w of 130 kD): 0.4 degree substitution; has a lower molecular weight than hetastarch but an increased half-life. (c) Pentastarch (Pentaspan® M_w of 264 kD): 0.5 degree substitution; has a shorter half-life.

12 i. They can cause a dilutional effect and affect von Willebrand's factor, factor VIII, and platelet function, as well as reduce fibrin polymerization. There is no clinical evidence of bleeding reported in animals receiving 6% hetastarch in saline (Hespan®) or 6% tetrastarch (Voluven®) at doses <20 ml/kg/day. Tetrastarch has no bleeding at doses <50 ml/kg/day.
ii.

- HES can be used for initial volume replacement, but plasma and pRBCs whole blood transfusions will be required to supplement coagulation proteins and restore clotting times, and provide RBCs.
- Pancreatitis is an SIRS disease characterized by vasodilation, increased capillary permeability, and hypercoagulable state. A differential charge between administered HES molecules and the capillary pore may occur, blocking the passage of HES molecules into the interstitium. HES may also downregulate and decrease expression of endothelial surface adhesion molecules, reported to decrease cytokine release, inflammation, endothelial injury, and leukocyte migration into the interstitium. HES has been shown to reverse changes in microvascular permeability caused by oxygen free radicals during reperfusion injury.
- HES products can be safely used in the surgical patient, remembering that blood flow and circulatory pressures may be enhanced, facilitating tissue oxygenation, compared with when crystalloids are used alone. Adequate hemostasis is always required, and blood products may be given to supplement coagulation proteins.

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13 i. Select the physical findings that are typically seen in the cat that has poor perfusion: hypothermia; hyperthermia; tachycardia; bradycardia; normal HR; hypotension; hypertension; normal BP; absent pulses; bounding pulses.
ii. What additional step or procedure performed during fluid resuscitation can be essential to the successful resuscitation of a cat with the typical physical findings of severe hypovolemic shock? How is this provided?
iii. When selecting fluid administration techniques (Step 4 of the Fluid Resuscitation Plan), cats derive the most benefit by using small volume resuscitation techniques to reach both 'low end' and 'high end' end-points. Why is this the better technique compared with large volume resuscitation for cats?

14 Use the 4-Step Fluid Resuscitation Plan for the cases below:
i. A 5-year-old Great Dane presented for non-productive vomiting for 3 hours because of GDV. T = 38.4°C (101.2°F); HR = 180 bpm; RR = 40 bpm; CRT = >3 sec; MM pale and dry; femoral pulses very weak; elevated skin tents over scapula; dry corneas.
ii. A 2-year-old Yorkshire Terrier presented within 30 minutes of big-dog-little-dog shaking and multiple bite wounds. T = 37.2°C (99°F); HR = 187 bpm; RR = 26 bpm; CRT = >3 sec; MM white and dry; no palpable femoral pulses; skin turgor is normal.
iii. An 11-year-old cat presented with a string FB. T = 34.4°C (94°F); HR = 140 bpm; RR = 27 bpm; no femoral pulses; CRT = >3 sec; MM gray and dry.
iv. A 12-year-old Toy Poodle presents with thrombocytopenia, grade 3/6 heart murmur. T = 39.1°C (102.4°F); HR = 110 bpm; CRT = 1–2 sec; femoral pulses strong; MM pink and dry with petechiae; skin tents mildly over scapula; dry corneas.

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Answers: 13, 14



13 i. Hypothermia, bradycardia or normal HR, and hypotension.
ii. Severe hypothermia can alter the vascular response to catecholamines and initiate a vasovagal-type response during shock in cats. IV fluids are administered in the cat until the femoral pulse is palpable and the Doppler SABP is at least 60 mmHg. Then the cat is aggressively warmed by a warming pad (water circulating) and warm circulating air, with the goal to get the temperature 36.7°C (≥98°F) within 30 minutes (**13**). Additional fluids are then given to reach the goals of resuscitation if needed. IV fluids are given prior to external warming to offset potential hypotension from peripheral vasodilation induced by surface heat.
iii. The cat has a normal or slow HR in shock as well as hypothermia. Administration of large volumes of fluid at a faster infusion rate (large volume techniques) can quickly lead to fluid intolerance in the cat and is often manifested by pulmonary edema. To offset this problem, IV fluid resuscitation is best accomplished by infusing smaller volumes of crystalloids and colloids and repeating these fluids as needed, together with the warming described above, to reach the desired end-points.

14 i. (1) Perfusion and hydration problems; (2) HES and balanced isotonic crystalloid (could use crystalloid alone); (3) high end target goals since likely SIRS disease; (4) large volume administration technique.
ii. (1) Perfusion and hydration problems; (2) HES and balanced isotonic crystalloids (could use crystalloids alone but resultant drop in IV COP can lead to interstitial edema); (3) low end target goals since trauma and concern for internal hemorrhage; (4) small volume titration of fluids.
iii. (1) Perfusion and hydration problems; (2) HES and crystalloids (could use crystalloids alone but anticipate tissue edema); (3) high end targeted goals because likely SIRS and sepsis; (4) small volume administration techniques because a cat and likely SIRS.
iv. (1) Hydration primarily; (2) crystalloids since interstitial problem; (3) low end target goals because of heart disease and coagulopathy; (4) small volume titration because of heart disease and low end target goal. Dehydration is primary problem at this time.

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15 You have provided analgesics and fluid resuscitation for hypovolemic shock for a dog with pyometra. Isotonic balanced crystalloids and HES were infused using large volume resuscitation techniques to high end end-points. Post-infusion parameters are: CVP = 10 cmH_2O; HR = 150 bpm; CRT = 2 sec; MM pale pink; weak femoral pulses; Doppler SABP = 78 mmHg; blood lactate = 3.5 mmol/l (31.5 mg/dl) (5.0 mmol/l [45 mg/dl] before fluids).

i. List at least five parameters or conditions that can contribute to non-responsive shock.

ii. Arterial blood gas, glucose, electrolyte panel, and hematocrit are normal. What step(s) are taken next to improve perfusion?

iii. Which of the following drugs might be used to treat non-responsive shock? How do they work? Dobutamine, dopamine, norepinephrine, Oxyglobin®, esmolol, diltiazem.



16 A 2-year-old male neutered cat presents for difficulty breathing. Appetite and weight have been declining over the past 2 weeks. The cat is showing a marked increase in respiratory effort.

i. What physical examination findings help localize a respiratory problem to the pleural space in the cat?

ii. You suspect the cat has fluid in the pleural space. Describe how you would treat this pet.

iii. You perform a thoracocentesis and collect 120 ml of fluid (**16**). What are your differential diagnoses, and how would you make the diagnosis?

iv. What is a mesothelial cell?

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Answers: 15, 16

15 i. Inadequate volume administered; pain; ongoing fluid loss; third-body fluid spacing; hypoglycemia; electrolyte disorders; acid–base disorders; cardiac arrhythmias; myocardial depression or failure; organ ischemia; anemia; brainstem pathology; excessive vasodilation or vasoconstriction; hypoxemia; hypercarbia; cardiac tamponade; decreased venous return.
ii. The CVP of 10 cmH_2O implies adequate central volume (unless right heart failure or pericardial effusion). A fluid challenge with 5–10 ml/kg of HES can be done to detect the effect on CVP and SABP with additional fluids. Inadequate response to fluid challenge is indication for pharmacologic management of BP.
iii. Dobutamine is a direct stimulant of beta1 receptors of the sympathetic nervous system and would be indicated for depressed myocardial contractility. Dopamine is an inotropic and vasopressor catecholamine and is often a first-line agent for pharmacologic BP support. Norepinephrine increases BP by increasing vascular tone through alpha adrenergic receptor activation. Oxyglobin® is polymerized bovine hemoglobin that acts as a colloid, carries oxygen, and has mild vasopressor activity. Esmolol is a selective beta1 receptor blocker that is only indicated if a severe tachycardia is responsible for the poor cardiac output. Diltiazem injectable is a calcium channel blocker only indicated if a severe tachycardia is responsible for the poor cardiac output.

16 i. The chest and abdomen moving in opposition to each other (asynchronous breathing or abdominal component breathing) is characteristic of pleural space disease. Upper airway noise is not present unless there is concurrent airway obstruction. Dull or muffled heart and lung sounds may be present on thoracic auscultation; however, normal lung sounds can often be heard throughout the chest in a cat with pleural air or fluid. Murmur/gallop/arrhythmia and mild hypothermia may be present with pleural fluid from CHF. Fever may be present with infectious or inflammatory pulmonary cavity disease.
ii. Mask or hood oxygen; a mild sedative (e.g. butorphanol, 0.2–0.4 mg/kg IV or IM) to alleviate distress; the chest wall hair is clipped and aseptically prepared for a bilateral thoracocentesis (tap dorsal region if suspect air, ventral if suspect fluid). Ultrasound-guided centesis may be needed to evacuate fluid pockets when numerous adhesions have formed. Delay diagnostic imaging until breathing has stabilized with oxygen and thoracocentesis.
iii. Pyothorax, chylothorax, neoplastic effusion most likely. Hydrothorax (from CHF) and hemothorax are less likely due to color of the fluid. Cytologic examination should be performed (neutrophils +/- macrophages and bacterial organisms are consistent with pyothorax; high numbers of small lymphocytes may be consistent with chylothorax; cells with characteristics of malignancy should be interpreted with caution). Paired serum and thoracic fluid triglyceride levels confirm chylothorax; cytology/Gram stain and a bacterial culture would confirm pyothorax.
iv. Mesothelial cells line the pleural and abdominal cavities and are present in most animals with effusions in these cavities. They have many characteristics of malignancy but are not malignant cells. They are large cells, may be multinucleate and/or have multiple nucleoli, have a high nuclear:cytoplasmic ratio, and even phagocytic vacuoles when reactive.

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17a

17 A 20-kg dog hospitalized in the ICU vomits and suffers a vasovagal-induced respiratory arrest. The dog is rapidly intubated and ventilated using a bag valve hand ventilator (Ambu bag) (**17a**).
i. What FiO_2 will be delivered by Ambu bag hand ventilation on room air?
ii. How could a small (5 kg) cat and a large (30 kg) dog each be safely ventilated by Ambu bag?
iii. How is the Ambu bag designed to prevent barotrauma from inspiratory pressures generated by hand ventilation?
iv. The dog has aspiration pneumonia and now has a SpO_2 of 93% on the maximum FiO_2. What can be done to improve this dog's oxygenation during hand ventilation?

18 i. Identify the following in the ECG below (**18a**): P; P-R interval; Q, R, S, T, Q-T interval; R-R interval.
ii. List at least four important parameters to identify when assessing the ECG and making the ECG diagnosis.
iii. List at least eight clinically important arrhythmias in the critical dog or cat.
iv. Identify the following on the ECG below (**18b**): normal beat; ventricular beat; fusion beat; run of ventricular tachycardia.


18a


18b

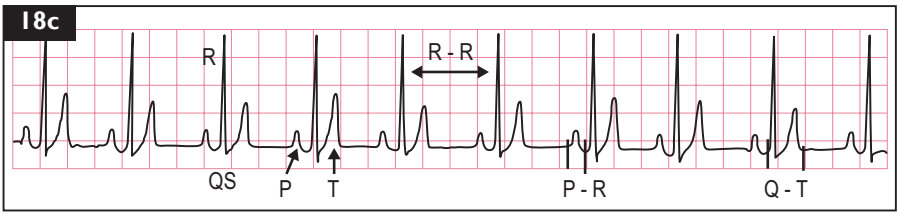
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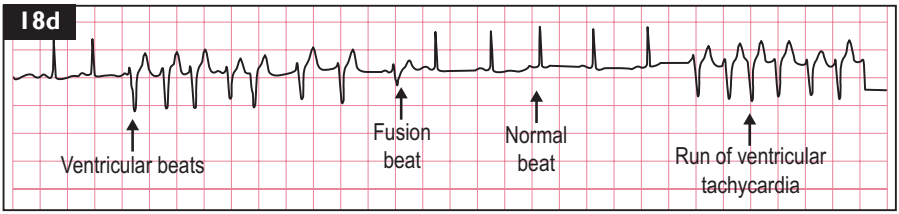
Answers: 17, 18



17 i. Without oxygen attached to the bag, the FiO_2 is 0.21 (room air). High-flow oxygen can be attached to the Ambu bag, increasing the FiO_2 to 1.0 (depending on oxygen flow rate and ventilation rate).
ii. Several sizes (infant, pediatric, adult) of Ambu bags should be available and the bag size selected to correspond with the size of the patient (infant – cat; adult – large dog).
iii. Most bags have a pressure relief (pop-up) valve to prevent overinflation of the lungs. A bypass clip is often incorporated in the event that higher pressure is needed for oxygenation. In addition, an inspiratory pressure meter is available to attach to the Ambu bag in order to monitor inspiratory pressures.
iv. Options for this dog include increasing the rate of ventilation, ensuring FiO_2 is 1.0, increasing peak inspiratory pressure if able to monitor, and PEEP. A PEEP valve (**17b**) can be attached, allowing the clinician to deliver 5–20 cmH_2O of PEEP.

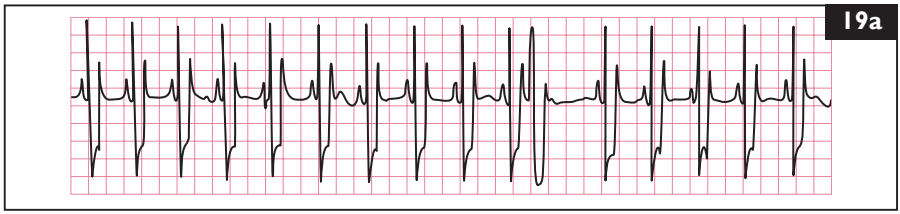
18 i. See **18c**.
ii. Parameters to assess on the ECG include: HR – bradycardia vs. tachycardia vs. normal; identify the dominant heart rhythm; origin of beats – supraventricular vs. ventricular (is there a P wave for every QRS and is there a QRS for every P wave?); measure the height and width of waveforms – wide or narrow; QRS complexes regular, irregular, irregularly irregular; evaluate for pauses or premature complexes.
iii. Sinus tachycardia; sinus arrhythmia; sinus bradycardia; atrioventricular block (1st, 2nd, and 3rd degree); ventricular premature complexes; supraventricular premature complex; ventricular tachycardia; accelerated idioventricular rhythm; supraventricular tachycardia; sick sinus syndrome; atrial fibrillation.
iv. See **18d**.

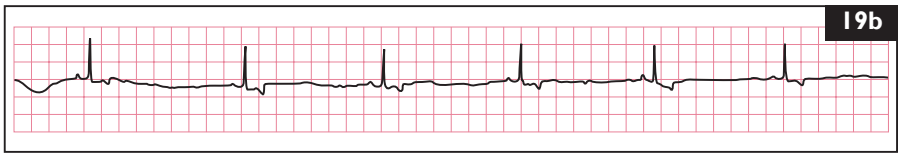




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19 Determine the following from the three lead II ECGs shown (**19a,** 25 mm/sec; 16 mm/mV; (**19b**, 25 mm/sec; 1 mV/cm; **19c**, 25 mm/sec; 1 mV/cm): HR (tachycardia, bradycardia, normal); R-R interval (regular, irregular, irregularly irregular); are there pauses or premature complexes; origin of the beat: is there a P wave for every QRS; is there a QRS for every P wave; are the QRS complexes: normal, wide, or bizarre; ECG diagnosis.







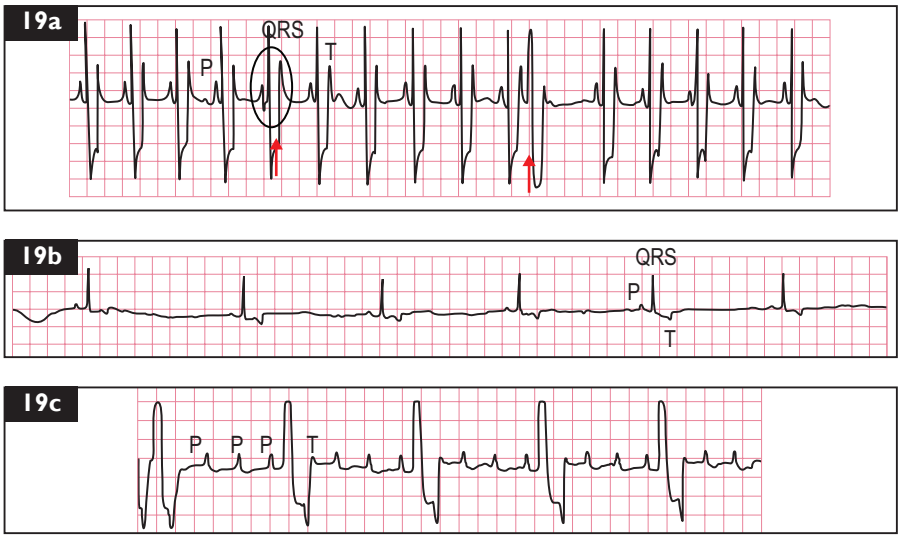
20 i. Define cardiac output and show the formula for calculation.
ii. Cardiogenic shock occurs when cardiac factors are insufficient to provide adequate perfusion to tissues. List the four factors that must be considered and treated when addressing insufficient cardiac output.
iii. Match the appropriate function with the appropriate receptor.

β_1	bronchoconstriction
β_2	vasoconstriction of arteries and veins
α_1	vasoconstriction of coronary arteries
α_2	dilates coronary vessels
	dilates arteries to skeletal muscle
	increases cardiac contractility
	increases heart automaticity
	increases HR
	bronchiole dilation

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Answers: 19, 20

19 19a: HR = 120 bpm; R-R interval: mostly regular; there is a premature complex (noted above); there is not a P wave for every QRS – see premature complex; there is a QRS for every beat; QRS complexes are normal width; S-T segment depression noted – suggestive of hypoxia or ischemia. ECG diagnosis: sinus rhythm with premature ventricular complex and S-T segment depression.
19b: HR = 40 bpm; R-R interval: regular; there are no premature complexes or pauses; there is a P wave for every QRS; there is a QRS for every beat; QRS complexes are normal width. ECG diagnosis: sinus bradycardia.
19c: HR = 60 bpm; R-R interval: regular; there are no premature complexes or pauses; there is a P wave for every QRS – this is coincidental; there is NOT a QRS for every P; QRS complexes are wide and bizarre. ECG diagnosis: 3rd-degree heart block.



20 i. Cardiac output is the amount of blood pumped from the heart during 1 minute. The formula for calculation is: stroke volume × heart rate = cardiac output
ii. Preload (the blood entering into the right and left ventricle, usually associated with vascular volume and venous tone); afterload (the end load against which the heart contracts to eject blood; typically the aortic and pulmonary pressures); HR; contractility of myocardial muscle.
iii. β_1: Increases cardiac contractility; increases heart automaticity; increases HR.
β_2: Primarily: dilates arteries to skeletal muscle; bronchiole dilation; dilates coronary vessels. Less than β_1: Increases heart automaticity; increases cardiac contractility; increases HR.
α_1: Vasoconstriction of arteries and veins; vasoconstriction of coronary arteries; bronchoconstriction.
α_2: Mediates pre- and post-synaptic transmission of nerves; vasoconstriction of arteries and veins; vasoconstriction of coronary arteries.

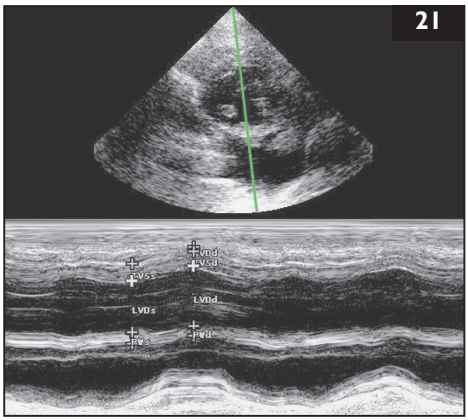
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21 i. With regard to the chart below, put the following cardiac drugs in the appropriate category(s) regarding their effect in treating heart failure: digoxin; diltiazem; metoprolol; dobutamine; dopamine; furosemide; oral benazepril; nitroprusside; nitroglycerine paste; spironolactone; pimobendan; hydrochlorothiazide; hydralazine; propranolol.

Preload	Afterload	Rate	Contractility

ii. You perform an echocardiogram on a dog in heart failure (**21**). You want to calculate the contractility and the ejection fraction. What are these and how are they calculated? (IVSs, intraventricular septum systole; IVSd, intraventricular septum diastole; LVDs, left ventricular diameter systole; LVDd, left ventricular diameter diastole; PWs, posterior or left ventricular wall systole; PWd, posterior wall diastole). The echocardiogram shows some pleural fluid.

iii. You have chosen to treat a dog (15 kg) diagnosed with dilated cardiomyopathy with dobutamine. The dosage you would like to administer is 5 µg/kg/min. Calculate the amount of drug (mg) to put in a 250 ml bag of 5% dextrose in water (D5W) to infuse at 10 ml/hr.



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Answer: 21

21 i.

Preload	Afterload	Rate	Contractility
Furosemide Nitroglycerine paste Spironolactone Hydrochlorothiazide Nitroprusside	Benazepril Nitroprusside Hydralazine Pimobendan Dopamine (low dose) Propranolol Metoprolol	Digoxin Diltiazem Pimobenden Dopamine Propranolol	Digoxin Diltiazem (negative inotrope) Dobutamine Dopamine (high dose) Pimobendan Metoprolol Propranolol (negative inotrope)

ii. The myocardial shortening fraction represents the myocardial contractility. It is determined on echocardiogram by measuring the left ventricular chamber width at the end of diastole and the end of systole in M mode or in dynamic cross-section. The calculation is as follows:

fractional shortening (%) = (end diastolic diameter – end systolic diameter) ÷ end diastolic diameter x 100

The ejection fraction represents the volume of blood that is ejected from the ventricle with a contraction. It is also typically measured from the left ventricle and is calculated as follows:

ejection fraction (%) = (end diastolic volume – end systolic volume) ÷ end diastolic volume x 100

iii.
5 μg/kg/min × 15 kg × 1,440 min (24 hours) = 108,000 μg/24 hours = 108 mg/24 hours.
10 ml is discarded from 250 ml bag leaving 240 ml.
Add 108 mg of dobutamine into the now 240 ml bag of D5W and drip at 10 ml/hr.

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22 Assessing venous blood gas provides information regarding the acid–base balance of the critical patient. An arterial blood gas allows evaluation of the efforts of ventilation ($PaCO_2$) and oxygenation (PaO_2). There are 5 steps to use when interpreting the results from blood gas analysis (**22**).

i. List at least four physiologic effects of acidosis.

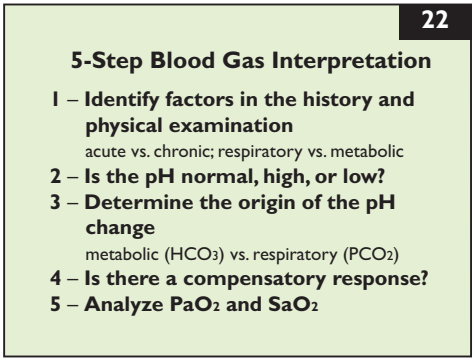
ii. List at least four physiologic effects of alkalosis.

iii. Which component of the blood gas is responsible for reflecting respiratory acidosis/alkalosis? As this value increases, do H+ ions increase or decrease? What action of the body affects this component?

iv. Which component of the blood gas is responsible for reflecting metabolic acidosis/alkalosis? As this value increases, do H+ ions increase or decrease? What action of the body affects this component?

v. Administration of sodium bicarbonate may be required in severe metabolic acidosis. What are the pros and cons of sodium bicarbonate?

vi. What therapy should be initiated in severe respiratory acidosis and in severe respiratory alkalosis?



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Answer: 22

22 i. Hyperventilation, shift of oxyhemoglobin curve to right, decreased 2,3 DPG levels in RBCs, sympathetic overactivity, resistance to action of catecholamines, peripheral arterial vasodilation, peripheral venoconstriction, pulmonary vasoconstriction, depressed myocardial contractility, cerebral vasodilation (high $PaCO_2$), shift of K+ out of cells causing hyperkalemia, increased extracellular phosphate concentration.
ii. Shift of oxyhemoglobin dissociation curve to left, inhibition of respiratory drive, cerebral vasoconstriction, increased neuromuscular excitability, hypokalemia.
iii. $PaCO_2$. A drop or rise in $PaCO_2$ results in a drop or rise of H+ ion concentration respectively. PCO_2 is affected by alveolar ventilation.
iv. HCO_3. The HCO_3 is inversely related to the H+ ion concentration (e.g. drop in HCO_3 leads to increase in H+ and rise in HCO_3 results in drop in H+). HCO_3 is affected by retention or excretion by the kidneys.
v. Pros: rapid treatment of metabolic acidosis and its deleterious consequences. Cons: increased mortality reported; shift in ionized calcium and cellular potassium; paradoxical intracellular acidosis; hypernatremia; rebound alkalemia.
vi. Increase alveolar ventilation; rebreathe exhaled air (breathe into a bag).

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23 Answer the following questions regarding the 5-Step Blood Gas Interpretation. Normal blood gas values: pH = 7.35–7.45; PCO_2 = 35–45 mmHg; HCO_3 = 22–26 mEq/l; PO_2 = 80–100 mmHg; SaO_2 = 95–100%.

i. Identify factors in the history and physical examination that can provide an idea of what acid–base disorder might be present. List at least three.

ii. Is the pH normal, high, or low? Match the pH with the appropriate acid–base disorder:

pH >7.45	no acid–base disorder
pH <7.35	alkalemia
normal pH	acidemia
	mixed acid–base disorder

iii. Assess the components of the blood gas to determine the origin of the disorder (metabolic or respiratory). Identify which of the following parameters reflects a metabolic process and which a respiratory process: PO_2; PCO_2; base excess; HCO_3; Na+; glucose; anion gap.

iv. Is there a compensatory response? One abnormal value will be the initial change and the other will be the compensatory response. Complete the following chart and identify which component changes and in what direction:

Acid–base disorder	Initial chemical change	Compensatory responses
Respiratory acidosis		
Respiratory alkalosis		
Metabolic acidosis		
Metabolic alkalosis		

v. Analyze the PO_2 and the SaO_2. True or false: (a) PO_2 reflects alveolar oxygenation and PCO_2 alveolar ventilation; (b) low PO_2 and low SaO_2 indicate hypoxemia; (c) it is important to evaluate the significance of a normal or decreased PaO_2 in association with FiO_2; (d) PvO_2 and PaO_2 can be used interchangeably to assess for hypoxemia; (e) $PO_2 \div FiO_2$ can be used as a clinical index of oxygenation.

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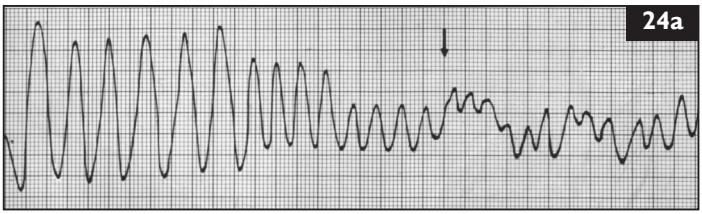
Answer: 23

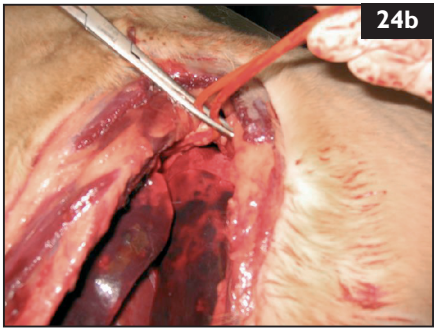
23 i. Onset and duration of clinical signs suggest acute vs. chronic; respiratory problems suggest respiratory causes (can sometimes be a compensatory mechanism); systemic illness, hypoperfusion, or infection suggests metabolic derangements.
ii. pH >7.5 = alkalemia; pH <7.35 = acidemia; normal pH = normal or mixed acid–base disorder.
iii. PCO_2 – respiratory acidosis or alkalosis; HCO_3 – metabolic acidosis or alkalosis; the base excess can be a reflection of the deviation of HCO_3 from normal.
iv.

Acid–base disorder	**Initial chemical change**	**Compensatory responses**
Respiratory acidosis	↑PCO_2	↑HCO_3 0.15 mEq/l (acute) and 0.35 mEq/l (chronic) for each 1 mmHg increase in PCO_2
Respiratory alkalosis	↓PCO_2	↓HCO_3 0.25 mEq/l (acute) and 0.55 mEq/l (chronic) for each 1 mmHg decrease in PCO_2
Metabolic acidosis	↓HCO_3	↓PCO_2 0.7 mmHg for each 1 mEq/l decrease in HCO_3
Metabolic alkalosis	↑HCO_3	↑PCO_2 0.7 mmHg for each 1 mEq/l increase in HCO_3

v. a, b, c, and e are true; d is false – venous blood gas will not accurately reflect the ability of the arterial blood to oxygenate at the pulmonary alveolar level.

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24 A 7-year-old male intact dog presented unconscious with agonal breathing after being hit by a car 20 minutes ago. No heart beat could be auscultated and no pulses were palpable. The owners gave permission to do anything possible to resuscitate the dog. Chest compressions were immediately instituted and the dog was rapidly intubated and ventilated with 100% oxygen. An IVC was placed. After 2 minutes a change in chest compression is performed. The ECG with a paper speed of 25 mm/sec is shown (**24a**).

i. What arrhythmia is shown? Name at least two other arrhythmias seen in cardiac arrest.

ii. When is external defibillation used, and how this is accomplished?

iii. Discuss the two theories/techniques for closed chest CPR.

iv. What is shown in **24b**? How does this improve outcome during CPR?

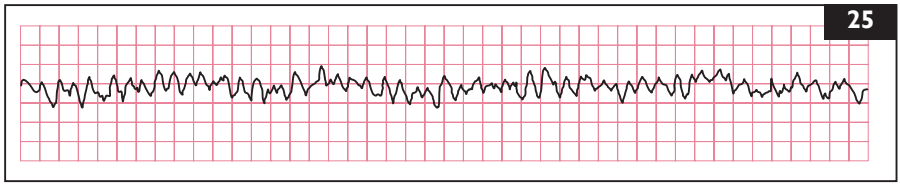
v. Discuss how you and your team members can be prepared and effective at administering CPR when it is necessary.

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Answer: 24

24 i. Ventricular tachycardia with R-on-T phenomenon progresses to course ventricular fibrillation. Other arresting rhythms include asystole, pulseless electrical activity (electromechanical dissociation), sinus bradycardia, and pulseless ventricular tachycardia.
ii. Defibrillation is used to convert ventricular fibrillation and, less commonly, pulseless ventricular tachycardia and supraventricular tachyarrhythmias. Initial energy setting is 3–5 J/kg (monophasic) and 2–4 J/kg (biphasic) defibrillation. Charge the paddles and cover with water-soluble gel (NOT alcohol), placing them firmly on either side of the chest. Vocalize 'CLEAR' and ensure that no person is touching the patient. Discharge defibrillator once and immediately resume compressions before rechecking the ECG. Energy setting can subsequently be increased 50%.
iii. The cardiac pump technique is used for small 'keel chested' animals with compressable thoracic cavities. One or two hands can be used to compress directly over the heart. The thoracic pump technique is used for larger 'barrel chested' animals, compressing the thorax approximately 30–50% at its widest part. Two hands are used with the dog in lateral or dorsal recumbency. Forward blood flow depends on elastic recoil resulting in negative intrathoracic pressure.
iv. A modified Rummel tourniquet has been placed on the descending aorta to minimize caudal blood flow and maximize blood flow to the brain and heart.
v. A 'ready area' with equipment, oxygen, and medications for CPR is inventoried regularly. Conduct 'drills' to keep CPR skill level high.

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25 A 3-year-old male neutered Labrador Retriever presents for sudden collapse at home. Shortly after being rushed into the treatment area he becomes unconscious and stops breathing, with no palpable femoral pulse. You begin chest compressions while an assistant performs orotracheal intubation and initiates assisted ventilation using an Ambu bag and 100% oxygen. You instruct your staff to place an IV cephalic catheter, attach ECG leads, and commence $ETCO_2$ monitoring. The ECG shown (**25**) is obtained 2 minutes after initiating compressions.

i. What is your ECG diagnosis, and what do you do for your patient?

ii. During closed chest CPR in this dog, are the results primarily a result of the intrathoracic pump mechanism or from direct cardiac massage? Give the mechanism for blood flow using the selected technique.

iii. Regarding this dogs CPR efforts, which statement best describes what is done once the ECG has been defined after 2 minutes of compression: (1) electrical defibrillation is immediately performed; (2) cardiac/thoracic compressions are continued for another 2 minutes and the ECG is re-evaluated; (3) epinephrine is immediately administered; (4) lidocaine is administered?

iv. Give indications/contraindications for the use of the following drugs during CPR: low-dose epinephrine; vasopressin; sodium bicarbonate; calcium gluconate; glucose; lidocaine.

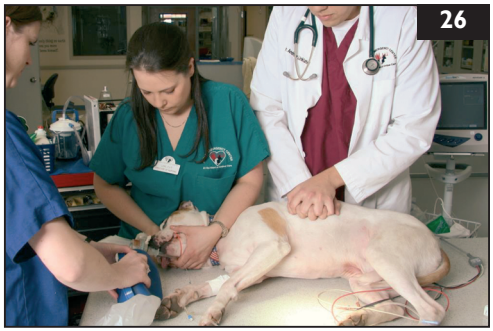
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Answer: 25

25 i. Ventricular fibrillation; electrical defibrillation.
ii. Thoracic pump mechanism. The thoracic compressions increase intrathoracic pressure, compressing the aorta and lungs and moving blood through and out of the left side of the heart. Upon release of the compression, elastic recoil of the chest allows blood to be drawn into the vena cavae, through the right side of the heart and into the lungs. Blood flow occurs in a unidirectional manner because of valves in the venous system.
iii. (1), as this is the correct treatment for ventricular fibrillation. Compressions are resumed as the defibrillator is being charged, and resumed immediately after defibrillation for a 2-minute cycle. Epinephrine and lidocaine are not indicated, and lidocaine could make the heart more refractory to defibrillation.
iv.

Drug	Indications	Contraindications
Low-dose epinephrine	Pulseless electrical activity or asystole	Ventricular fibrillation
Vasopressin	Pulseless electrical activity or asystole	Ventricular fibrillation
Sodium bicarbonate	Prolonged arrest (>10–15 minutes) has occurred or a disease process causing severe acidosis is suspected	Alkalosis, respiratory acidosis
Atropine	Bradyarrhythmia is present or high vagal tone suspected	Tachyarrhythmia
Glucose	Hypoglycemia is suspected as part of the arrest	None
Lidocaine	Ventricular tachyarrhythmia, or when repeated attempts at electrical defibrillation for ventricular fibrillation fail	Pulseless electrical activity or asystole

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26 A 5-year-old neutered male Pitbull presents after being hit by a car. The dog walked but on triage to the treatment area had a sudden cardiopulmonary arrest. The owners elect for CPR to be perfomed on the dog; you intubate, ventilate, and start chest compressions (**26**).

i. Which of the following monitoring tool(s) is useful during CPR and why: (a) CVP; (b) pulse oximetry (SpO_2); (c) ECG; (d) indirect Doppler BP; (e) direct arterial BP?

ii. Name four indications for open-chest cardiac massage.

iii. What is the approach if open-chest CPR is initiated during abdominal surgery?

iv. What procedure will maximize forward blood flow during open-chest cardiac massage?

v. $ETCO_2$ is a valuable parameter for assessing the quality of cardiac/thoracic compressions. What values are associated with: (a) ineffective CPR efforts; (b) effective CPR efforts; (c) return of spontaneous circulation?

27 A busy shift in the small animal emergency room has hospitalized the following patients: chest trauma dog with a chest tube; hypernatremia in a comatose cat with diabetic ketoacidosis; hypoglycemic puppy with parvovirus diarrhea; postoperative GDV Great Dane; and urethral obstruction male cat with hyperkalemia post obstruction. The goal is to **anticipate** complications or problems before they occur rather than **react** to them after they happen.

i. List at least three issues that all of these patients have in common.

ii. List at least 10 parameters that should be put onto a check-off list to ensure that the monitoring and treatment of these critical patients are thorough.

iii. Often overnight staffing numbers are reduced since incoming patient numbers are lower. What can be done when writing patient orders to assist the nursing staff in accomplishing timely treatments and making decisions regarding monitored parameters?

Anticipation NOT Reaction

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26 i. (a) Requires a central catheter, which cannot be rapidly placed during CPR. (b) Requires sufficient peripheral blood flow, which is unlikely during CPR. (c) ECG is essential for diagnosing the heart rhythm and directing drug therapy. (d) Indirect BP monitoring has limited use during CPR; a Doppler transducer can be placed on the cornea (with gel) to assess ocular blood flow. This may reflect perfusion to the head associated with cardiac massage, but must be interpreted with movement of the body. (e) Direct BP measurement would assess peripheral limb perfusion, but arterial catheter placement is unlikely during CPR.
ii. Dog weighing >15 kg (33 lb); chest wall trauma disease, penetrating thoracic injuries, known or suspected pleural space (pneumothorax, hemothorax, hydrothorax) or pericardial disease (hemopericardium); ineffective external cardiac massage after 2–5 minutes; unwitnessed arrest, intraoperative arrest, hemoperitoneum.
iii. If cardiac arrest occurs during abdominal surgery, a radial incision can be made through the diaphragm starting in the midline, ventrally, and opening the pericardial sac to initiate direct cardiac compression.
iv. Cross clamping the descending aorta with a modified Rumel tourniquet.
v. (a) <8 mmHg; (b) 8–15 mmHg; (c) >20 mmHg.

27 i. They all have potentially life-threatening disease; their vital parameters may change quickly; excessive, insufficient or delayed therapy could be fatal; each patient may have SIRS; each deserves detailed written orders, treatments completed on time, careful monitoring, and appropriate nursing care.
ii. Scenarios as presented lead to the composition of the Rule of 20 (see below). These 20 critical parameters should be assessed at least 1–2 times daily in a critical patient. The order of importance is patient specific.

Rule of 20

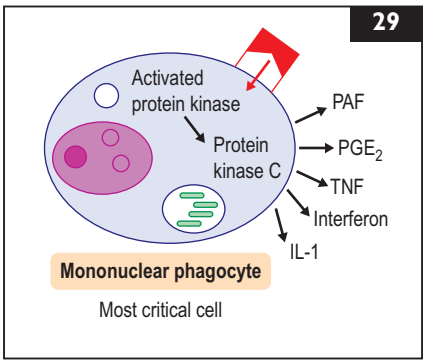
- ❑ Fluid balance
- ❑ Oxygenation/ventilation
- ❑ Blood pressure
- ❑ Heart rate, contractility, rhythm
- ❑ Glucose, mentation
- ❑ Body temperature/metabolism
- ❑ RBCs, hemoglobin
- ❑ Albumin, oncotic pull
- ❑ Electrolytes
- ❑ Acid–base, lactate
- ❑ GI motility, integrity
- ❑ Nutrition
- ❑ Renal function
- ❑ Coagulation
- ❑ WBCs, infection patrol
- ❑ Drug dosages
- ❑ Wound care, bandages
- ❑ Pain control
- ❑ Nursing care
- ❑ Tender loving care

iii. Doctors/nurses/technicians must discuss cases when changing shifts and prioritize cases and individual treatments; treatment and monitoring orders should be grouped together at one time (e.g. BP q4h, CVP q2h, PCV/TS q8h, IV cefazolin q8h). Nurses should be told when to notify a veterinarian of a problem or intervention.

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28 i. Define SIRS, sepsis, severe sepsis, septic shock, and MODS.
ii. Discuss the role of cytokines with relation to SIRS.
iii. List at least two physical indicators and at least two laboratory indicators of SIRS.

29 SIRS is initiated when the tissues of the body recognize an antigen or substance as abnormal. A positive feedback cycle of pro-inflammatory and anti-inflammatory mediators ensues (**29**). Three of the most recognized pro-inflammatory cytokines are tumor necrosis factor (TNF), interleukin-1 (IL-1), and interleukin-6 (IL-6).
i. What is a cytokine?
ii. Match the following actions with the cytokine(s) TNF, IL-1, and IL-6: (a) triggers the production and release of other cytokines; (b) T-cell activation; (c) pyrogen activity; (d) procoagulant activity; (e) eicosanoid production; (f) B-cell activation; (g) PMN chemotaxis; (h) production of acute phase proteins.
iii. List at least three consequences of SIRS at the arteriole and capillary levels.
iv. Endothelial cell dysfunction plays a key role in the pathophysiology of SIRS. List at least two contributing mechanisms.
v. As cell membranes are damaged, the eicosanoid cascade is stimulated. List at least two consequences of production of platelet activating factor.
vi. The hallmarks of SIRS pathophysiology are peripheral vasodilation, increased vascular permeability, and negative inotropic activity of the heart. This results in three types of shock occurring simultaneously. Name the three types.



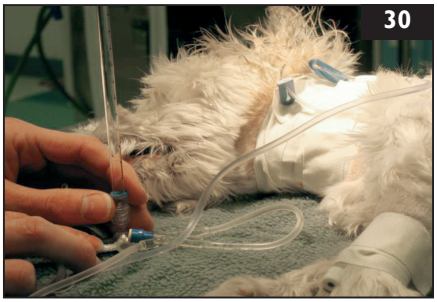
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Answers: 28, 29

28 i. SIRS: whole body hyperinflammatory response of the immune system to a pathogen or substance in the body. Sepsis: SIRS caused by documented or suspected infection. Severe sepsis: sepsis with sepsis-induced organ dysfunction (e.g. hypotension due to sepsis; lactate >reference limits; urine output <0.5 ml/kg/hr, >2 hours with adequate fluid support; creatinine >176.8 µmol/l [2.0 mg/dl]; acute lung injury – PaO_2/FiO_2 <250 without lung pathology or <200 with lung pathology; bilirubin >34.2 mmol/l [2 mg/dl]; platelet count <100 × 10^9/l; coagulopathy, INR >1.5). Septic shock: sepsis associated with arterial hypotension. MODS: parallel or sequential dysfunction of more then two organs.
ii. The immune system produces cytokines, signaling immune cells to the site of infection or inflammation. A positive feedback loop can occur between cytokines and immune cells with highly elevated levels of cytokines, oxygen free radicals produced, and coagulation factors consumed. Both pro-inflammatory (e.g. IL-1, TNF, IL-6) and anti-inflammatory (e.g. IL-10, IL-1 receptor antagonist) cytokines are elevated in the serum. This leads to systemic inflammation and SIRS.
iii. Indicators chosen for a diagnosis of SIRS include two or more of the following (with a clinical problem related to SIRS): fever or hypothermia; tachycardia; rapid RR; high WBC or low WBC count; >10% band response; PCO_2 <32 mmHg. Since these criteria are non-specific, other common concurrent findings increase the likelihood and include hypoalbuminemia, declining platelet count, abnormal coagulation profile, MODS.

29 i. A soluble non-antibody regulatory protein(s) secreted by activated immunocytes mediating both local and systemic responses resulting from infection or exposure to abnormal substances.
ii. (a) TNF, IL-1, Il-6; (b) TNF, Il-1, IL-6; (c) TNF; (d) TNF, IL-1; (e) TNF, IL-1; (f) IL-1, IL-6; (g) TNF, IL-1, IL-6; (h) TNF, IL-1, IL-6.
iii. Vasodilation; increased permeability; leukocyte adherence and adhesion; endothelial apoptosis; activation of platelets; activation of coagulation proteins; production of eicosinoids; maldistribution of blood flow; microthrombosis; further production of inflammatory mediators; protease activation; pulmonary vascular hypertension.
iv. Coagulation/anti-coagulation; production/inhibition of vasoactive substances (vasomotor tone); cellular adhesion molecule expression; altered capillary permeability.
v. Negative inotrope, vasoconstriction in lung, heart; peripheral vasodilation; increased vascular permeability; activate WBCs and platelets; activate proteases.
vi. Hypovolemic, distributive, and cardiogenic.

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30 Fluid balance is the first concern of the Rule of 20. It involves providing the most appropriate fluid(s) in the right amount and at the right time.
i. With regard to fluid balance, what information can the following monitored parameters provide: PCV/TS, body weight, CVP, urine output, 'ins and outs'.
ii. Describe how to measure CVP using a water manometer (**30**).
iii. List conditions that can cause changes in the CVP value unrelated to intravascular volume.

31 i. A 25 kg, mixed-breed dog has vomiting from pancreatitis. Provide an assessment of the fluid balance in the patient over the 8-hour time period from the monitored parameters given below:

Time	0	30 min	1 hr	2 hr	4 hr	6 hr	8 hr
HR (bpm)	190	160	145	130	124	128	135
Systolic BP (mmHg)	60	80	90	100	98	110	100
CVP (cmH_2O)		2.0	4.0	6.0	4.6	6.4	6.2
Urine output (ml/kg)		0		0.8	0.6	1.0	0.95
Body weight (kg)	25			26		26.6	26.4
PCV/TS (%/g/dl [l/l/g/l])	45/5.2 0.45/52			26/3.2 0.26/32			28/4.0 0.28/40

ii. Assessing BP is an important component of the Rule of 20 for keeping the critical animal alive in the ICU. Fill in the blanks:
(a) Oliguria occurs when the mean arterial pressure is less than __ mmHg.
(b) Indirect BP measurement devices use either the _____ or the _____ technique.
(c) In the cat: femoral systolic pressure = Doppler systolic pressure + ___ mmHg.
(d) The systolic BP goal in head injury is __ mmHg.
(e) The ____ ____ (physical parameter) is always assessed with the BP.
(f) (Systolic + [2 × diastolic]) ÷ 3 = _____.
iii. When a patient is suspected of having an SIRS disease, what resuscitation end-points (high end or low end of normal) are selected, and why? What conditions of the animal might warrant making a different selection? What resuscitation fluid administration technique is chosen (large volume or small volume)?

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30 i.

- PCV/TS: reflects the proportion of RBCs (change in PCV), plasma proteins (change in TS), and intravascular water (both move in same direction).
- Body weight: change over hours, typically because of loss or gain of fluids.
- CVP: reflects the pressure within or on the vena cava; change over hours, typically a reflection of loss or gain in intravascular volume in the vessel being assessed.
- Urine output: >0.5 ml/kg implies MAP >60 mmHg and adequate hydration. Urine output less than or exceeding infused fluid volumes directs assessment of patient hydration status, ongoing fluid losses, rate/volume of fluids administered, and renal function.
- Ins and outs: amount of fluid going in (IV, SC, oral) should be close to the amount coming out (urine, vomitus, diarrhea, insensible loss) after perfusion and hydration have been achieved.

ii. Requires a central venous catheter with the tip near the right atrium within the thoracic cavity or within the medial femoral artery with the tip within the abdominal vena cava. IV extension tubing is attached to the central catheter and to a 3-way stop-cock. The stop-cock also supports a water manometer and IV crystalloid fluid infusion tubing. The manometer is filled with crystalloid to 15–20 cmH_2O. For CVP measurement, the stop-cock is turned off to the crystalloid bag and on to the manometer and patient. The patient is in right lateral recumbency and the 0-point of the manometer at the level of the right atrium. The fluid in the manometer is allowed to equilibrate with the fluid pressure from the central catheter.

iii. Right heart failure, cardiac tamponade, increase in pleural pressure (e.g. pneumothorax or mechanical ventilation), increase in intra-abdominal pressure.

31 i. Between time 0 and 2 hours fluid resuscitation and analgesic therapy were successful in lowering the HR, elevating BP, and increasing CVP. PCV and TS both declined proportionately, suggesting hemodilution by fluids. Between 2 and 4 hours, the rate of fluid input may have adjusted down, demonstrated by the drop in urine output and CVP. However, by 6 hours the fluids had likely been adjusted upward with a satisfactory HR, BP, CVP, urine output and weight gain. This remained stable between 6 and 8 hours, with a slight adjustment down in fluid infusion suggested by the slight increase in both PCV/TS and decrease in weight.

ii. (a) 60; (b) Doppler, Oscillometric; (c) 14; (d) 90; (e) HR; (f) MAP.

iii. High end of normal resuscitation end-points to bring high levels of oxygen to the tissues so that patients can produce high levels of energy if they are capable. Large volume technique is chosen for the dog. Low normal end-points are chosen if there is ongoing hemorrhage, brain or lung edema, or oliguric renal failure. Small volume resuscitation techniques are selected for low normal end-point goals and for all end-point goals in the cat.

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32 i. List at least three causes of hypertension and at least two medications used to treat hypertension.
ii. Hypotension is a hallmark of most forms of shock. Non-responsive shock occurs when aggressive fluid infusion fails to bring BP into an acceptable targeted range. List at least six causes of non-responsive shock.
iii. Explain your approach to non-responsive shock in an SIRS patient.
iv. A hypovolemic dog with severe hypotension is placed on high-dose norepinephrine to raise the BP to normal. Eight hours later, the dog becomes oliguric with AKI. What is the likely cause of the oliguria and kidney pathology?



33 This dog (**33**) has pancreatitis and experienced a hypotensive crisis 2 hours ago. Resuscitation was successful but required rapid infusion of 2,100 ml of LRS. The dog now has an elevated RR and facial and hindlimb edema. Laboratory database obtained post resuscitation: PCV = 0.3 l/l (30%); TS = 20 g/l (2.0 g/dl); glucose = 4.44 mmol/l (80 mg/dl); BUN = 8.9 mmol/l (25 mg/dl); Na+ = 128 mEq/l; Cl^- = 103 mEq/l; K+ = 3.0 mEq/l; lactate = 1.4 mmol/l (12.6 mg/dl).
i. What is the most likely cause of the peripheral edema in this dog (consider Starling's forces)?
ii. The Rule of 20 requires that oncotic pull and serum albumin are assessed with adjustments made as needed. What is the relationship between these two items?
iii. What is the size (daltons) of the albumin molecule, and why might that be significant to consider?
iv. What function(s) does albumin have in the body?
v. What complications might result from peripheral edema?
vi. Hyponatremia is now present in this dog. What is the likely cause, and what complication might occur?

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32 i. Causes: fluid overload; renal failure; hyperthyroidism; cardiomyopathy; hyperadrenocorticism; idiopathic; pheochromocytoma; CNS disease; medications. Medications include: beta-blockers; calcium channel blockers; ACEIs; diuretics; vasodilators.
ii. Third-body fluid spacing; hypoglycemia; inadequate fluid infusion; persistent systemic vasodilation; persistent systemic vasoconstriction; cardiac arrhythmia; poor cardiac contractility; decreased venous return (tamponade or thrombosis); severe electrolyte alterations (hypomagnesemia; hypophosphatemia, hypokalemia); severe acidemia or alkalemia; cortisol deficiency (hypoadrenoccorticism, critical illness-related corticosteroid insufficiency); brain disease; hypothermia; organ ischemia; hypoxia; anemia; ongoing fluid or blood loss; severe polyuria.
iii. In SIRS, CVP should be 8–10 cmH_2O. If it is low, HES at 5 ml/kg IV increments is titrated until BP is up and/or CVP is 8–10 cmH_2O. If the CVP is adequate or high, an echocardiogram is done to assess contractility. If poor contractility is present, the use of a positive inotrope (e.g. dobutamine) is warranted to improve cardiac output and increase BP. If during hypotension the CVP is between 8 and 10 cmH_2O and the contractility is adequate, vasopressors (e.g. dopamine, 5 µg/kg/min IV as CRI) can be used until the BP is stable.
iv. Pressure does not equal flow. The dog had inadequate intravascular volume and medications administered caused dramatic vasoconstriction. While the 'BP' may now be within normal limits, the 'flow' to the kidneys was inadequate. Intravascular volume must be adequate before any medications are used to treat hypotension.

33 i. Infusion of a large volume of crystalloids resulted in: (1) sudden increase in intravascular HP, (2) dilution of intravascular COP, (3) the dog has an SIRS process with probable increased capillary permeability, each favoring crystalloid passage through the large capillary 'pore' space.
ii. Albumin is the primary natural colloid of the body, determining the natural COP in that space.
iii. 65,000–69,000 daltons (may vary between species). An increase in capillary permeability that allows albumin loss suggests the leak is >65,000–69,000 daltons. Administration of a colloid sized larger than albumin (e.g. tetrastarch, HES) favors intravascular retention of that colloid.
iv. Regulates COP of blood; also binds electrolytes, hormones, drugs, fatty acids, bilirubin.
v. The distance oxygen must be transported from the capillary to the targeted cells increases. Uptake and transport of oxygen from the lung alveoli into the capillaries is difficult. Interstitial HP is elevated and interstitial COP declines. Elevated interstitial HP can collapse capillaries, veins, and lymphatics interfering with the flow dynamics and the function of nerves in the area.
vi. Hyponatremia is most commonly caused by excess body water diluting serum sodium. Lipemia will dilute serum sodium (pseudohyponatremia). When interstitial sodium concentration is less than intracellular sodium, water moves into the cells, causing swelling (severe in the brain, heart, and lung). Increasing sodium concentration rapidly (<24–36 hours) can result in permanent central pontine myelinosis.

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34 Glucose and altered mentation are monitored as part of the Rule of 20 (**34**). A decline in mentation can be one of the first clinical indicators of the onset of deleterious complications.
i. List at least four metabolic changes that can result in an alteration in mentation.
ii. List at least two consequences to the patient from depressed mentation.
iii. Provide cause(s) of and effect(s) from hypoglycemia.
iv. Provide cause(s) of and effect(s) from hyperglycemia.



35 This cat has hypokalemia and ventroflexion of the head and neck (**35**). The Rule of 20 necessitates evaluation of serum electrolytes, to include Na+, K+, Cl^-, Mg++, PO_4, and Ca++.
i. Match the effect with the appropriate electrolyte(s): (a) deficiency may cause hemolysis; (b) serum value reflects solute free water content; (c) excess can slow cardiac nerve conduction; (d) deficiency can result in weakness, poor muscular contraction; (e) deficiency can result in tachyarrhythmias and seizures; (f) deficiency can result in metabolic alkalosis; (g) excess can reflect impaired GFR; (h) excess can cause AKI.
ii. Maintenance fluids are typically supplemented with which electrolyte? Why?
iii. Indicate which crystalloid solution(s) best fulfills the following: (a) highest Na+ concentration; (b) highest K+ concentration; (c) contains Ca++; (d) lowest K+ concentration; (e) contains no electrolytes; (f) lowest Na+ concentration.
iv. Which electrolyte(s) normally has a higher intracellular concentration than extracellular concentration?
v. List at least three major roles of phosphorus in the body.

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Answers: 34, 35

34 i. Low glucose, high osmolality, low oxygen, high CO_2, low CO_2, hepatic encephalopathy (e.g. hyperammonemia), hyper/hyponatremia, hypokalemia, hypotension, arrhythmias, hyper/hypothyroidism, hypercalcemia, uremic encephalopathy, drugs/medications.
ii. Depressed gag and swallow (reflexes) resulting in aspiration, anxiety, seizures, stupor, coma, anorexia leading to malnutrition.
iii. Causes: too much insulin, liver disease, sepsis, liver shunt, high exercise, low intake, extrahepatic neoplasia, beta cell neoplasia, hypoadrenocorticism, laboratory error. Effects: low energy production in all tissues; the brain does not store or create glucose, needing a continuous source of glucose; signs include weakness, altered mentation, seizures, tremors, hypotension.
iv. Causes: diabetes mellitus, pancreatitis, increase in stress hormones, iatrogenic. Effects: increased thirst, increased urination, dehydration, infections, altered mentation, delayed wound healing.

35 i. a: PO_4; b: Na+; c: K+; d: K+; e: Mg++; f: Cl^-; g: K+, PO_4, Na+; h: Ca++.
ii. K+. Fluid diuresis promotes the urine loss of potassium.
iii. a: hypertonic saline, normal saline; b: commercial maintenance solutions (e.g. LRS, PlasmaLyte) or partial parenteral solutions (FreAmine®, ProcalAmine®); c: LRS; d: hypertonic saline, normal saline, ½ strength saline, 5% dextrose in water; e: 5% dextrose in water; f: commercial maintenance solutions, 5% dextrose in water, ½ strength saline or half-strength LRS.
iv. Mg++, K+, PO_4.
v. Bone structure ($CaPO_4$), energy production and storage (ATP), structure of phospholipids (all cell membranes), storage and transmission of genetic information (DNA, RNA), phosphorylation for activation of enzymes, hormones, cell-signaling molecules, buffer, affects ability of hemoglobin to carry oxygen.

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36 i. The Rule of 20 highlights coagulation as one of the important aspects to monitor in SIRS patients. What is disseminated intravascular coagulation (DIC)?
ii. How is DIC diagnosed?
iii. How is DIC treated?



37 A 3-year-old intact female Beagle presents for anorexia, depression, and a swollen, hot mammary gland (**37**). She has been nursing six pups for 3 weeks. Physical examination: T = 40.3°C (104.6°F); HR = 168 bpm; RR = 30 bpm; CRT = 1 sec; MM bright red, dry; femoral pulses bounding; estimated dehydration 6–8% by skin turgor, MM moisture. Thoracic auscultation and abdominal palpation findings were within normal limits. The left mammary chain is swollen and hot. The skin over the area is taut with ecchymotic hemorrhages.
i. The Rule of 20 directs the clinician to evaluate the need for antibiotics in the emergency or ICU patient. List at least three historical/physical examination findings and three laboratory findings that support antibiotic administration.
ii. What testing can be done to better define the need for antibiotic therapy?
iii. What criteria are used when selecting a specific antibiotic or combination of antibiotics?

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Answers: 36, 37

36 i. DIC is characterized by systemic activation of blood coagulation resulting in generation and deposition of fibrin, leading to microvascular thrombi. Severe bleeding may occur as the coagulation proteins are depleted. However, microthrombosis can occur without excessive consumption of coagulation factors and bleeding.
ii. Diagnosis is difficult and no single routinely available laboratory test is sufficient. Diagnosis is based on presence of trauma or SIRS disease, low platelet numbers, prolonged PT/aPTT, decreased fibrinogen levels, increased fibrin degradation products, elevated D-dimers, schistocytes on blood smear, and decreased antithrombin and protein C.
iii. Treating the underlying disease, increasing capillary blood flow, and supporting target organs are the mainstays of therapy. Replacement of coagulation proteins, +/- platelets, is done to meet patient and procedural needs. Heparin is appropriate to treat the thrombotic stage of the disease but is ineffective without sufficient antithrombin. Administration of protein C has been of benefit to subgroups of humans with sepsis.

37 i. History: endemic area (e.g. leptospirosis, Lyme disease), tick removal, penetrating injury, recent boarding (e.g. tracheobronchitis), poor vaccination history, wound history, recurrent infections. Physical examination: fever, hypothermia, severe hypoperfusion, heart murmur with fever, occult abdominal pain, open wounds, purulent discharge, pain and swelling, phlebitis, cellulitis. Laboratory support: left shift with or without neutrophilia, neutropenia, hypoglycemia, thrombocytopenia, hypoalbuminemia, bacteria on cytology, bactiuria or pyuria, hyperbilirubinemia, abnormal coagulation (all compatible with SIRS), culture and susceptibility.
ii. Provide a sample for cytology, Gram stain, and culture and susceptibility. Radiography, ultrasound, CT for free fluid or masses that can be aspirated. Echocardiography for evidence of endocarditis or pericardial effusion. Transtracheal wash or bronchoscopic aspiration; diagnostic lavage. Titers or PCR can be submitted for specific pathogens.
iii. (1) The most likely pathogen and spectrum of the drug (based on site of infection, cytology, and Gram staining); (2) route of administration (IV provides for 100% bioavailability and ideal for patients that cannot tolerate oral dosing); (3) antibiotic penetration to site of infection (volume of distribution); (4) patient parameters (e.g. age and/or species may preclude use of some drugs, perfusion status, albumin concentration, whether drainage possible); (5) metabolism and elimination of drug (e.g. patient hepatic, renal function); (6) dosing frequency; (7) drug interactions; (8) potential side-effects (e.g. vasodilation, renal failure, thrombocytopenia, hypocalcemia); (9) culture and susceptibility testing. Do not use a mallet when a small hammer will do the job.

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38 The Rule of 20 requires that attention be paid to the list of medications (to include vitamins and herbals) that a patient is receiving. New clinical signs, treatment failure, and life-threatening complications can be the result of prescribed medications rather than progression of the underlying disease.

i. What aspect(s) of drug therapy should be assessed when prescribing medications to a patient receiving multiple drugs?

ii. What is the cytochrome P450 system, and how can it affect drug interactions?

iii. List at least four patient parameters that must be considered when selecting a specific drug, dosage, and route of administration.

iv. Match the potential side-effect with the drug:

a. kidney failure	i. cephaloporins
b. vomiting	ii. potassium bromide
c. prolonged rate of hepatic metabolism of P450 drugs	iii. amikacin
d. shortened rate of hepatic metabolism of P450 drugs	iv. cimetidine
e. respiratory problems in cats	v. phenobarbitol

39 The ICU (**39**) is not a good place to diet. Nutritional concerns for the critical patient are addressed in the Rule of 20.

i. What is the most important nutrient for the dog or cat?

ii. Provide the formula to calculate caloric requirements for the dog and cat.

iii. Complete the following chart:



Nutrient	Dog	Cat
Protein (%)		
Fat (%)		
Carbohydrates (%)		

iv. What amino acid must be supplemented in the cat but not in the dog?

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Answers: 38, 39

38 i. Attention must be paid to drug–drug interactions, particularly pertaining to drug 'ADME' (absorption, distribution, metabolism, and elimination), side-effects, and dose of medications, as well as patient factors including hepatic and renal function.
ii. It is necessary for the metabolism of drugs, with more than 50 enzymes in the system. A drug can be an inhibitor or an inducer by causing P450 drug interactions. When an inducing agent is prescribed with another medication, the rate of metabolism is increased and the dosage of the other medication may need to be adjusted. If a medication is taken with an agent that inhibits its metabolism, then the drug level can rise with potential harmful or adverse effects.
iii. Patient perfusion and hydration status; patient species and age; concurrent medical problems; liver and kidney function; GI function and motility; patient albumin concentration (many drugs bind to albumin).
iv. a, iii; b, i; c, iv; d, v; e, ii.

39 i. Water.
ii. RER (kcal/day) = 30 (kg body weight) + 70.
iii.

Nutrient	Dog	Cat*
Protein (%)	20–25	34
Fat (%)	10–20	15–-20
Carbohydrates (%)	30–70	0–40

* Cats are true carnivores with no natural requirement for carbohydrates demonstrated in the adult cat. However, they can utilize carbohydrates for energy.

iv. Taurine.

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40 i. What is partial parenteral nutrition (PPN) ?
ii. Why is force feeding not advised in critical patients?
iii. Why might a nasogastric feeding tube be of benefit in a vomiting patient?
iv. The benefits of enteral nutrition early in the course of most critical illness have been documented. Outline how you would implement 'trickle flow feeding' in an anorexic patient with GI signs (e.g. parvovirus puppy, pancreatitis cat).
v. What can be done to reduce GI signs during enteral tube feedings?



41 An 8-year-old female neutered mixed-breed dog was attacked by another dog 45 minutes earlier. The dog presented with bite wounds and lacerations along the entire left lateral side of her body and significant skin bruising (**41**). Trauma associated with multiple bite wounds is an SIRS problem. Assessing the status of wounds and any applied bandages is an important part of the Rule of 20.
i. List at least three types of wounds present in a critical patient that should be monitored.
ii. List at least three complications from wounds.
iii. List at least three functions of a bandage.
iv. A good bandage consists of three layers. What are they? Discuss the function of each layer.
v. It is important to monitor bite wound size resulting from any contaminated source. Why is this important, and how is this accomplished?
vi. The nursing/technical staff should monitor all bandages. List what changes might be observed and what these might indicate. Also list any routine bandage care.

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40 i. Typically provides glucose and branched-chain amino acids through peripheral veins and can be an important nutritional bridge while starting enteral feeding or total parenteral nutrition.
ii. Forced feeding can cause unwanted struggling and stress, food aversion (especially in cats), and aspiration. It may be painful for animals (orofacial disease) and can put staff at risk of injury (bites).
iii. Because it empties directly into the stomach, it allows intermittent aspiration of air and fluids from the stomach, reducing gastric retention and peripheral receptor input to the vomiting center.
iv. The initiation phase of enteral feeding provides a liquid diet, administering ~25–30% of the daily caloric requirements. This quantity of diet is placed in an empty IV fluid bag and the concentrated diet is diluted with a commercial glucose/electrolyte solution or water. The amount of diluent is based on the estimated sensitivity of the GI tract (e.g. very sensitive, 25:75; moderate, 50:50; not sensitive, concentrated). An IV infusion line is attached to the bag through an infusion pump and connected to the feeding tube. An initial drip rate between 0.6 and 2.0 ml/kg/hr is selected depending on the sensitivity of the bowel. The concentration can be increased after the diet is tolerated for 2–4 hours. Once full concentration, the volume can be increased.
v. Anti-emetics, motility modifiers, suction gastric tube. Adding food coloring to a liquid diet helps recognize poor gastric motility or too much volume infused when recovered from gastric tube suctioning.

41 i. Catheter insertion sites, venipuncture sites, incision line(s), bite wounds, lacerations, decubitus ulcers, self-mutilation, abscess, cellulitis, urine scalding.
ii. Infection, inflammation, bleeding, swelling, dehiscence, fasciitis, necrosis of skin/subcutaneous tissues, thrombosis of regional vessels, ischemia to wound or surrounding area, herniation of underlying organs/tissues, pain.
iii. Protection, support, compression, immobilization, securing a dressing, debridement of wound with removal, absorb discharge, keeping injury clean, apply medications directly to wound, avoid self-mutilation.
iv. (1) Primary or contact layer is in direct contact with the wound and may be used to apply medications, debride or hydrate a wound, and absorb/transfer fluid to secondary layer. (2) Secondary or absorbent layer keeps primary layer in contact with wounds, provides stability. (3) Tertiary or outer layer provides additional stability, pressure (to limit dead space), and protects the underlying layers.
v. The bite wound surface can mask underlying tissue damage and contamination. Expansion of skin swelling, bruising, inflammation, or necrosis reflects extension of infection, cellulitis, or fasciitis. After treating the initial wound, the boundary of each skin wound is outlined with a permanent marker to detect spreading of wound pathology.
vi. Slipping or swelling above or below suggests that the bandage is too loose or too tight, respectively. Strike through indicates necessity to change bandage and concern for environmental contamination. Bending or slipping suggests inadequate support or protection. The bandage should be covered by a plastic bag or wrap when the patient goes outside. Bandages covering exudative wounds should be changed at least daily to detect spreading of wound pathology (**41**).

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42 The nursing/technical staff play a major role in the successful outcome of a critical patient. The Rule of 20 directs clinicians to prepare orders for veterinary nurses regarding the special needs of each patient.
i. Default orders are instructions for automatically monitoring minimal patient parameters. Identify the minimal patient parameters to be assessed daily for all hospitalized patients.
ii. What is the most important procedure that nursing staff should undertake to minimize spread of disease when working on multiple patients?
iii. It is important to anticipate potential complications and be ready in advance. Provide steps that the nursing staff can take to prevent or anticipate problems: (a) dog with labored breathing on high flow nasal oxygen; (b) cat having had seizures due to insulin overdose; (c) managing lines in postoperative patients with an abdominal drain, two IV lines, urine catheter with collection line, and nasogastric tube line with nutrition; (d) dog having cluster seizure activity; (e) patient too weak to stand on his own.
iv. Identify nursing instructions aimed at protecting and minimizing complications in the unconscious patient.
v. List at least three things that nursing staff can do to provide Tender Loving Care (one of the Rule of 20 parameters) to the critical patient.

43 i. What are the components of a thorough neurologic examination?
ii. List the differences between the following modalities regarding information obtained when imaging the spinal cord: plain film radiography, contrast myelography, CT, MRI.

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42 i. Body weight, temperature, pulse, RR, PCV, TS, mental status, physical examination.
ii. Washing hands with antibacterial soap between each patient.
iii. (a) Have ETs and laryngoscope cage side, monitor RR and effort, gum color, and SpO_2 frequently. (b) Have 50% dextrose and syringe with needle ready at cage side, monitor mental status frequently. (c) Label each line so that there is no confusion and check whenever a patient is moved. (d) Provide heavily padded cage; have injectable anticonvulsant readily available. Audible signals (bells on collar) may be used in addition to visual inspection to alert staff to seizures. (e) Provide passive range of motion and massage; support patient to stand and/or place in support frame for intervals throughout the day. Rotation and movement of body position can reduce pressure sores, atelectasis, muscle wasting, and promote GI motility.
iv. Keep patient sternal with the head and neck in normal position; reposition the patient every 2–4 hours to avoid hydrostatic congestion; lubricate corneas; keep patient clean of urine and feces; manipulate with passive range of motion exercises; minimize environmental stresses; continuous pulse oximetry and RR monitoring.
v. Use soft voice and gentle touch; allow family to visit pet; provide box or blanket for cats to hide under if condition allows; partially cover cage door, minimize loud sounds and exposure to strange animals; place items from home familiar to the pet in their cage; turn down lights to simulate night when conditions allow.

43 i. Evaluation of cranial nerves and mentation; retinal examination; palpation/manipulation of the spine (including tail) for heat, swelling, step-sign, panniculus, and pain reaction; evaluate posture, limb strength or tone; gait and voluntary motor; limb proprioception response; peripheral/spinal reflexes (including withdrawal, panniculus); cutaneous and deep pain response; anal tone and perineal reflexes; movement examination (e.g. hopping, hemi-walking); muscle mass, and orthopedic abnormalities.
ii. Plain film radiography: evaluates bony spinal structures, disc mineralization, bone proliferation, and intervertebral disc spaces. Positioning requires chemical restraint. The spinal cord is not visualized.

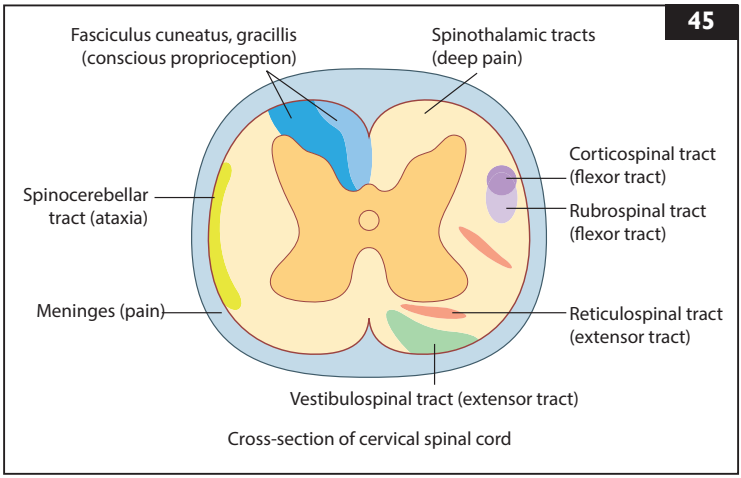
Contrast myelography requires anesthesia. Contrast outlines the spinal cord and alterations or attenuation in the dye column indicates intra/extradural and intra/extramedullary lesions. Bradycardia post contrast injection may necessitate atropine or glycopyrrolate. Possible post-myelogram seizures require careful body positioning, monitoring, and treating seizures when they occur.

CT requires GA. The spinal cord tissue, other soft tissues, blood vessels, and bone are visualized through multiple slices in sagittal and longitudinal planes through the area of interest. Contrast can be given by either myelogram, to highlight compressive lesions, or IV to identify altered blood flow.

MRI requires GA and more time than CT. There is more detail of tissues surrounded by bone, specific for changes within and immediately around the spinal cord. Images are collected in several planes and IV contrast may enhance tissues having increased blood flow.

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44 i. Match the area(s) of the brain most likely to have pathology with the clinical signs or problems.
Area of brain: A, cerebrum or diencephalon; B, rostral medulla oblongata; C, cerebellum; D, midbrain; E, medulla oblongata.
Clinical signs or problems: 1, seizures; 2, intention tremors; 3, dementia; 4, head tilt and nystagmus; 5, ventral and lateral strabismus; 6, facial droop on left; 7, tongue atrophy or weakness; 8, unable to locate food by smell; 9, hypermetria; 10, circling to the right.
ii. Match the clinical signs/problems with the area(s) of the nervous system likely to have pathology (assume the patient has normal mentation).
Clinical signs/problems: 1, hyporeflexia hindlimbs; 2, hyperreflexia hindlimbs; 3, hyporeflexia forelimbs; 4, proprioception deficits all four limbs; 5, hypermetria all four limbs; 6, hyporeflexia all four limbs; 7, hyperreflexia all four limbs; 8, respiratory depression; 9, decreased anal/tail tone.
Area(s) of the nervous system likely to have pathology: A, spinal cord C1–5; B, spinal cord C6–T2; C, spinal cord T3–L3; D, spinal cord L4–S2; E, nerve roots S1–Cd5; F, cerebellum; G, dorsal horns of spinal cord; H, peripheral nerves/myoneural.



45 i. What part(s) of the neurologic examination for spinal pathology demonstrates 'the severity of the lesion'?
ii. What part(s) of the neurologic examination for spinal pathology indicates 'the location of the lesion'?
iii. List the order in which the following signs occur as a mild ventral disc protrusion progresses with dorsal/lateral compression of the cord (refer to **45**): ataxia, loss of voluntary motor activity (paralysis), pain with movement, conscious proprioception deficits, weakness, loss of deep pain.
iv. Why are spinal cord segments and vertebral body segments NOT at the same level in the dog?

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Answers: 44, 45

44 i. 1: A; 2: C; 3: A; 4: B, C (or peripheral CN 8); 5: D; 6: B (CN 7); 7: E (CN 12); 8: A (CN 1); 9: C; 10: A (usually circle toward side of lesion).
ii. 1: D; 2: B; 3: B; 4: A, B, C, D, G; 5: F; 6: B and D together or H; 7: A; 8: A; 9: E.

45 i. Strength of limbs and extensor tone (thrust), voluntary motor activity, conscious proprioception response, superficial pain, deep pain, gait (ataxia).
ii. Segmental limb reflexes, panniculus reflex, presence/absence of cross-extensor reflexes, withdrawal reflex, localizable pain, postural changes (Schiff–Sherrington, root signature).
iii. Pain on movement (meningeal inflammation); ataxia (spinocerebellar tract); weakness (extensor tracts); proprioceptive deficits (fasciculus cuneatus, gracilis); loss of voluntary motor activity (extensors and flexors); loss of deep pain (spinothalamic and other deep tracts).
iv. There are eight cervical spinal cord segments and nerve roots and only seven cervical vertebrae. Nerve roots C1–C7 run at the cranial edge of the same numbered vertebrae. Caudal to C8 the nerve roots run along the caudal edge of the vertebra of the same number. Caudal to L3 the spinal segments shorten and end approximately at L6 vertebra in dogs and L7 in cats. Vertebral bodies from L7–Cd5 contain nerve roots forming the cauda equina.

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46 i. Arrange the following clinical signs in order of least to most severe in animals with cerebrum or diencephalon lesions:
Mentation: coma, normal, obtundation, dementia, stupor, delirium.
Pupil size: miotic, mydriatic, mid-range/fixed, normal.
Respiration: Cheyne–Stokes, apnea, normal, hyperventilation, shallow/erratic.
ii. Which of the following systems is responsible for conscious mentation: vestibular system; oculocephalic reflex system; ascending reticular activating system; limbic system?
iii. Place the neurologic findings in the most likely location of the lesion in an animal with stupor or coma.
Neurologic finding: seizures, no oculocephalic reflex, fixed dilated pupils, decerebrate rigidity, ventrolateral strabismus, apneustic breathing, normal cranial nerves.
Most likely location of the lesion in an animal with stupor or coma: cerebral/diencephalon, midbrain or brainstem.
iv. In the unconscious patient, the neurologic examination will localize the pathology to either the midbrain/brainstem or cerebral cortex (diffuse). Which localization carries the better prognosis?

47 i. Match the following therapies for traumatic brain injury with the associated comment:

a	High-dose corticosteroids	i	Osmotic diuretic that is an oxygen-radical scavenger
b	Mannitol	ii	A loop diuretic that may reduce the rebound increase in ICP that can follow mannitol administration
c	Withholding fluids	iii	May increase arterial oxygen content
d	Hypertonic saline	iv	Will promote decreased blood flow and contribute to lowering cerebral perfusion pressure
e	Hydroxyethyl starch	v	Will promote intravascular volume replacement and MAP
f	Furosemide	vi	A hyperosmolar crystalloid that may reduce ICP and neutrophil adhesion
g	Supplemental oxygen	vii	Has no effect on improving outcome in traumatic brain injury, and is associated with increased mortality

ii. List at least three strategies for improving outcome in traumatic brain injury.

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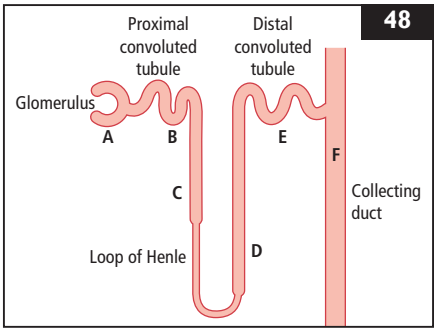
Answers: 46, 47

46 i. *Mentation*: normal, dementia, delirium, obtundation, stupor, coma.
Pupil size: normal, miotic, mydriatic, mid-range/fixed.
Respiration: normal, Cheyne–Stokes, hyperventilation, shallow/erratic, apnea.
ii. Ascending reticular activating system.
iii. *Cerebral/diencephalon*: seizures, normal cranial nerves.
Midbrain: fixed dilated pupils, decerebrate rigidity, ventrolateral strabismus.
Brainstem: apneustic breathing, no oculocephalic reflex.
iv. In general, localization to the cerebral cortex carries a better prognosis.

47 i. a, vii; b, i; c, iv; d, vi; e, v; f, ii; g, iii.
ii. Maintain SAP >90 mmHg, attempt to reduce intracranial pressure with osmotic diuretics; promote arterial oxygen content with supplemental oxygen (PaO_2 >80 mmHg [SpO_2 >94%]); avoid interventions and therapy that may contribute to regional brain ischemia (e.g. compressing both jugular veins) or excessive cerebral blood flow; maintain normal head position; elevate head, neck, and shoulders up to 20 degrees; maintain PCO_2 between 35 and 45 mmHg; maintain blood glucose within normal range; early enteral nutrition; avoid hyperthermia; promptly control seizures or thrashing; rapidly correct systemic problems that affect BP and oxygenation.

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48 The kidney is made up of thousands of individual nephron units (**48**, A = glomerulus; B = proximal convoluted tubule; C = descending loop of Henle; D = ascending loop of Henle; E = distal convoluted tubule; F = collecting duct).



i. Match the functions listed with the appropriate section of the nephron (more than one segment may be appropriate): a, primary site of sodium reabsorption; b, site of aldosterone action; c, urine is highly concentrated through osmotic gradient; d, site of action of furosemide; e, urine highly diluted in the distal portion of this segment; f, final urine electrolyte content determined here; g, concentration of urine definitively determined here; h, site of ADH action; i, water extracted from distal portion of tubule by osmotic gradient; j, capillary pore size contributes to urine content; k, highest energy consuming segment; l, responsible for resorbing filtered glucose; m, urine concentration is isosthenuric at end of segment; n, electrolytes actively withdrawn and impermeable to water; o, contents of urine here same as in the blood.

ii. Match the renal test below with the segment(s) of nephron listed above primarily responsible for the value: 1, serum creatinine; 2, hyposthenuria; 3, coarse granular casts; 4, fractional excretion of sodium; 5, proteinuria; 6, urine glucose; 7, WBC casts.

iii. Define GFR. What laboratory tests are used to evaluate glomerular function and GFR?

49 A 3-year-old female Daschund presents for vomiting eight times in the last 24 hours. T = 39.4°C (103°F); HR = 180 bpm; RR = panting; CRT = >3sec; MM gray, dry; femoral pulses weak; perfusion - early decompensatory shock; 8% dehydrated by skin turgor, dry MM/corneas. Biochemistry laboratory abnormalities: BUN = 28.5 mmol/l (80 mg/dl); creatinine = 177 µmol/l (2.0 mg/dl); K+ = 3.0 mEq/l; lactate = 3.4 mmol/l (30.6 mg/dl); pH = 7.31; HCO_3 = 15 mEq/l; PCO_2 = 30 mmHg.

Pre-renal vs. renal — **49**

Parameter	A	B
Osmolality (urine)	>500	<400
Na+ (urine)	<20	>40
(urea)/(creatinine) (serum)	>0.1	<0.05
creat (urine)/creat (serum)	>40	<20
FE_{Na+}*	<1	>3

*Fractional excretion of sodium

i. It is often difficult to differentiate pre-renal azotemia from renal azotemia. Given these tests and results (**49**), which column is pre-renal and which is renal.

ii. List markers of kidney disease found on blood tests and on urinalysis.

iii. List four proposed mechanisms for oliguria in AKI.

iv. Gram-negative rods were seen in the abdominal fluid in this dog, found sensitive only to an aminoglycoside antibiotic. Describe how to monitor this dog for early evidence of nephrotoxicity caused by the aminoglycoside.

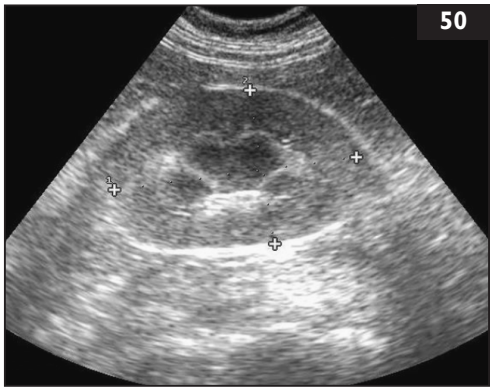
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Answers: 48, 49

48 i. A – j, o; B – a, l, k, m; C – c, i; D – d, e, n; E – f (anterior portion), b, h (distal segment), m; F – g, h.
ii. 1 – A, B (secreted here); 2 – E (distal portion), F (without ADH); 3 – B, C, D, E, F; 4 – B, E; 5 – A, B (small amino acids); 6 – A, B; 7 – A.
iii. GFR describes the flow rate of urine produced from filtration of the blood through the glomerular capillaries. BUN and creatinine can provide a gross representation of GFR. Creatinine clearance provides a better estimate of the rate of creatinine cleared from the blood by glomerular filtration (reflecting GFR). Urine protein:creatinine ratio helps assess the permeability of the glomerulus.

49 i. Column A is pre-renal; column B is renal.
ii. Blood: elevated BUN; elevated creatinine; hyperphosphatemia; hyperkalemia; hypokalemia; metabolic acidosis; hypoalbuminemia. Urine: isosthenuria; proteinuria; cylinduria; renal hematuria; inappropriate urine pH; glycosuria.
iii. Vascular theory: vasoconstriction of pre- and post-glomerular arterioles making renal glomerular capillary pressure inadequate for filtration. Tubular swelling: damage to tubular cells causes swelling and dysfunction. Tubular obstruction: damaged tubular cells exfoliate, creating a cast that obstructs the urine outflow from that tubule. Tubular back leak: fluid and molecules from within the renal tubule back leak into the peri-tubular capillary.
iv. Nephrotoxicity is due to altered phospholipid metabolism as the drug accumulates in the proximal tubular cells, made worse by poor perfusion and dehydration. Monitor: urine sediment for increasing presence of casts; glycosuria with normal blood glucose; increasing BUN and/or creatinine (occurs later than urine changes); BP, urine output; physical perfusion and hydration parameters; body weight; and occasionally serum drug concentrations.

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50 A 1.5-year-old male neutered cat presents for vomiting and inappetence of 2 days' duration. Blood work done 2 months ago was normal. T = 36.7°C (98°F); HR = 180 bpm; RR = 20 bpm; CRT = 2 sec; MM gray, dry; palpable femoral pulses; perfusion – concern for early decompensatory shock; 6–8% dehydrated (dry MM, corneas). Both kidneys are enlarged and painful. Urinary bladder feels empty. CBC = neutrophilic left shift; BUN = 53.5 mmol/l (150 mg/dl); creatinine = 442 µmol/l (5.0 mg/dl); K+ = 6.5 mEq/l; PO_4 = 1.3 mmol/l (4.0 mg/dl). Venous blood gas: pH = 7.32; HCO_3 = 13 mEq/l; $PvCO_2$ = 29 mmHg.

i. Provide three categories for initiating mechanisms of AKI in the cat or dog. List potential metabolic consequences.

ii. Abdominal ultrasound demonstrated moderately enlarged kidneys, with a thickened cortex and a bright corticomedullary line (**50**), no free abdominal fluid, and a small bladder. How does this information contribute to the diagnosis?

iii. What additional diagnostics should be considered for this cat?

iv. Describe initial treatment plans for this cat and outline how to monitor the fluid balance.

v. Name the mechanism of action of each of the following medications/techniques when utilized in a patient with AKI: (a) mannitol; (b) furosemide; (c) dialysis; (d) dopamine; (e) diltiazem; (f) fenoldopam.

51 i. Match the following urine outputs with the appropriate term:

1. Polyuria	A. Lower than expected urine output (i.e. <1 ml/kg/hr for a patient on diuresis)
2. Oliguria	B. <0.08 ml/kg/hr
3. Anuria	C. >2 ml/kg/hr
4. Relative oliguria	D. <0.3 ml/kg/hr

ii. What treatment plan is initiated for an animal with a urine output <0.3 ml/kg/hr?

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50 i. (1) Pre-renal: decreased blood flow. (2) Renal: infectious or inflammatory, structural alterations, toxins. (3) Post-renal: obstruction or disruption to outflow tract. Metabolic complications include: metabolic acidosis, hyperkalemia, gastric ulceration, coagulopathy, neurologic signs, vomiting, diarrhea, changes in body fluid balance, and dysfunction of other organs.
ii. Bright corticomedullary rim sign can be seen in many normal cats and has also been associated with toxins (ethylene glycol), renal hypercalcemia (in dogs), and interstitial diseases.
iii. Include urinalysis, urine culture and susceptibility, ethylene glycol test, and FeLV/FIV testing. Leptospirosis titers if endemic area. A renal aspirate might identify juvenile lymphoma, interstitial nephritis, or FIP. Renal biopsies provide more definitive information. BP reflects renal blood flow and identifies hypertension.
iv. IV isotonic crystalloids to restore perfusion using low volume infusion techniques to normal end-points. The rehydration rate is then added to the maintenance fluids over 4 hours. Monitor urine output, body weight, temperature, BP with HR, RR and effort every 2–4 hours until stable. Recheck electrolytes, blood gases, creatinine, and phosphorus daily. CVP can reflect central volume and is important if oliguic, anuric, or polyuric.
v. (a) Osmotic diuretic. (b) Inhibits Na/2Cl/K cotransporter in ascending loop of Henle. (c) Diffusion of molecules across a semipermeable membrane. (d) In low doses in dogs will cause renal arteriolar dilation and increase GFR. (e) Scavenges endothelin, resulting in vasodilation. (f) A dopaminergic receptor partial agonist causing arteriolar vasodilation and diuresis in cats.

51 i. 1, C; 2, D; 3, B; 4, A.
ii. Ensure that there is a patent urine collection system. Patient must have adequate hydration and mean arterial BP >60 mmHg. Rule out lower urinary tract obstruction or disruption and ensure there is no leakage of urine around the catheter into the bedding or cage. Then, a fluid challenge can be given; infuse 10–20 ml/kg of crystalloid and observe for an increase in urine output and/or signs of fluid intolerance (increased RR and effort, peripheral edema). If no or poor response, furosemide and/or dopamine or fenoldapam can be given to initiate diuresis. Mannitol is not given if there is fluid intolerance. If there is no response, hemodialysis, peritoneal dialysis, or continuous renal replacement therapy may be necessary to stabilize fluid and electrolyte abnormalities.

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RIFLE Score 52

	Creatinine	GFR	Urine output
Risk	↑ x 1.5	↓ x 25%	<0.5 ml/kg/h(6h)
Injury	↑ x 2.0	↓ x 50%	<0.5 ml/kg/h(12h)
Failure	↑ x 3.0**	↓ x 75%	<0.3 ml/kg/h(24h)
Loss	persistent AKI, loss function >4 wk		
End-stage disease	loss function >3 months		

**or >4 mg/dl (352 µmol/l)
* RIFLE – Risk, injury, failure, loss and end-stage kidney

52 A 5-year-old female neutered 22 kg Labrador Retriever presented for acute onset of lethargy, anorexia, and vomiting yellow foam. The dog ran for 90 minutes the day before in 31.1°C (85°F) heat. T = 37.6°C (99.7°F); HR = 120 bpm; RR = 36 bpm; CRT = 2 sec; MM pink, dry; strong peripheral pulses; perfusion adequate; 6–8% dehydrated based on skin turgor, dry MM. The dog has muscle soreness. Systolic Doppler BP = 150 mmHg. Initial laboratory abnormalities include: PCV = 0.3 l/l (30%); TS = 80 g/l (8.0 g/dl); serum had red coloration; creatinine = 530 µmol/l (6.0 mg/dl); BUN = 21.8 mmol/l (61 mg/dl); PO_4 = 3.6 mmol/l (11.3 mg/dl). Urinalysis: red–brown color, SG = 1.011, 3+ protein, 3+ blood, 0–3 granular casts/hpf.

i. Which RIFLE category (**52**) describes this dog's renal status?

ii. How are hemoglobin and myoglobin differentiated from blood in the urine in the clinical setting?

iii. Assess the following monitored values at the times marked 6 hours (A) and 8 hours (B) and provide recommendations for intervention.

Time post fluids (hours)	PCV (l/l [%])	TS (g/l [g/dl])	Systolic BP (mmHg)	CVP (cmH_2O)	Urine output (ml)
0	0.33/30	80/8.0	150	-1.0	0 (emptied bladder)
4	0.22/22	63/6.3	148	+2.0	225/4 hours
6 (A)	0.2/20	60/6.0	130	+2.5	100/2 hours
8 (B)	0.18/18	54/5.4	110	+8.0	100/2 hours

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Answer: 52

52 i. The creatinine of 530 µmol/l (6.0 mg/dl) puts this dog in the failure category, with a decline in GFR of at least 75%.
ii. Hematuria leaves a pellet of red cells in the tube bottom after centrifugation; no pellet and red/brown supernatant with myoglobin/hemoglobin. Red serum with hemoglobin but not myoglobin. Tentative diagnosis for this dog: hemoglobin and myoglobin-induced AKI.
iii. (A) PCV/TS are dropping with rehydration. Urine output is inappropriately low (1.8 ml/kg/hr, a relative oliguria) given the fluid volumes administered. CVP can be increased, allowing an increase in fluid infusion, while carefully monitoring CVP, BP, and urine output. (B) CVP is up but the urine output has not increased proportionately. Oliguria and fluid overload are a concern. The rate and volume of crystalloid infusion are reduced. Obstruction of the urine collection apparatus, leakage of urine around the catheter, and disruption in the lower urinary tract must be ruled out. Furosemide (2–4 mg/kg IV on IM, or 0.75 mg/kg/hr CRI IV × 6 hours) and low-dose dopamine (2–3 µg/kg/min CRI) are then administered with the goal of increasing urine output and regulating systemic fluid and electrolyte balance.

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Stages CKD – Creatinine[x] **53**

Stage	Dogs	Cats
1[+]	<1.4	<1.6
2[++]	1.4 – 2.0	1.6 – 2.8
3[#]	2.1 – 5.0	2.9 – 5.0
4[**]	>5.0	>5.0

x hydrated, 2 tests 2 weeks apart
\+ no clinical signs kidney dysfunction
++ cats ± wt loss, low appetite
\# many clinical systemic signs
** increasing risk systemic clinical signs and uremic crisis

53 A 12-year-old female neutered DSH cat presented for weight loss and increasing water intake over 6 months and vomiting white foam twice that day. T = 38.9°C (102°F); HR = 180 bpm; RR = 25 bpm; CRT = 1–2 sec; MM pink, moist; peripheral pulses normal; hydration adequate. A loss of muscle mass was seen in the paralumbar muscles. Significant laboratory abnormalities: creatinine = 177 µmol/l (2.0 mg/dl); BUN = 12 mmol/l (34 mg/dl); PO_4 = 1.5 mmol/l (4.5 mg/dl); urine: SG = 1.020, microscopic hematuria, 3+ proteinuria.

i. One definition of chronic kidney disease is kidney damage that has existed for at least 3 months or a reduction in GFR >50% from normal for at least 3 months. What is the significance of the 3 months time period?

ii. Differentiate between azotemia and uremia.

iii. The International Renal Interest Society has developed a staging for dogs and cats with chronic kidney disease (**53**). In which stage is this cat?

iv. Proteinuria and hypertension can promote the progression of chronic kidney disease. Explain the mechanism and provide a diagnostic approach for each.

v. The cat above has a urine protein:creatinine (UPC) ratio of 0.45 and an indirect BP of 160/100 mmHg. What are the goals of treatment, and what is recommended?

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Answer: 53

53 i. Renal compensatory hypertrophy and improvement in renal function can continue for 3 months.
ii. Azotemia is an abnormal concentration of urea, creatinine, and other non-protein nitrogenous substances in blood. Origins can include, liver, GI tract, kidney, and lower urinary tract. Uremia is abnormal quantities of urine constituents in the blood caused by primary generalized kidney disease and is associated with polysystemic syndrome (e.g. oral ulcerations, bleeding, nausea).
iii. In stage 2, but the creatinine is repeated in 2 weeks to confirm.
iv. Proteinuria. Urine protein is toxic, causing renal tubular cells to release cytokines and resulting in inflammation. Chronic inflammation causes conversion of tubular cells to fibroblasts and loss of function. Hemorrhage and inflammation are ruled out as the cause and the proteinuria must be persistent. The UPC is done (<0.2 normal for dog and cat).
Hypertension. Glomerular capillary hypertension stretches the glomerular podocytes, stimulating local renin release and production of angiotensin II. Local inflammation and scarring result and glomerular arteriolar vasoconstriction is enhanced. BP is taken on three separate occasions to confirm. Evidence of any retinal or CNS signs of hypertension will be important.
v. Goals: to correct abnormalities, maintain systemic health, and slow progression of disease.

This cat might benefit from commercial feline canned renal diet, phosphate binders, H2-blockers, possibly subcutaneous fluids, and monitoring for anemia and disease progression. Amlodipine (1/4 of a 2.5 mg tablet) can lower BP in cats by 20–50 mmHg and lower proteinuria. If repeated UPC fails to demonstrate control of proteinuria, benazepril (ACEI) can be added.

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54 Historical data and physical examination findings can help initial characterization of the GI pathology in the vomiting patient.
i. Match the color and content of the vomitus with the likely location of GI pathology and any possible characterization of the problem.

Vomitus	Possible location	Potential pathology
White or clear foamy	Stomach	Acute onset
Blood streaked white liquid	Upper duodenum	Intestinal obstruction
Dark 'coffee grounds'	Lower duodenum/ileus	Ulceration
Yellow liquid	Upper ileum	
Green liquid		
Dark brown fetid liquid		
Bright red bloody liquid		

ii. Complete the chart below (Localization of vomiting) with the following options (use each once only): peripheral receptor input; gastric atony; gastric/esophageal reflux; GDV; pyloric outflow obstruction; gastric/upper duodenal ileus; or outflow obstruction.

Force/timing	Pathology
Retching with abdominal palpation	
Passive efforts; no abdominal contractions	
Vomiting undigested food (≤6 hours)	
Projectile force of vomiting	
Non-productive vomiting efforts	

55 i. Define borborygmus and explain the significance of hearing bowel sounds.
ii. List four anatomic locations that can send afferent nerve impulses to stimulate the brainstem vomiting center and initiate vomiting.
iii. Complete the chart below:

Anti-emetic drug	Site of action	Target receptors	Species (dog/cat)
Metoclopramide			
Ondansetron			
Maropitant			
Chlorpromazine			
Diphenhydramine			
Meclizine			
Trimethobenzamide			

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Answers: 54, 55

54 i. White or clear foamy: stomach; typically acute. Blood streaked white liquid: gastric irritation from vomiting. Dark 'coffee grounds': pathologic gastric bleeding, ulceration; metabolic cause possible. Yellow liquid: stomach, digested reflux bile; not acute; metabolic cause possible. Green liquid: upper duodenum, reflux of bile; ileus/obstruction; typically acute. Dark brown fetid liquid: lower small bowel; ileus/total obstruction. Bright red bloody liquid: gastric hemorrhage; acute bleed; ulceration.

ii.

Force/timing	Pathology
Retching with abdominal palpation	Peripheral receptor input
Passive efforts; no abdominal contractions	Gastric/esophageal reflux
Vomiting undigested food (≤6 hours)	Gastric atony, pyloric obstruction
Projectile force of vomiting	Pyloric/upper duodenal ileus or outflow obstruction
Non-productive vomiting efforts	GDV

55 i. Borborygmus is the rumbling or gurgling noise that occurs when fluid and gas moves by way of peristalsis through the GI tract. Lack of bowel sounds suggests infrequent peristalsis and should elicit a concern for reduced intestinal motility or ileus. Increase in borborygmus implies unusually high peristaltic activity, which could reflect GI inflammation or irritation.

ii. (1) Peripheral afferent receptors responsive to stretch and inflammation of serosal or submucosal surfaces of the abdominal organs; (2) vestibular apparatus; (3) chemoreceptor trigger zone; (4) higher CNS pressure or inflammation.

iii. CRTZ = chemoreceptor trigger zone; PAR = peripheral afferent receptors; VA = vestibular apparatus; HCNS = higher central nervous system; VC = vomiting center; D = dopamine; 5-HT = serotonin; ACH = acetylcholine; M = muscarinic; H = histamine.

Anti-emetic drug	Site of action	Target receptors	Species (dog/cat)
Metoclopramide	CRTZ, PAR, VC prokinetic	D2, 5-HT3, 5-HT4, ACH	Dog, cat
Ondansetron	CRTZ, PAR	5-HT3	Dog, cat
Maropitant	VA, CRTZ, VC	NK-1, substance P	Dog, cat
Chlorpromazine	VC, CRTZ,	D2, M1 cholinergic (cat), H1, NK1, 5-HT3	Dog, cat
Diphenhydramine	VA	H1, ACH high doses	Dog
Meclizine	VA, CRTZ	H1	Dog, cat
Trimethobenzamide	CRTZ	D?	Dog

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56 A 6-year-old male mixed-breed dog presented for sudden onset of anorexia and depression of 2 days' duration (**56**). T = 39.4°C (103.0°F); HR = 180 bpm; RR = 36 bpm; CRT = 1 sec; MM bright pink, very dry; femoral and dorsal metatarsal pulses bounding; skin turgor normal but dry corneas; perfusion hyperdynamic; estimated 6–8% dehydrated. Systolic Doppler BP = 150 mmHg. Rectal examination revealed foul smelling dark bloody diarrhea (blackberry jam). Emergency database: PCV = 0.6 l/l (60%); TS = 90 g/l (9.0 g/dl); glucose = 4.4 mmol/l (80 mg/dl); BUN = 21.4 mmol/l (60 mg/dl); lactate = 3.2 mmol/l (28.8 mg/dl); Na+ = 156 mEq/l; K+ = 3.5 mEq/l; pH = 7.26; PCO_2 = 30 mmHg; HCO_3 = 12 mEq/l. Ultrasound found fluid in the small bowel with decreased small bowel and gastric motility. A diagnosis of hemorrhagic gastroenteritis (HGE) is made.

i. Provide a problems list and an initial therapeutic plan.

ii. List the four mechanisms described for the pathology of diarrhea.

iii. What are the characteristics of small bowel diarrhea compared with large bowel diarrhea?

iv. Maintaining perfusion and hydration may be very difficult in this dog with HGE. Why and how is this addressed?

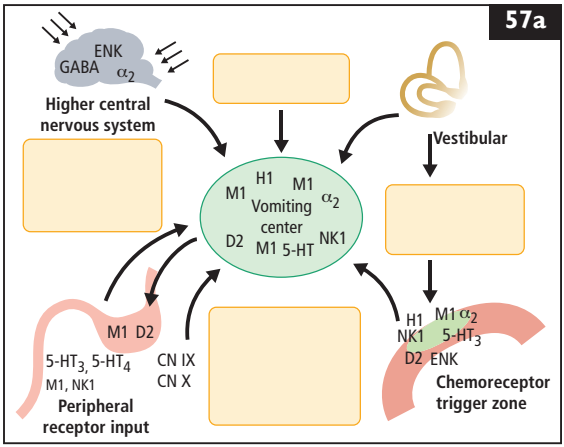
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Answer: 56

56 i. Problems list: hyperdynamic perfusion, dehydration, fever, blackberry jam diarrhea, fluid in bowel, hemoconcentration/hyperviscous blood, hyperlactatemia, compensated metabolic acidosis, azotemia, decreased GI motility. Initial treatment plan: IVC, flow-by oxygen, isotonic balanced crystalloids and HES using large volume technique to high end end-points (likely SIRS and third-body fluid spacing), opioid analgesia.
ii. (1) Decreased motility. (2) Secretory diarrhea. (3) Breakdown of mucosal barrier. (4) Osmotic diarrhea.
iii. Small bowel: projectile watery consistency, melena or blood throughout feces, no mucus, systemic signs. Large bowl: 'pudding' consistency, mucoid, red blood on outside of feces, few systemic signs, frequent tenesmus.
iv. Blackberry jam diarrhea indicates a breakdown of the mucosal barrier, promoting translocation of fluid, proteins, and electrolytes from the GI capillaries and interstitium into the lumen. Significant quantities of fluid can accumulate within this third-body fluid space with no outward evidence of ongoing fluid loss. Addition of a synthetic colloid enhances fluid retention in the capillaries and reduces the quantity of diarrhea. Promoting GI motility and enteral feeding help restore the GI balance.

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57 A 9-year-old male neutered DSH cat presented laterally recumbent after vomiting yellow foam for 2 days after chewing on a steak bone. There are no past significant medical problems. T = 35.6°C (96°F); HR = 148 bpm; RR = 24 bpm; CRT = >3 sec; MM pale gray, dry; femoral pulses not palpable; perfusion poor (early to late decompensatory shock); 8% dehydrated by dry MM/corneas, poor skin turgor; cat retches on abdominal palpation. Thoracic auscultation normal. Pain elicited in right upper quadrant on abdominal palpation. No bowel sounds heard in abdomen. Systolic Doppler BP = 50 mmHg.

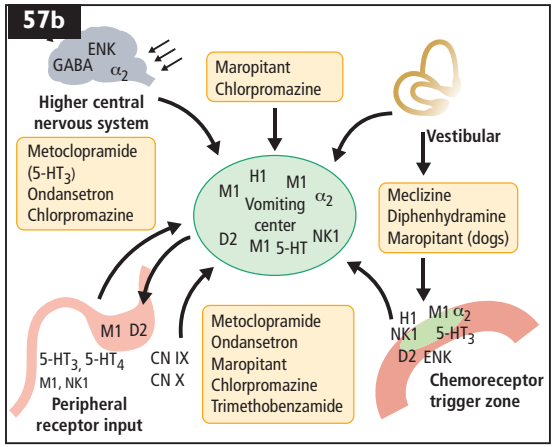


i. Make a problems list for this cat and provide your initial treatment, monitoring, and diagnostic plan.
ii. What are likely mechanisms of vomiting in this cat? Explain.
iii. Place the following anti-emetics into the proper box(es) related to the appropriate mechanism of vomiting (can be in more than one box) (**57a**): metoclopramide, ondansetron, maropitant, chlorpromazine, diphenhydramine, meclizine, trimethobenzamide.

58 **i.** Identify the canine blood groups and differentiate between positive and negative dog erythrocyte antigen (DEA) groups.
ii. Briefly outline the content differences between: fresh whole blood (FWB); stored whole blood (SWB); packed RBCs (pRBCs); fresh frozen plasma (FFP); frozen plasma (FP); cryoprecipitate (CP).

Product	RBCs	WBCs	Plasma proteins	Coagulation proteins	Platelets
FWB					
SWB					
pRBCs					
FFP					
FP					
CP					

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57 i. Problems list: poor perfusion with hypotension (physical perfusion parameters, systolic BP); dehydration; historical vomiting yellow liquid; laterally recumbent; right upper quadrant abdominal pain; no bowel sounds. Initial treatment plan: IVC; flow-by oxygen; isotonic balanced crystalloids and HES given by small volume technique to high end end-points (likely SIRS disease); opioid analgesia; patient warming. Monitor: BP; physical perfusion parameters; bowel sounds; rectal temperature. Diagnostics: emergency database to include blood gas and electrolytes and blood drawn for CBC; biochemical profile; abdominal radiographs; abdominal ultrasound; coagulation profile.
ii. Peripheral receptor input likely supported by the retching on abdominal palpation and lack of bowel sounds; chemoreceptor trigger zone input from circulating mediators likely due to degree of systemic illness and potential of SIRS disease.
iii. See **57b**.

58 i. Over 13 canine blood groups have been described with eight internationally recognized groups: DEA 1.1, 1.2, 3, 4, 5, 6, 7, 8. The major antigens are DEA 1.1 and DEA 1.2. Dogs can be positive for either DEA 1.1 or 1.2 or are negative for both. Dogs that are DEA 1.1 positive can be considered to be universal recipients and receive blood of any type without expecting an acute hemolytic reaction. Dogs that are DEA 1.1 negative can be considered to be universal donors. Blood from DEA 1.1-positive dogs should not be transfused into DEA 1.1-negative dogs when other options are available. After such a transfusion, the DEA 1.1-negative dog will forever be sensitized to DEA 1.1 blood. If it receives a second transfusion, a life-threatening transfusion reaction could occur, making a cross-match critically important.
ii.

Product	RBCs	WBCs	Plasma proteins	Coagulation proteins	Platelets
FWB	+	+	+	+ (all if used immediately)	Few
SWB	+	+	+	Decreased factor V and VIII	None
pRBCs	+	Few	Trace amounts	None	None
FFP	None	None	+	+ (all factors)	None
FP	None	None	+	Decreased factors V and VIII	None
CP	None	None	Few	Contains factors VIII, XIII, fibrinogen, and von Willebrand factor	None

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59 i. What testing should be done on a blood donor dog before admission to the donor pool?
ii. A 26 kg (58 lb) dog has a PCV of 0.13 l/l (13%) and requires a transfusion. The desired PCV post transfusion is 0.2 l/l (20%). Calculate the amount of whole blood that should be administered (fresh whole blood has a PCV of 0.5 l/l [50%]).
iii. A dog has had a transfusion in the past. What can be done to identify whether or not the donor dog's blood might be incompatible with this dog's blood? Why are the results significant?



60 A 5-year-old male neutered Persian cat is referred with a PCV of 0.12 l/l (12%) for a blood transfusion. The owner's second cat is to be the donor.
i. What blood groups are identified for cats?
ii. What concerns are there with giving blood to the owner's Persian cat from the cat shown (**60**)?
iii. What should be tested in both cats before the transfusion is given?
iv. What infectious disease testing is recommended in cats for routine donation?
v. How much blood can be collected from a donor cat?
vi. How should the blood be administered to the Persian cat?
vii. What causes a transfusion reaction, and what are the acute clinical signs in the cat? How should a reaction be treated?

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Answers: 59, 60

59 i. Blood typing, CBC, biochemical profile, urinalysis, fecal examination, and antibiody titers for contagious blood-borne diseases. Heartworm, mycoplasmosis, Rocky Mountain spotted fever, and borreliosis are also important.
ii. Donor blood (ml) = 80 (dog*) × kg × $\frac{\text{desired PCV – patient PCV}}{\text{PCV transfused blood}}$

*Use 60 for cats

80 × 26 × [(20-13) ÷ 50] = 291.2 ml frozen whole blood from donor, assuming that blood loss or acute hemolysis is not ongoing.
iii. Cross-match and blood typing. If a dog has never received a prior transfusion, a cross-match prior to the first transfusion is not essential. The major cross-match tests for alloantibodies in the recipient's plasma against the donor's RBCs, with incompatibility predicting that the transfused donor's blood will be attacked by the recipient's plasma. A minor cross-match is of less concern because the donor's plasma volume is typically small (especially if receiving pRBCs). Commercial cross-match tests (e.g. Rapid-Vet-H®) are available. A cross-match may be difficult to interpret in a patient who is auto-agglutinating.

60 i. Type A, type B, and type AB.
ii. Type A (most) and type B (many pedigree) cats have alloantibodies to the opposite blood type. Type A blood can cause a fatal reaction in type B cats. The recipient cat is a pedigree Persian (potentially type B) and the donor cat is non-pedigree (likely type A). Type AB can receive blood from any of the three blood groups. Recently, a second major blood grouping has been identified involving the Mik red cell antigen. Significant transfusion reactions in cats typed to be compatible (even AB blood groups) may involve this antigen.
iii. Both cats: blood type and FeLV/FIV status; cross-match (possibility of Mik red cell antigen).
iv. Hemoplasmosis (mycoplasmosis) and bartonellosis recommended; conditionally, testing for cytauxzoonosis, ehrlichiosis, anaplasmosis, and neorickettsiosis.
v. 11–13 ml/kg lean body weight of donor cat (typically 60 ml with anticoagulant).
vi. Place IVC; place donor fresh whole blood into commercial blood administration bag (can use syringe with syringe pump if only option); attach blood filter to bag or an in-line Hemonate® blood filter; stop infusion of any other colloid; begin blood infusion at 0.5 ml/kg/hr for the first 15 minutes, observing for tachycardia, hyperpnea, weakness, or swelling; if no adverse signs, infuse remainder at rate necessary to meet the cat's needs.
vii. Blood transfusion reaction can be due to administered donor blood that is: mismatched blood type; contaminated; causing circulatory overload; improperly stored causing damaged RBCs; initiating an immune reaction to the donor's blood cells or plasma. Acute symptoms include fever, facial swelling, vomiting, weakness, incontinence, shock, collapse, and severe hemolysis. Treatment begins with stopping infusion of donor blood. Shock/hypotension are treated with IV fluid resuscitation. Other treatment depends on the suspected cause: contaminated blood – antibiotics; immune reaction – glucocorticoid administration; fever, vomiting, facial swelling – symptomatic treatment.

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61

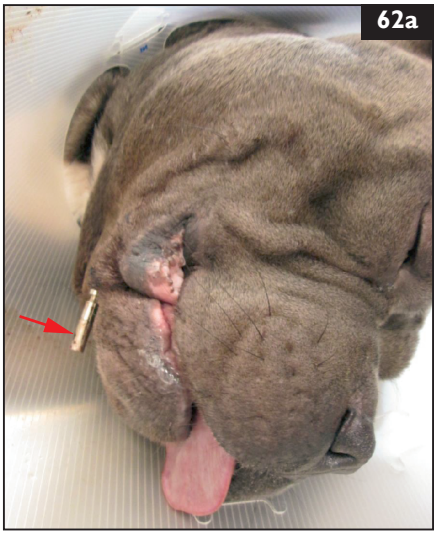
61 A 5-month-old intact female mixed-breed puppy presented for sudden collapse (**61**). The dog had received its first two vaccinations but no further veterinary care. T = 37.7°C (99.8°F); HR = 176 bpm; RR = 24 bpm; CRT = 3 sec; MM white; femoral pulses bounding; moribund. There were over 1,000 tiny ticks on the dog's skin and haircoat. Emergency laboratory database: PCV = 0.09 l/l (9%); TS = 68 g/l (6.8 g/dl); glucose = 3.3 mmol/l (60 mg/dl); BUN = 5.4 mmol/l (15 mg/dl).

i. Prepare a treatment plan for this puppy in order of priority.

ii. How would you treat the tick problem on this puppy? What are potential complications to anticipate during tick treatment?

iii. What additional diagnostic testing is recommended as a consequence of the tick infestation?

iv. What is recommended for continued care of this puppy in the hospital?


62a

62 A 3-year-old male intact Pitbull is presented by the local police department. The police, raiding a house, were attacked by the dog and an officer used an electrical current based non-lethal device (TASER) to control the dog. On presentation, the dog is too aggressive to perform a complete physical examination. RR and mental status are normal and MM color appears pink. You sedate the dog to remove the metallic prongs (**62a**, arrow).

i. What would you use to sedate this aggressive dog, and how would you administer it?

ii. What are the mechanisms by which a TASER may cause injury to this dog?

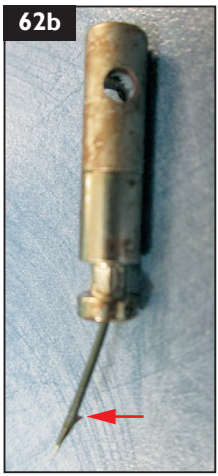
iii. How would you remove the TASER prong?

iv. Discuss how you would monitor this dog and why.

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61 i. Supplemental oxygen, an IVC, and 0.5 ml/kg of 25% dextrose solution are provided. BP is monitored and a transfusion of packed RBCs administered with isotonic balanced crystalloids.
ii. With an oral or topical tick preventative that kills the adult stage (fipronil, permethrin, etofenprox). Manual removal of ticks may be needed. Oral products may be more appropriate than topical if there are skin lesions. Anaphylaxis or allergic reaction can occur from exposure to high-dose tick antigens and may require treatment.
iii. Test for tick-borne diseases (e.g. *Borrelia*, *Ehrlichia*, *Anaplasma, Rickettsia*, *Neorickettsia*, *Babesia*, *Bartonella*, *Hepatozoan)*. Snap testing, PCR, or antibody testing is available at most commercial laboratories. CBC to look for blood cell parasites and characterize the anemia with reticulocyte count, saline agglutination, or Coombs test. Full biochemistry profile and urinalysis are evaluated for organ injury. Fecal examination for internal parasites is recommended.
iv. Antibiotic treatment, starting with doxycycline, is modified based on infectious disease testing results. Deworming and heartworm preventative are carried out with monitoring of vital signs, fluid and nutritional support, and monitoring PCV/TS and glucose.

62 i. When IV access is not possible in an aggressive patient, IM sedative/analgesics are administered at a dose that permits complete examination. Reversible medications are ideal and include dexmedetomidine, full agonist opioids, and midazolam. Acepromazine is not recommended because of possible bite inhibition and not being reversible. Morphine may cause vomiting and hydromorphone can cause panting. The patient is monitored while sedated. When compliant, IV access is obtained and medications given as needed.
ii. (1) Local injury from the needle entering the skin and current passing into the body (thermal injury/burn, break in skin) may lead to infection. (2) Injury secondary to the electrical current passing through the body (may lead to neurologic disruption, non-cardiogenic pulmonary edema, and cardiac arrhythmias). (3) Direct stimulation of the muscles causing muscle contraction (may lead to muscle soreness, self-inflicted wounds, such as bite wound to own tongue, and injury from falling).


62b

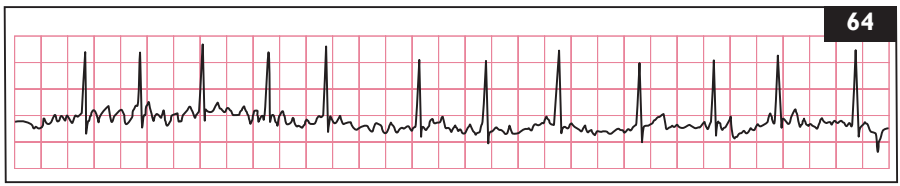
iii. TASER prongs are relatively small and the barbs do not require clipping (**62b**). Under sedation, they may be removed with mild traction. The area should then be clipped and cleaned.
iv. Since the dog is sedated, a full physical examination should be performed. The area where the barb entered should be monitored for evidence of infection/inflammation/thermal injury (swelling, discomfort, redness, discharge). Other parameters to monitor include HR/ECG for development of arrhythmias, RR and effort for possible non-cardiogenic pulmonary edema, neurologic status, and level of pain.

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63 A 10-year-old male neutered DSH cat presents for lethargy, weakness, walking strangely, and not eating. He has had PU/PD for 2 months. T = 36.1°C (97°F); HR = 200 bpm; RR = 12 bpm; CRT = 2–3 sec; MM gray and dry; weak femoral pulses. The cat is mentally dull with normal cranial nerves, tetraparesis, and ataxia. Corneas are dry and there is a significant skin tent (**63**). Initial database: PCV = 0.48 l/l (48%); TS = 98 g/l (9.8 g/dl); pH = 7.2; PCO_2 = 50 mmHg; HCO_2 = 7 mEq/l; Na = 136 mEq/l; K = 5.9 mEq/l; Cl = 115 mEq/l; lactate = 4.6 mmol/l (41.4 mg/dl); glucose = 54 mmol/l (973 mg/dl); BUN = 43 mmol/l (120 mg/dl); creatinine = 282.9 µmol/l (3.2 mg/dl). Urinalysis: SG = 1.012, pH = 6.0, occasional granular cast, protein 3+, glucose 4+, ketones 3+.

i. Formulate the 4-Step Fluid Resuscitation Plan for this cat.
ii. What is the differential diagnosis for PU/PD?
iii. What is the importance of urinalysis when evaluating a patient with PU/PD?
iv. What is your assessment of the acid–base status of this cat?
v. Discuss what can be affecting the potassium level in this cat.
vi. What plasma electrolyte can decrease with initiation of definitive therapy, potentially causing hemolysis?
vii. This cat was likely diabetic for a few months. Why is it sick now?



64 A 7-year-old female neutered Dalmatian presents for collapse and coughing. T = 38°C (100.4°F); HR >180 bpm; RR = 48 bpm; CRT = 2–3 sec; MM pale pink; poor perfusion; adequate hydration. Breathing pattern is synchronous. Thoracic auscultation finds soft moist crackles in all lung fields and a rapid and irregularly-irregular rhythm, with variable femoral pulse quality. A lead II ECG is obtained at 50 mm/sec (**64**).

i. What is your ECG rhythm diagnosis?
ii. What patient problems may be causing abnormal perfusion?
iii. What are the immediate treatment recommendations?
iv. List additional tests to further evaluate the patient with this abnormal heart rhythm.

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63 i. Step 1: perfusion and hydration deficits. Step 2: combination of isotonic, balanced crystalloids and HES. Step 3: low normal resuscitation end-points because of the change in mentation and hyperosmolar serum. Step 4: small volume resuscitation techniques and the patient is warmed. An hydration timescale of 4–6 hours is chosen.
ii. Renal disease, diabetes mellitus (DM), central and nephrogenic diabetes insipidus, psychogenic polydipsia, urogenital infection (e.g. pyometra, pyelonephritis), hypercalcemia, hyperadrenocorticism, hypoadrenocorticism, hyperthyroidism, steroid or diuretic therapy, chronic liver disease.
iii. Urine SG indicates urine concentrating ability. In a dehydrated cat, a SG <1.035 is insufficient. Casts in the urine, proteinuria, and glucosuria without hyperglycemia support renal tubular injury. True hyposthenuria (SG <1.008) indicates excessive drinking, ADH receptor dysfunction (e.g. *E. coli* infection), or an ADH deficiency. Inflammatory cells and bacteria in the sediment support urinary tract infection. Glucosuria with hyperglycemia indicates DM. Ketonuria occurs with extreme starvation, insulin resistance, and complete lack of insulin production (e.g. type I DM).
iv. The cat has an acidemia characterized by metabolic and respiratory acidosis.
v. Potassium moves out of cells to buffer elevated hydrogen in acidosis. Insulin therapy then drives potassium into the cells. Hypokalemia can be a consequence of insulin therapy.
vi. Phosphorus.
vii. A stressful event produces stress hormones and insulin resistance. Fatty acids are released and metabolized to acetoacetic acid and betahydroxybutyrate used as oxidative fuels by cells. Ketoacidosis results.

64 i. Atrial fibrillation. Note 'f' waves and irregular R-R intervals.
ii. Both respiratory distress from pulmonary edema caused by CHF and decreased cardiac output caused by the tachyarrhythmia could contribute to perfusion problems.
iii. Oxygen supplementation supports arterial oxygenation. Mild sedation (e.g. butorphanol) is given if the dog is anxious or struggling. Preload is addressed with IV diuretics (e.g. furosemide) to reduce edema and improve gas exchange. The contractility of the heart is assessed and a positive inotrope (e.g. dobutamine, pimobendan) provided when needed. Oral digoxin can be started pending cardiac assessment if a delay is anticipated. Afterload is reduced with a vasodilator, either an ACEI (e.g. benazapril), a beta-blocker (e.g. atenolol), a nitric oxide enhancer (e.g. nitroprusside), a vascular smooth muscle relaxant (e.g. hydralazine), or a phosphodiasterase inhibitor (e.g. pimobendan). If tachycardia persists, the HR can be decreased with calcium channel blockers (e.g. diltiazem) or beta-blockers (e.g. atenolol, esmolol, or sotolol).
iv. Indirect arterial BP, emergency laboratory database to include an electrolyte and venous blood gas panel, pulse oximetry, 2-view thoracic radiographs, echocardiogram.

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65 A 1.5-year-old female neutered Poodle-mix presents laterally recumbent with a 1-week history of watery diarrhea and vomiting. The dog is recumbent and non-responsive; T = 35.6°C (96°F); HR = 30 bpm; RR = 24 bpm; CRT = >3sec; MM pale pink, dry; femoral pulses absent; frank blood draining from the rectum. A lead II ECG is shown (**65**).

i. This dog has signs of poor perfusion. What aspects of the examination do not fit with typical clinical signs of hypovolemic shock in the dog?

ii. Initial laboratory database: PCV = 0.3 l/l (30%); TS = 46 g/l (4.6 g/dl); pH = 7.24; PCO_2 = 30 mmHg; HCO_3 = 15 mmHg; Na = 112 mEq/l; K = 22 mEq/l; Cl = 95 mEq/l; iCa = 0.7 mmol/l (2.8 mg/dl); lactate = 8.6 mmol/l (77 mg/dl); glucose = 2.25 mmol/l (50 mg/dl); BUN = 46 mmol/l (140 mg/dl); creatinine = >282 µmol/l (4.2 mg/dl). Create a problems list for this dog in order of priority and identify your working diagnosis.

iii. Explain how hyperkalemia, hypocalcemia, and acidemia affect the myocardial action potential.

iv. What are the potential ECG findings caused by hyperkalemia?

v. Select the test that confirms a diagnosis of hypoadrenocorticism: urine cortisol:creatinine ratio; ACTH stimulation test; Na:K ratio from electrolyte panel; modified Thorn test; low- or high-dose dexamethasone suppression test; none of these?

vi. It takes time to get the results of the confirmatory test. What immediate treatment is necessary to stabilize the dog and not affect the results of the test?



66 A 9-month-old Pitbull presents for a 'red bubble' sticking out of his anal opening. The dog has had watery diarrhea for 4 days but is still eating and active. Physical examination finds the problem shown (**66**). The dog is estimated to be 8% dehydrated and has watery fecal material on the hindlimbs.

i. What is your diagnosis?

ii. What are likely causes in this dog?

iii. How would you treat this problem in this dog?

iv. What can be done to minimize the chance of recurrence in this dog?

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65 i. The bradycardia.
ii. Order can vary: late decompensatory shock with high serum lactate, bradycardia, hyperkalemia, hyponatremia, hypoglycemia, non-responsive mentation, lateral recumbency, blood from rectum, dehydration, azotemia, compensated metabolic acidosis, hypoproteinemia, history of vomiting. Working diagnosis: hypoadrenocorticism with an addisonian crisis.
iii. Hyperkalemia lowers the resting membrane potential, inactivates the sodium–potassium channels, and prolongs repolarization. Hypocalcemia prolongs phase 2 of the action potential, downregulating myocardial beta receptors. Acidemia decreases the number of beta receptors in nodal tissue and indirectly affects membrane stability, causing potassium to move extracellularly.
iv. Sinus tachycardia and then bradycardia, tall tented T waves, wide QRS complexes, decreased R wave amplitude, lengthening of PR interval, prolonged P wave duration, absent P waves, ST segment deviation, and eventually asystole or ventricular fibrillation.
v. ACTH stimulation test response.
vi. The 4-Step Fluid Resuscitation Plan is used. Step 1: hydration and perfusion deficits. Step 2: combination of LRS and HES since hyponatremia and potential SIRS. Step 3: low end end-points because of the bradycardia. Step 4: small volume infusion technique to minimize the chance of volume overload. IV calcium gluconate (supports myosin and actin function, helps restore the membrane potential differences) and IV regular insulin and dextrose (temporarily drives extracellular potassium into muscle tissues) can treat the bradycardia and hypoglycemia. Additional glucose may be required. Dexamethasone (replaces cortisol deficiency, does not affect ACTH stimulation test) is administered at physiologic (0.03–0.05 mg/kg) or higher dose (0.06–0.1 mg/kg) to support vasomotor responsiveness and induce gluconeogenesis.

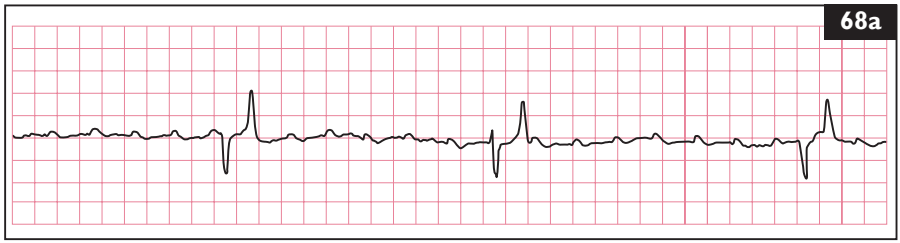
66 i. Rectal prolapse.
ii. Excessive straining related to diarrhea, intestinal parasitism, or intestinal foreign body.
iii. The rectal tissue needs to be placed back into the rectum. This may require heavy sedation or anesthesia. Tissue swelling may be reduced by coating the mucosa with hypertonic saline or sugar. A large syringe case can be used to help push tissue back through rectal opening. The rectal orifice is reduced by placing a purse-string suture around the opening, small enough to keep the tissue in place as it heals, but open enough to allow stool to come out. If the tissue appears to be necrotic, a partial rectal amputation may be performed.
iv. Testing for and treating intestinal parasites; imaging (abdominal radiographs +/- ultrasound) to look for a FB obstruction.

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67 A 4-year-old male neutered mixed-breed dog presented after being bitten in the abdomen by a larger dog. T = 37.2°C (99.0°F); HR = 176 bpm; RR = 30 bpm; CRT = <2 sec; MM bright pink, dry; femoral pulses bounding; perfusion abnormal; 6–8% dehydrated based on MM moisture. Thoracic auscultation normal. Abdominal palpation abnormal. Bite (puncture) wounds evident on right side of abdomen. A firm swelling (**67**, arrow) was found on the left side of the abdomen.

i. Describe the abnormality seen on the left side of the abdomen.
ii. Provide the 4-Step Fluid Resuscitation Plan for this dog.
iii. What is the likely problem, and what complications are anticipated?



68 An 11-year-old female neutered Pug presents for lethargy. She has a normal appetite and is urinating normally, but does not want to move around very much. T = 38.3°C (101.0°F); P = 30 bpm; RR = 24 bpm; MM pink; pulses slow, strong, synchronous with heart beats. You obtain the ECG shown (**68a**) (paper speed 25 mm/sec).

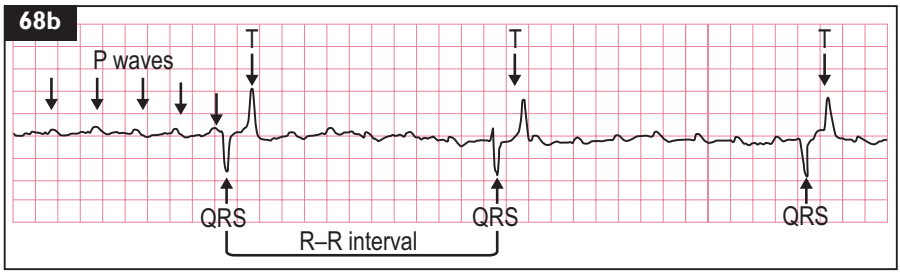
i. What is the ECG diagnosis?
ii. How do you calculate ventricular rate with this small strip of ECG?
iii. What is your recommended diagnostic plan for this dog?
iv. Results of the diagnostic tests are all normal. What is the therapy for this problem?
v. Describe the difference between the different degrees of atrioventricular (AV) block.

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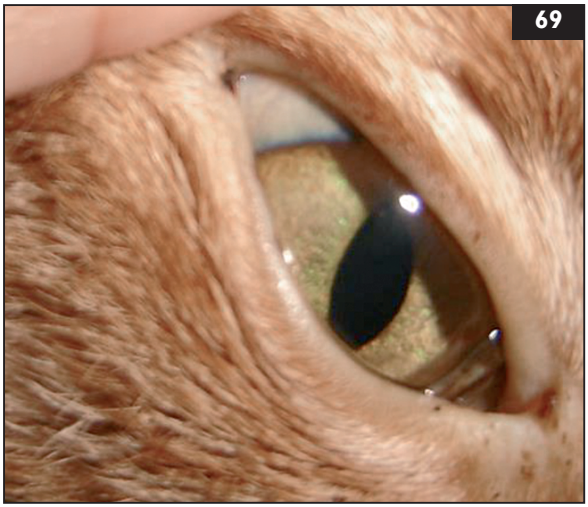
Answers: 67, 68

67 i. There is an abnormal swelling on the left side of the body wall, most likely an abdominal rent with abdominal organs located in the subcutaneous space.
ii. Step 1: both perfusion (compensatory shock) and hydration deficits are present. Step 2: a combination of isotonic balanced crystalloids (e.g. Normosol-R, Plasmalyte-A) and HES (e.g. tetrastarch, hetastarch) to promote intravascular retention of fluids. Step 3: low end resuscitation end-points due to trauma and potential for abdominal hemorrhage. Step 4: small volume titration of fluids to avoid rapid increase in intravascular HP.
iii. Abdominal herniation with organs entrapped within the skin pocket. Complications include: distension of gas/fluid-filled organs leading to ischemia or perforation; abdominal wall necrosis; peritonitis, continued pain and hemorrhage.

68 i. Third-degree AV block, ventricular rate ~30 bpm (atrial rate ~170 bpm) (**68b**).
ii. Ventricular rate can be calculated by several methods using a paper speed of 25 mm/sec. (1) Count the number of small boxes between 'R' waves and divide 1,500 into that number (i.e. 1,500 ÷ 55 = 27 bpm); (2) count the number of beats in 3 seconds (75 small boxes) and multiply by 20. Both methods demonstrate bradycardia (calculated rates ≤40 bpm).
iii. Systemic disease should be ruled out: laboratory evaluation of blood and urine (including CBC, chemistry profile, blood gas and electrolytes, urinalysis), BP, full neurologic examination, thoracic radiographs, echocardiogram, +/- abdominal imaging (to rule out cause of high vagal tone).
iv. Pacemaker placement. Medications that stimulate increased sinus rate (beta agonists, methylxanthines) are likely to work on the atrial rate and not the ventricular rate.
v. First-degree AV block is a prolonged PR interval (there is still a QRS for every P); 1st-degree/Mobitz type I is a progressive, predictable prolongation of the PR interval until a QRS is dropped ('long, longer, longer, block'); 2nd-degree/Mobitz type II has a dropped QRS in an upredictable manner and may progress to 3rd-degree, which is a complete disassociation between the atrial (P) rate and the ventricular (QRS) rate.



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69 A 7-year-old female neutered DSH cat presented for anorexia and weight loss over the past few weeks and elevated liver enzymes discovered today. T = 39°C (102.3°F); HR = 180 bpm; RR = 18 bpm; CRT = 2 sec; MM dry and pale yellow; femoral pulses strong and synchronous; perfusion adequate; estimated 8% dehydrated by skin turgor and MM moisture; icteric sclera (**69**). Heart and lung sounds normal, hepatomegaly found on abdominal palpation. The cat currently weighs 4.5 kg (10 lb) (past weight 6 kg [13.2 lb]); BCS of 2/9.

i. What are the caloric requirements for this cat?

ii. What options are there for feeding an anorexic small animal? Provide the pros and cons for each.

iii. What are the causes of icterus in the cat? What are the anticipated complications seen with these underlying diseases?

iv. Outline treatment of liver disease in the cat regarding dietary concerns, potential drug therapy, supportive care, and general definitive therapy.

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Answer: 69

69 i. Calculation formula: body weight (kg) × 30 + 70 = daily kcal. For this patient = 205 kcal.

ii.

	Pros	**Cons**
Appetite stimulants	Non-invasive	Potentially hepatotoxic, short-term solution, sometimes ineffective
Force/syringe	Non-invasive, inexpensive, concentrated diets	Can cause food aversion, short-term solution
Temporary tube (e.g. nasogastric, nasoesophageal)	Sedation only to place, inexpensive, can trickle flow feed	Requires sedation, small diameter tube, liquid diet needed
Long-term tube (e.g. esophagostomy, gastrostomy, jejunostomy)	Larger diameter tube, concentrated diets, well tolerated	Requires anesthesia, more expensive, possible infection

iii.

Causes of icterus	**Potential complications**	**General examples**
Extravascular hemolysis	Anemia/hypoxia, nephrotoxicity of bilirubin	Autoimmune disease, toxicity
Liver disease	Coagulopathy, hypoalbuminemia, hepatoencephalopathy, GI ulcerations, vomiting, diarrhea, fluid imbalance	Neoplasia, lipidosis, chronic active hepatitis, hepatotoxins, inherited disorders, infectious diseases, cholangiohepatitis
Post-hepatic disease	As above	Cholelithaisis, gall bladder/bile duct pathology, pancreatitis, duodenal disease, liver fluke

iv. Dietary modification must ensure adequate calories and nutrients. Protein restriction and oral lactulose may be beneficial if encephalopathy present. Diets may require supplementation with vitamins E, C, and K, and zinc. Medications such as S-adenosylmethionine, milk thistle (silbyn), and/or ursodiol may improve liver function and promote regeneration. Treatment with corticosteroids, antibiotics, and anti-fibrotic agents depends on the etiology. Supportive care should incorporate maintaining proper fluid and electrolyte balance. Blood transfusions are given if anemia, coagulopathy, or hypoalbuminemia. Medications directed at eliminating GI signs of nausea, vomiting, or diarrhea may be warranted. Definitive treatment may include specific antidotes if toxic cause, surgical intervention, and specific drug therapy directed at a specific underlying etiology.

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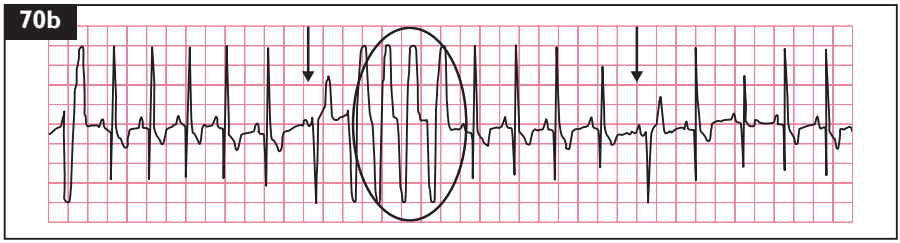


70 A 10-year-old male intact Shepherd-cross presents for pacing, non-productive vomiting, and arching his back. T = 38.9°C (102.1°F); HR = 190 bpm; RR = 54 bpm; CRT = 3 sec; MM pale pink; weak femoral pulses with pulse deficits; poor perfusion; hydration normal. Thoracic auscultation unremarkable. The dog has significant abdominal distension with gastric tympany. A lead II ECG strip from this dog during initial volume resuscitation is shown (**70a**).
i. Identify the most life-threatening problems for this dog.
ii. What is your ECG rhythm diagnosis?
iii. What problems may be causing abnormal perfusion?
iv. What are the immediate treatment recommendations?
v. When should IV antiarrhythmic therapy be considered?
vi. What are potential side-effects of lidocaine therapy?



71 A 12-year-old male neutered Husky presented for 2 days of vomiting after being missing for a day. He had an intestinal resection and anastamosis 1 month ago for an intestinal FB. T = 38.7°C (101.7°F); HR = 114 bpm; RR = panting; CRT = 2 sec; MM pink; pulses strong; perfusion adequate; 6–7% dehydrated (history/MM moisture). Tense and painful abdomen on palpation. A ventrodorsal view abdominal radiograph is shown (**71**). The circular metallic object in the caudal abdomen is a row of staples from an intestinal stapling device.
i. What changes should be anticipated in the blood work of a dog with an upper GI tract FB obstruction?
ii. An intestinal FB must be ruled out. What diagnostic options are available?
iii. Interpret the radiograph and provide a radiographic diagnosis.
iv. What complication should be anticipated from the previous surgery?

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70 i. Poor perfusion due to hypovolemic, distributive, and potentially cardiogenic shock secondary to GDV syndrome and a cardiac arrhythmia.
ii. Sinus tachycardia with paroxysmal ventricular tachycardia (encircled beats) and fusion beats (thin arrows) (**70b**).
iii. Decreased cardiac output and oxygen delivery from the tachyarrhythmia; hypovolemia; decreased venous return to heart due to gastric distension compressing veins; pain.
iv. Supplement oxygen to support arterial oxygenation; administer analgesia; volume resuscitate to improve perfusion and reduce HR; followed by gastric decompression.
v. Antiarrhythmics such as lidocaine are considered when ventricular tachyarrhythmia continues to affect perfusion after analgesia, oxygen, and volume resuscitation; when there is R-on-T phenomenon on the ECG or when the ventricular beats are polymorphic. Also, lidocaine infusion therapy can be considered as an adjunctive analgesic, and may increase survival when administered early during resuscitation of GDV patients.
vi. Vomiting, diarrhea, weakness, sedation, seizure.

71 i. GI obstruction can lead to vascular compromise of the bowel, SIRS, and possibly sepsis from perforation. Important disorders to anticipate depend on the severity of complications: hemoconcentration; neutrophilia; stress leukogram; thrombocytopenia; hypochloremic metabolic alkalosis; hyperlactatemia and metabolic acidosis (if poor perfusion, sepsis); hypokalemia; hypomagnesemia; hypoalbuminemia; hypoglycemia (if sepsis); azotemia (pre-renal most likely); hyperphosphatemia (ischemic bowel).
ii. Plain abdominal radiographs (FB may not be obvious); a barium series (risk of barium peritonitis and aspiration of barium); ultrasound examination (dependent on skill of operator); advanced imaging such as CT or MRI (not MRI if metal in abdomen); exploratory surgery.
iii. The anterior small bowel is gas distended more than twice the width of the vertebra, indicative of an intestinal obstruction. Radiographic diagnosis: the small intestinal gas pattern is suggestive of small intestinal obstruction.
iv. Stricture of GI tract and adhesion formation causing obstruction; bowel entrapped in mesentery from tear or dehiscence; failure of an additional FB ingested to pass through previous surgical site.

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72 Dog 1: A 5-year-old, 20 kg mixed-breed dog presents for vomiting white foam and bloody diarrhea of 1 day's duration. T = 37.8°C (100.2°F); HR = 156 bpm; RR = 48 bpm; CRT = >3 sec; MM pale pink; weak femoral pulse, synchronous with the heart.
Dog 2: A 2-year-old, 20 kg pitbull dog presents after being hit by a car 20 minutes prior. The dog is conscious with no evidence of hemorrhage. T = 38.5°C (101.3°F); HR = 165 bpm; RR = 52 bpm; CRT = >3 sec; MM pale pink; weak femoral pulse, synchronous with the heart.
i. Identify the stage of shock for dog 1 and dog 2.
ii. Can the quantity of IV fluids each dog will need for adequate resuscitation be predicted? Explain.
iii. What is the major goal of IV volume resuscitation?
iv. What are the clinically monitored end-points or goals of resuscitation for these two dogs?

73 Use the 5 Steps for Interpreting Blood Gases (see case **23**) to assess the following blood gas results.
i. 4-year-old neutered male DSH cat with urethral obstruction. Venous blood gas values: pH = 7.18; PCO_2 = 44 mmHg; PvO_2 = 60 mmHg; SaO_2 = 96.0%; HCO_3 = 16 mEq/l.
ii. 8-year-old male Labrador Retriever with a 10-day history of projectile vomiting. Venous blood gas values: pH = 7.60; $PvCO_2$ = 37 mmHg; PvO_2 = 58 mmHg; SaO_2 = 97% on 40% oxygen; HCO_3 = 35 mEq/l. Interpret these values, and identify what electrolyte you assess to determine the course of treatment.
iii. 3-year-old female Bulldog with sudden upper airway distress. Arterial blood gas values: pH = 7.27; $PaCO_2$ = 50 mmHg; PaO_2 = 50 mmHg; SaO_2 = 79% on 21% oxygen; HCO_3 = 24 mEq/l. Interpret these values, and indicate what immediate treatment is needed.
iv. 11-year-old female calico cat with diabetes mellitus with blood glucose = 800 mg/dl (44.4 mmol/l); 4+ ketonuria. Venous blood gas values: pH = 7.45; $PvCO_2$ = 22 mmHg; PvO_2 = 70 mmHg; SaO_2 = 98% on 40% oxygen; HCO_3 = 15 mEq/l.
v. 3-year-old Rottweiler with shock and labored breathing 1 hour after being hit by a car. Arterial blood gas values: pH = 7.30; $PaCO_2$ = 30 mmHg; PaO_2 = 68 mmHg; SaO_2 = 92% on 40% oxygen; HCO_3 = 14 mEq/l. Interpret these values, and explain the oxygenation status.

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72 i. Both dogs are in early decompensatory (middle) stage of shock demonstrated by tachycardia, slow CRT, pale MM, weak femoral pulses. The body is shunting flow from the periphery and abdomen to the lungs, brain, and heart.
ii. No. Variables such as underlying pathology, age, heart function, vasomotor activity, vascular integrity, hemorrhage, and hemostatic status play a role.
iii. To improve oxygen delivery to all tissue beds.
iv. Typically include normalization of physical peripheral perfusion parameters (HR, CRT, MM color, pulse intensity), restoration of BP to targeted value, improvement of abnormal acid–base status, and reduction of blood lactate. CVP can be monitored as a reflection of changes in pressure/volume in thoracic large capacitance veins.

Dog 1 likely has an SIRS disease that benefits from rapid, aggressive IV volume replacement. High-normal quantities of oxygen and nutrients should be delivered to tissues. 'High end' end-points are chosen to restore physical peripheral perfusion parameters, systolic BP to high normal (100–150 mmHg), and CVP to high normal (8–10 cmH_2O).

Dog 2 has had trauma and potential for internal bleeding. Resuscitating to high end end-points could dislodge the clot. Post-trauma, brain or lung edema/hemorrhage, oliguric, and heart failure patients benefit from targeting 'low end' end-points with milder increases in intravascular HP, which include restoration of physical peripheral perfusion parameters, systolic pressure ≥90 mmHg for cerebral perfusion, and low normal CVP (2–5 cmH_2O).

73 i. (1) Acute, metabolic; (2) pH low – acidemia; (3) HCO_3 low – metabolic acidosis; (4) PCO_2 normal – no compensation; (5) venous sample, SaO_2 is normal. Diagnosis: uncompensated metabolic acidosis
ii. (1) Not acute, likely metabolic; (2) pH high – alkalemia; (3) HCO_3 high – metabolic alkalosis; (4) $PvCO_2$ normal – uncompensated; (5) venous sample with normal SaO_2. Diagnosis: uncompensated metabolic alkalosis; should assess serum Cl^-.
iii. (1) Acute respiratory problem; (2) pH low – acidemia; (3) PCO_2 high – respiratory acidosis; (4) HCO_3 normal – uncompensated; (5) low PaO_2 and SaO_2 – hypoxemia. Diagnosis: uncompensated respiratory acidosis with hypoxemia. Needs oxygen supplementation and potentially ventilation if does not improve.
iv. (1) Not acute, likely metabolic; (2) pH normal – normal or mixed; (3) $PvCO_2$ low – respiratory alkalosis; HCO_3 low – metabolic acidosis; (4) compensation does not bring pH to normal (mixed process); (5) venous blood with normal SaO_2. Diagnosis: mixed metabolic acidosis and respiratory alkalosis.
v. (1) Acute systemic and respiratory; (2) pH low – acidemia; (3) HCO_3 low – metabolic acidosis; (4) $PaCO_2$ low – respiratory compensation: the $PaCO_2$ should decrease 0.7–0.9 mmHg for each 1 mEq/l decrease in HCO_3. Depending on the value used for 'normal' $PaCO_2$, compensation may be 'partial'; (5) the PaO_2 is low on 40% oxygen. Diagnosis: metabolic acidosis with partial respiratory compensation. Hypoxemia. The PaO_2/FiO_2 ratio is 68/0.4 = 170; suggests significant pulmonary gas exchange problems.

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74 A 30-kg dog presented for labored breathing and is in the ICU with bilateral nasopharyngeal cannulas placed. Arterial blood gas (FiO_2 = 0.6) reveals: pH = 7.30; HCO_3 = 25.2 mEq/l; $PaCO_2$ = 60 mmHg; PaO_2 = 75 mmHg with SaO_2 of 94%. The dog is struggling to breathe, with pink foam periodically coming from his mouth.
i. Use the 5-Step Blood Gas Interpretation for the arterial blood gas at this time.
ii. What is your immediate treatment?
iii. What are the initial goals of ventilator therapy?
iv. Provide the initial settings on the ventilator for the following parameters: mode of ventilation – assisted vs. mandatory vs. spontaneous; FiO_2; RR; tidal volume; peak inspiratory pressure; PEEP.
v. How would you monitor this dog?



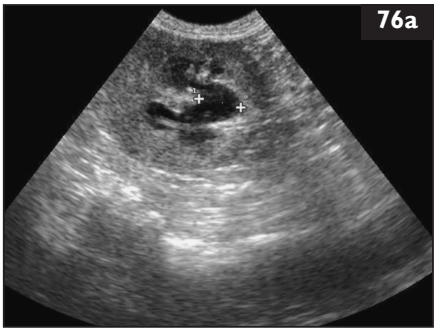
75 An 11-year-old male intact Dachshund presents for increased respiratory effort and a soft wet cough of 2 days' duration (**75**). The dog's head and neck are extended and the elbows abducted. T = 35.7°C (96.2°F); HR = 110 bpm; RR = 70 bpm; CRT = 1 sec; MM gray/pink; perfusion and hydration normal. An oscillometric BP of 135/85 (MAP = 101 mmHg) is obtained. Thoracic auscultation reveals a left-sided V/VI systolic heart murmur and severe bilateral pulmonary crackles. The dog has a synchronous breathing pattern with increased effort and a shallow depth of respiration. There is a mild, bilateral serous nasal discharge. The dog is immediately given flow-by oxygen. Two minutes later, the dog worsens such that respiratory arrest appears imminent.
i. Describe your immediate intervention.
ii. After you have stabilized the immediate crisis, the dog can maintain a SpO_2 of 99%. However, a large amount of serosanguineous fluid is coming from the large airway. What procedures can you perform to rapidly remove the large airway fluid?
iii. What is your tentative diagnosis?
iv. What emergency medications might be required to stabilize this dog?

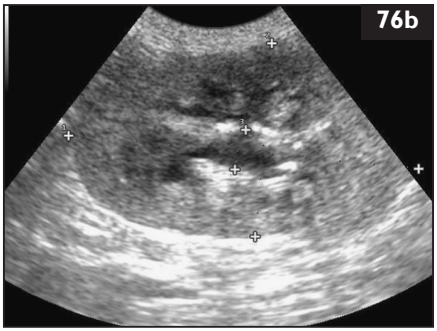
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74 i. (1) Acute, respiratory, not oxygen responsive (PaO_2/FiO_2 = 75/0.6 = 125); (2) pH low – acidemia; (3) $PaCO_2$ high – respiratory acidosis; (4) HCO_3 high – compensatory; (5) hypoxemia on 60% oxygen.
ii. Rapid anesthetic induction (e.g. ketamine or etomidate with benzodiazepine or propofol if BP stable), endotracheal intubation, hand ventilation with 100% oxygen, suction or postural drainage of airways; place on mechanical ventilation. This patient is likely to require continuous infusion of anesthetic to maintain ventilator therapy.
iii. Goals include PaO_2/FiO_2 of >300, improve oxygenation = PaO_2 >60, maintain $PaCO_2$ = 35–45 mmHg, normalize pH, avoid complications (i.e. barotrauma, oxygen toxicity, ventilator induced pneumonia); patient comfort.
iv. At this stage, assisted controlled or continuous mandatory ventilation takes over the work of breathing; better for reaching pressure/volume targets. FiO_2 1.0 initially with reduction within 4–6 hours if possible. Initial RR 10–15 bpm (adjust if $PaCO_2$ does not rapidly decline to normal range). Normal tidal volume in the medium to large size dog is 10–15 ml/kg. This may need to be reduced with ARDS. Start at 140–180 ml and adjust as needed. Initial peak inspiratory pressure – 15–20 cmH_2O, increase as needed. Initial PEEP is 5 cmH_2O and adjusted upward based on response of PaO_2. PEEP is needed for patients with ARDS.
v. Monitoring includes BP, pulse oximetry, $ETCO_2$, CVP, arterial blood gas, urine output, patient weight.

75 i. Obtain IV access, administer an IV anesthetic (e.g. etomidate, ketamine, or propofol) with a benzodiazepine, intubate, secure the tube, and ventilate with 100% oxygen.
ii. Suction the tube with a sterile 'whistle tip' suction tip. Postural drainage (also called elevated pulmonary parenchymal evacuation) can be done by elevating the dog's hind end, slanting the body and thus directing the ET downward. The thoracic cavity can be gently compressed to help evacuate fluid from smaller airways.
iii. CHF secondary to mitral regurgitation; dilated cardiomyopathy is less likely.
iv. Address cardiac preload, rate, contractility, and afterload. IV furosemide (4–6 mg/kg IV or 0.75 mg/kg/hr CRI IV × 6 hours) can reduce preload. HR is acceptable at 110 bpm and contractility is likely normal or increased if mitral regurgitation is the etiology. The severity of the pulmonary edema warrants a nitroprusside infusion (starting at 1 µg/kg/min IV CRI) for arterial and venous vasodilation. The dose can be titrated up by 0.5–1 µg/kg/min increments, monitoring every 5 minutes to maintain BP ≥90 mmHg. Nitroglycerin 2% topical ointment (1/4 to 1 inch topically on the skin or gums q6–8h) is a less effective venodilator. Hydralazine (0.5–2 mg/kg PO q8–12h) is an alternative for arterial vasodilation. If depressed contractility, dobutamine (2–20 µg/kg/min IV CRI) is considered for inotropic support.

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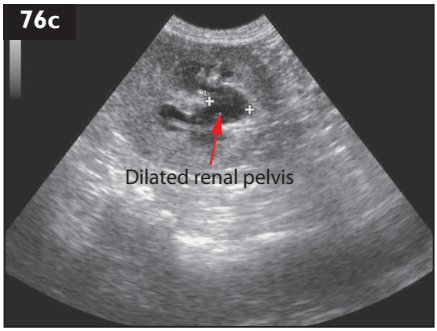
76 A 6-year-old male neutered DSH cat presents for 1 day of lethargy and vomiting yellow fluid. No known exposure to toxins, no significant prior medical history, and no changes in urination and defecation noted. T = 40.3°C (104.6°F); HR = 180 bpm; RR = 50 bpm; CRT = 1 sec; MM pale, dry: femoral pulses palpable; perfusion adequate; 6–8% dehydrated (dry MM). Kidney palpation elicits pain; urinary bladder small. PCV = 0.35 l/l (35%); TS = 82 g/l (8.2 g/dl); neutrophilia with left shift; BUN = 28.5 mmol/l (80 mg/dl); creatinine = 362 µmol/l (4.1 mg/dl); pH = 7.2; HCO_3 = 11 mEq/l; PCO_2 = 42 mmHg. Urinalysis: SG = 1.035, 3+ protein, 2+ blood, sediment: 5–8 WBCs/hpf, occasional coarse granular cast. Ultrasonographic views of the right kidney are shown (**76a,** saggital; **76b,** longitudinal); the left kidney is normal.

i. What abnormalities are noted in the ultrasonograms?
ii. Create a problems list.
iii. What is your initial plan for stabilization, monitoring, and diagnosis?
iv. Provide a differential diagnosis for this cat.

77 A 7-year-old female neutered DSH cat presents for making loud yowling noises and dragging her back end. The cat has open-mouth breathing. T = 38.4°C (101.1°F); HR = 260 bpm; RR = 54 bpm; CRT = 1 sec; MM pink; no palpable femoral pulses. Thoracic auscultation finds a IV/VI left systolic heart murmur. She has decreased pain response, withdrawal reflex, and postural reflexes in both hindlimbs. The nail beds in the hindlimbs are much paler than the pink nail beds of the forelimbs.

i. What is your working diagnosis?
ii. What immediate therapy do you provide?
iii. What additional tests are warranted to support your diagnosis?
iv. What do you discuss with the client regarding this condition?

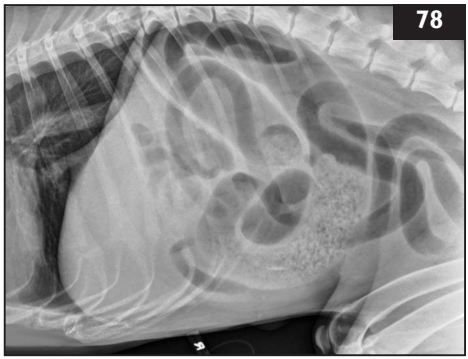
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76 i. Enlarged right kidney with a hypoechoic to anechoic region in the middle, suggesting dilation of the renal pelvis (**76c**), surrounded by hyperechoic renal pelvic fat.
ii. Azotemia, fever, dehydration, uncompensated metabolic acidosis, active urine sediment (cast, bacteria, WBCs), possible anemia once rehydrated, neutrophilia with left shift.
iii. Collect blood for CBC, biochemical profile, and venous blood gas. Collect urine for urinalysis and culture and susceptibility. IVC, isotonic balanced crystalloids to correct dehydration over several hours, opioid analgesics, broad-spectrum bacteriocidal parenteral antibiotic (e.g. ampicillin/sulbactam or first-generation cephalosporin), urinary catheter with closed collection for urine output, gastroprotectants. Additional diagnostics may include FIV, FeLV, and leptospirosis titers, contrast study if poor urine production or no response to diuresis (rule out obstruction), and renal aspirate/biopsy. Monitor body weight, PCV/TS. Repeat creatinine, electrolytes, and blood gas after rehydration, urine output once hydrated, HR and RR and effort, CVP (if central line placed), rectal temperature, BP. Recheck for renal ultrasound changes over 24–48-hour period.
iv. Includes pyelonephritis, hydronephrosis (ureteral obstruction). Less likely differentials include severe lower urinary (urethral) obstruction, extreme fluid diuresis, or neoplasia.

77 i. Caudal abdominal aortic (saddle) thrombus.
ii. Analgesia with a full agonist opioid (methadone or hydromorphone). This is presumed to be a very painful condition.
iii. Compare fore- and hindlimb. Doppler blood flow in the distal limbs; the affected limbs may have reduced or no blood flow compared with the normal limbs. Lactate and/or glucose can be measured in fore- and hindlimbs to support the diagnosis of saddle thrombus (lower glucose and higher lactate in affected limbs). Abdominal ultrasound may identify an intravascular mass effect in the caudal abdominal aorta. Echocardiogram may show evidence of cardiomyopathy and/or spontaneous echocardiographic contrast suggestive of turbulent blood flow and/or an intraluminal mass suggestive of a clot in the left atrium that could have embolized. Thoracic radiographs may show evidence of soft tissue masses suggestive of pulmonary neoplasia that could have embolized.
iv. Unfortunately, the current thrombus cannot be removed. Common clot-eliminating medication used in humans has not improved outcome in cats, and can cause a hemorrhagic event. Supportive care providing analgesia, promoting blood flow, identifying and treating the primary cause, and preventing additional thrombus formation will be the prime directives. If arterial thromboembolism affects one limb, ~70–80% of treated cats survive to discharge; if two limbs affected, ~30–40% survive to discharge and >15% of those that do survive will re-embolize.

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78

78 A 3-year-old female neutered mixed-breed dog presents for depression and acute onset of vomiting food then green liquid. There is no exposure to toxins. The dog is known to eat towels and underwear. The dog is depressed. T = 38.6°C (101.4°F); HR = 192 bpm; RR = 40 bpm; CRT = >3 sec; MM very pale pink, dry; weak femoral pulses; perfusion poor, 8% dehydration based on MM, corneal moisture. Thoracic auscultation is normal. Abdominal palpation finds pain with a tubular structure mid-abdomen. Emergency laboratory database: PCV = 0.62 l/l (62%); TS = 92 g/l (9.2 g/dl); glucose = 4.16 mmol/l (75 mg/dl); BUN = 28.6 mmol/l (80 mg/dl); Na+ = 160 mEq/l; K+ = 4.2 mEq/l; Cl^- = 108 mEq/l; venous blood gas: pH = 7.58, $PvCO_2$ = 50 mmHg, HCO_3 = 27 mEq/l; lactate = 4.5 mmol/l (40.5 mg/dl); platelet estimate = 150 × 10^9/l; ACT = 100 sec.

i. Provide a problems list in order of priority for this dog.

ii. Provide the 4-Step Fluid Resuscitation Plan for this dog.

iii. A lateral cranial abdominal radiograph (**78**) is obtained after 30 minutes of fluid resuscitation. Assess the radiograph and indicate whether the animal is ready for surgery.

iv. Ileus is anticipated postoperatively. What can be done to minimize the occurrence of aspiration pneumonia? What other benefit(s) does this provide to the patient?

v. Provide a postoperative fluid therapy plan with justification for decisions that are made.

79 A 5-year-old male neutered yellow Labrador Retriever presented with a 5-day history of progressive anorexia and depression and occasional vomiting of white foam. T = 40°C (104°F); HR = 80 bpm; RR = 30 bpm; CRT = 2 sec; MM pink, dry; femoral pulses strong; perfusion adequate, estimated 8% dehydrated by skin turgor, dry membranes; no bowel sounds auscultated; heart and lung auscultation normal. The dog will 'fly bite' when startled and head press. Neurologic examination: sluggish direct and consensual pupillary response to light in both eyes; mentally dull; tetraparesis with normal reflexes; proprioceptive responses normal; pain elicited on manipulation of neck.

i. Based on the neurologic findings, where is the pathology most likely located within the CNS?

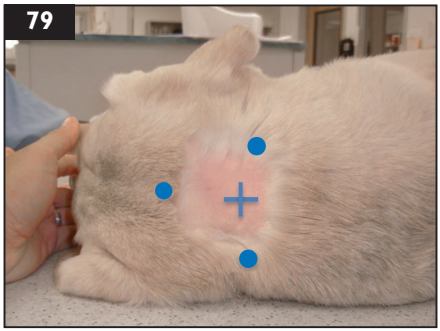
ii. An acronym for the causes of CNS disease is DAMN IT (each letter the first letter of a pathological process). List the pathologies and give an example of etiology for each of the letters.

iii. Describe how to perform a cisternal CSF tap.

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78 i. Early decompensatory (middle stage) shock; dehydration; vomiting green; abdominal pain with tubular structure; hypochloremic metabolic alkalosis; hyperlactatemia; azotemia; mild hypernatremia; mild thrombocytopenia.
ii. (1) Poor perfusion and dehydration; (2) 0.9% NaCl (due to hypochloremic metabolic alkalosis) and HES; (3) high end resuscitation end-points since SIRS is likely and no brain or lung edema or hemorrhage; (4) large volume infusion techniques.
iii. Segmental ileus of the small bowel with a FB within the lumen; the dog is not ready for anesthesia/surgery. The vena cava is very small, suggestive of inadequate intravascular volume resuscitation at this time.
iv. The use of motility modifiers and the placement of a nasogastric tube. These can also be used to initiate early (within first 24 hours) postoperative enteral nutrition.
v. Replace any residual dehydration that was not corrected preoperatively; include maintenance requirements that the patient is not ingesting on her own and account for continued losses which may occur from diarrhea (disposable urine collection pads can be measured), gastric fluid pooling (which can be measured with the nasogastric tube). Maintenance colloid therapy (20–50 ml/kg/day) may be continued as well due to potential capillary-leak disease, edema of the intestines, and continued high-protein fluid losses through (potential) diarrhea.

79 i. Cerebrum and diencephalon.
ii. **D**egenerative (e.g. leukodystrophies, hypomyelination); **A**nomalous (e.g. hydrocephalus, lysosomal storage disorders); **A**rterial/venous problems (e.g. thrombi, hemorrhage); **M**etabolic (e.g. hypoglycemia, uremia, hepatoencephalopathy); **N**eoplastic (e.g. meningioma, glioma, metastatic); **N**utritional (e.g. thiamine deficiency); **I**nfectious/inflammatory (e.g. fungal, bacterial, viral, protozoal); **I**diopathic (e.g. epilepsy); **T**raumatic (e.g. hit by car), **T**oxin (e.g. ethylene glycol, ivermectin).
iii. Ensure that there are no high cervical fractures or brain shifting through advanced imaging before a high cisternal CSF tap when possible. Anesthesia, intubation, and ventilation with 100% oxygen is initiated and an area (typically >4 × 4 cm) clipped and surgically prepared at the base of the skull overlying the atlanto-occipital foramen (**79**). The spine must be straight and parallel to the table. Flex the head (muzzle perpendicular to the spine) and locate the triangle made by the wings of the atlas and the two occipital protuberances (blue dots). Insert the needle (20 or 22 gauge spinal needle) (+) through the skin, subcutaneous tissue, and muscle slightly cranial to the center midline of that triangle, perpendicular to the spine and parallel to the table with the bevel forward. If the needle hits bone, gently move the tip caudally until it enters the subarachnoid space. A subtle 'pop' is felt passing through the ligamentum flavum and a stronger 'pop' passing into the subarachnoid space. Collect fluid by gravity flow into EDTA and clot tubes and culture media or swabs.

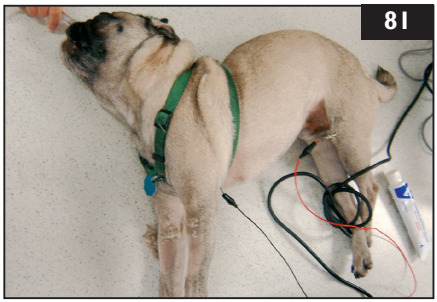

79

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80 A 2-year-old female neutered Shi Tzu is presented 30 minutes after being attacked by a big dog. The owners had attended the Pet First Aid class at your clinic and transported the dog taped to heavy cardboard (**80**). T = 38.3°C (101°F); HR = 176 bpm; RR = 30 bpm; CRT = >3 sec; MM pale pink, dry; femoral pulses very weak. The dog appears painful when touched. A 2 cm area of skin and muscle over the caudal to mid-thoracic region expands and contracts with each breath.

i. Describe what occurs with a flail chest.
ii. What would be seen on thoracic radiographs?
iii. What are indications for stabilization of a flail segment?
iv. What procedures can be done to stabilize a flail chest segment?



81 A 4-year-old male neutered Pug presents after having four severe generalized seizures (**81**). He has a history of seizures and was controlled on phenobarbital until today. Two minutes after presentation, he has one tonic/clonic seizure that lasts 30 seconds and resolves. Physical examination is normal except for mild post-ictal disorientation, which resolves within 5 minutes.

i. What recommendations are given for the dog in this acute care setting?
ii. List some options for long-term seizure control in this dog.
iii. Which antiepileptic is contraindicated in cats, and why?
iv. Match the antiepileptic drug to the mechanism of action:
(1) gabapentin; (2) zonisamide; (3) potassium bromide; (4) phenobarbital; (5) levetiracitam; (6) felbamate.
(a) Interference with presynaptic vesicles to impede calcium channel conduction. (b) Believed to promote release of GABA, decreases current through voltage-gated calcium channels, and may block formation of new synapses. (c) Depresses motor centers of the cerebral cortex by enhancement of response to GABA, inhibits glutamate release and Ca++ influx. (d) Inhibits voltage-dependent Na and T-type Ca channels. (e) Enhances postsynaptic GABA currents (moves across GABA-activated Cl channels), leading to hyperpolarization of cell membranes. (f) Inhibition of NMDA receptor-mediated Ca or Na influx and potentiation of GABA Cl^- influx.

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Answers: 80, 81

80 i. When two or more ribs are broken in two or more places, a section of the chest wall is no longer fixed to the thoracic cavity. This results in paradoxical movement of the flail segment, following the pressure differences between the pleural space and the external environment (inward movement during inspiration; outward movement during expiration).
ii. Two or more ribs fractured in two or more places. Concurrent injuries such as pneumothorax, pulmonary contusions, or atelectasis of one or more lung lobes may also be seen.
iii. Hypoxemia (SpO_2 <95%); hypoventilation ($PvCO_2$ >45 mmHg); severe pain; markedly increased effort of breathing; the segment is traumatizing the lung tissue.
iv. Pain relief is essential: systemic opioids and/or local/regional anesthetic rib blocks. Occasionally, a thoracic body bandage (or placing the patient with the affected side down) may be sufficient if external movement of the flail segment is significant and internal movement is minimal. When the flail segment is considered to be interfering with ventilation, surgical options are the preferred method of stabilization and include removal or stabilization of the segment. Non-surgical options may be required for financial reasons and include placing sutures around the broken ribs to an external splint and attaching that splint to a normal portion of the chest wall.

81 i. Hospitalization and monitoring for continued seizures. A CBC and biochemistry panel to include blood ammonia and phenobarbital level, screens for toxins, and infectious disease titers as indicated are submitted to rule out a metabolic, toxic, or infectious cause. Because there was a cluster of seizures, adjusting the anti-epileptic drugs (AEDs) is warranted. Several options are available in the hospital setting, including administering a benzodiazepine (midazolam or diazepam) as a continuous infusion, rapidly increasing blood levels of phenobarbital with an IV loading dose (2–5 mg/kg) and increasing the oral dose, or adding another AED. Propofol infusions (0.05–0.4 mg/kg/min CRI) can be administered if status epilepticus occurs. If the dog appears to have neurologic signs consistent with increased intracranial pressure, furosemide (0.75–2.0 mg/kg IV) with mannitol (0.1–0.5 g/kg IV) may be beneficial.
ii. Increasing the dose of phenobarbital (based on blood levels and presence of side-effects) or adding a different AED (e.g. potassium bromide, levetiracetam, zonisamide) is warranted.
iii. Potassium bromide. It causes an idiopathic eosinophilic pneumonitis, which can be life-threatening in a large percentage of cats.
iv. 1, b; 2, d; 3, e; 4, c; 5, a; 6, f.

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82 A 12-year-old female neutered Golden Retriever presents for vomiting digested food and clear fluid. The dog is unable to stand. T = 37.5°C (99.6°F); HR = 170 bpm with muffled heart sounds; RR = 24 bpm; CRT = 3 sec; MM pale; jugular vein distension; poor femoral pulse quality. Radiographs demonstrate a mild increase in interstitial pattern in the lungs compatible with age and a globoid enlarged cardiac silhouette. An ultrasound image from the ventral 4th rib space is shown (**82a**).

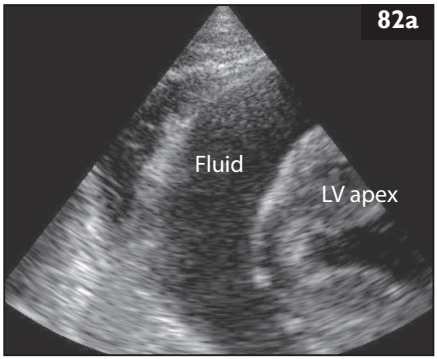
i. What is the most likely cause of the clinical signs in this dog?

ii. What procedure would you perform, and how would you do it?

iii. List differential diagnoses.

iv. After successful completion of the procedure, the dog is bright, alert, and responsive. HR = 100 bpm, indirect ABP = 134/78. An ECG is recorded (25 mm/sec) (**82b**). What is your ECG diagnosis? Explain your criteria.

v. Give indications for intervention if you see this rhythm.



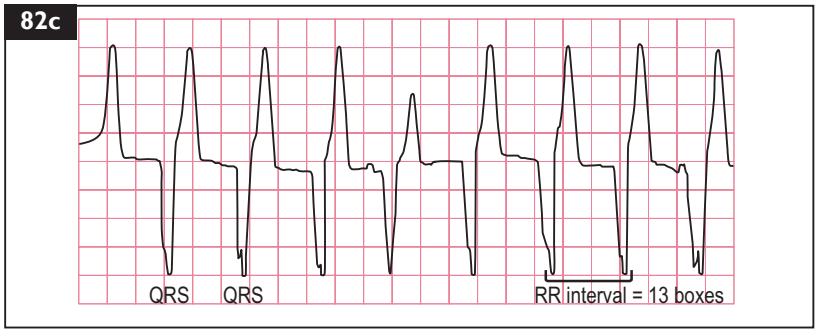


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Answer: 82

82 i. Cardiac tamponade. (Decreased ventricular preload from accumulation of pericardial fluid.)
ii. Pericardiocentesis. Clip and aseptically prepare skin on the right thoracic wall, from 2nd to 6th rib space, mid chest to ventral midline. The right side is chosen to decrease the risk of lung puncture/laceration ('cardiac notch' between right cranial and middle lung lobes) and decrease risk of coronary artery laceration. Administer a local anesthetic in skin, subcutaneous tissue, muscle at site of needle insertion. Monitor ECG for evidence of arrhythmias. Insert a 14–18 gauge 2 inch catheter or needle perpendicular to the thoracic wall in the 3rd or 4th rib space on the cranial aspect of the rib. Advance 1–3 mm after fluid is noted in the hub, attach a 3-way stop-cock and extension set, and aspirate the fluid. The needle/catheter is removed if the heart can be felt touching the catheter and/or an arrhythmia occurs. Observation and guidance by ultrasound is ideal.
iii. Ruptured neoplasm or cardiac chamber (left atrium), coagulopathy, neoplastic effusions, idiopathic pericardial effusion, right heart failure, pyopericardium (less likely).
iv. Accelerated (idio)ventricular rhythm. The QRS complex is wide and bizarre, indicating a ventricular-origin beat (rate is 1,500/13 = 115 bpm) (**82c**), which is faster than physiologic ventricular rhythm and slower than ventricular tachycardia.
v. Intervention is indicated if there is evidence of poor cardiac output, collapse, or 'malignant'-appearing rhythms such as multiform/multifocal ventricular rhythms, R-on-T phenomenon (no return to baseline), or ventricular tachycardia (typically if >160–180 bpm). With a ventricular rate of 100–140 there is often adequate cardiac output.

82c



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83 A 2.5-year-old female neutered Yorkshire Terrier presented after being bitten in the face by a St. Bernard. T = 38.6°C (101.4°F); P = 120 bpm; RR = 36 bpm; perfusion, hydration, auscultation, and palpation normal. Left eye was normal; right eye is shown (**83**).

i. Describe the abnormalities seen pertaining to the right eye.

ii. List recommended diagnostics before formulating a treatment plan.

iii. Describe the general treatment of the dog prior to knowing the test results requested above.

iv. Describe how treatment varies depending on the results of the tests done.

v. What is the purpose of topical atropine therapy?



84 A 1.5-year-old male neutered cat presented for seizures, salivation, lacrimation, and body tremors of 40 minutes' duration (**84**). The cat was treated for fleas that morning with a topical over-the-counter flea control product containing organophosphates (OPs). Primary survey finds the cat having generalized seizure activity with muscle fasciculations and extreme salivation. The pupils OU were pinpoint in size. HR = 140 bpm; CRT = 1 sec; MM bright pink. An IVC was placed and blood sampled for initial laboratory database: PCV = 0.3 l/l (30%); TS = 67 g/l (6.7 g/dl); glucose = 2.8 mmol/l (50 mg/dl); BUN = 10.7 mmol/l (30 mg/dl).

i. What is the mechanism of the clinical signs seen in this cat with likely OP toxicity?

ii. What is your immediate resuscitation plan for this cat?

iii. After the seizures have been controlled, how will you continue treatment of this cat?

iv. What products are considered safe for the treatment of fleas in cats?

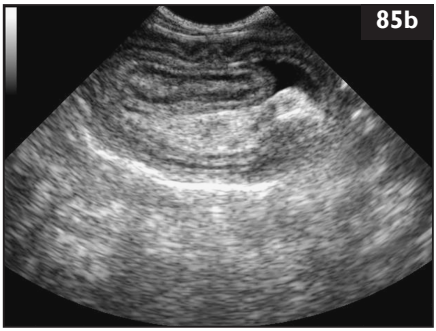
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83 i. Hyphema in the entire anterior chamber, a corneal defect (ulcer, scratch, deposit), periorbital (conjunctival) swelling, hemorrhage, and redness. Blood on fur ventral to eye could indicate a wound.
ii. Fluorescein staining of the cornea, measurement of intraocular pressure (IOP), Schirmer tear testing. Increased IOP can be a sequela of hyphema. Ophthalmic ultrasound can be done to visualize the lens, vitreous, and retinal attachment.
iii. Pain medication. The hair around the eye is clipped and the skin inspected for a bite wound. Wound care and oral antibiotics are given if there is a break in the skin. An Elizabethan collar is placed. The dog should rest and avoid strenuous activity to allow time for the blood to resorb. This patient is currently blind in this eye, temporarily if due to hyphema alone.
iv. Fluorescein stain. No stain uptake: topical ophthalmic atropine and steroids are routine for hyphema. IOP and fluorescein stain should be monitored. Stain uptake: topical ophthalmic antibiotics (NO STEROIDS), atropine +/- topical NSAIDs (flurbiprofen). IOP and fluorescein stain should be monitored.
IOP. Typically low during acute phases of hyphema. Should the pressure rise, refer to a veterinary ophthalmologist for further treatment.
Schirmer tear test. Low tear production warrants careful monitoring for tear duct injury from the trauma and careful lubrication of the cornea to keep it moist.
Ultrasound. Lens luxation, retinal detachment, and other intraocular pathology warrant specialist referral for assessment and definitive therapy.
v. It decreases pain from spasms of the ciliary muscles. By dilating the pupil, may help prevent formation of synechiae and increase aqueous flow, assisting in clearing the blood.

84 i. OP insecticides act by inhibiting acetylcholinesterase hydrolysis of acetylcholine at sites of cholinergic transmission. Accumulation of acetylcholine enhances cholinergic activity at preganglionic autonomic fibers, postganglionic parasympathetic fibers, and a few postganglionic sympathetic fibers in the CNS. Muscarinic signs that occur due to OP toxicosis include hypersalivation, increased lacrimation, urination, increased GI motility, emesis, miosis, and bradycardia. Nicotinic signs include muscle stiffness, fasciculations, tremors, paresis, and paralysis. Hypoglycemia caused by persistent muscular activity can also contribute to seizure activity.
ii. Administer dextrose IV (0.5 g/kg), benzodiazepine IV (midazolam 0.2–0.5 mg/kg), and methocarbamol IV (40–220 mg/kg IV). The goal is to reduce muscular activity, not necessarily eliminate it entirely.
iii. Atropine IV may be used to increase HR and reduce salivation q3–6h as needed. Bathe the cat and dry thoroughly. Replace hydration deficits over 4–6 hours closely monitoring blood glucose, electrolytes, and level of consciousness.
iv. Nytenpyram, lufenuron, imidacloprid, fipronil +/- S-methoprene, selamectin.

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85 A 2-year-old intact male German Shorthair Pointer presents for 9 days of vomiting after a jejunotomy for FB removal. At this time the dog will eat but vomits brown foul smelling fluid. T = 38.6°C (101.4°F); HR = 120 bpm; RR = 40 bpm; CRT = 2 sec; MM moist, pale pink; femoral pulses normal. Abdominal palpation reveals a firm, painful tubular structure. The dog vomits on abdominal palpation (**85a**). Digital rectal examination finds a pasty tarry stool. BCS is 2/9.

i. What are the potential causes of the firm tubular structure?

ii. What findings support an intestinal obstruction?

iii. What diagnostic imaging modalities can be used to evaluate the GI tract, and what are their limitations?

iv. What does the abdominal ultrasound scan show (**85b**)? What is your diagnosis?

v. What therapeutic and diagnostic recommendations do you make?

86 A 1-year-old male intact Pitbull terrier presents 30 minutes after being shot. T = 38.4°C (101.2°F); P = 110 bpm; RR = 40 bpm; CRT = 1–2 sec; MM pink; pulses strong and synchronous. Hydration appears adequate. Increased bronchovesicular sounds are present on the right side, and there are two full-thickness wounds (penetrating injuries) (**86**).



i. What is your diagnostic plan for this dog?

ii. What types of injuries may occur with a bullet wound to the thorax?

iii. Describe what happens to a bullet as it enters the body, and why this is important.

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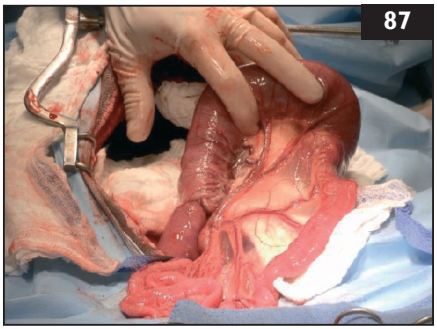
85 i. Adhesions, intestinal intussusception, intestinal volvulus, FB, neoplasia or other mass lesion.
ii. The vomitus being large volume and fetid smelling (like feces) plus the intra-abdominal firm tubular structure.
iii. Plain radiography can demonstrate gas–fluid dilation of the intestinal tract, a foreign object, and/or loss of contrast indicating abdominal fluid. Barium-enhanced contrast GI radiography demonstrates an obstruction or outlines a foreign body. Oral barium can precipitate vomiting, barium pneumonitis from aspiration, and barium peritonitis if GI perforation exists. Radiography with barium impregnated polyethylene spheres may collect at the site of obstruction, but not outline a FB. A pneumogastrogram may provide enough contrast to outline a gastric FB. Ultrasonography and CT identify bowel obstruction, identify obstructions to blood flow, demonstrate bowel wall thickness and motility, and localize the lesion(s). Ultrasonography does not require anesthesia, is less expensive, and is more readily available than CT.
iv. The segment of intestine within another segment of intestine supports a diagnosis of intestinal intussusception.
v. The dog is stabilized prior to anesthesia and surgical exploration with a combination of fluid resuscitation, analgesia, and centrally acting anti-emetics (e.g. maropitant). Preanesthetic laboratory work evaluates electrolyte, acid–base, blood lactate, organ function, and signs of severe sepsis. Nasogastric tube placement prior to anesthesia permits gastric decompression and reduces the risk of vomiting during anesthetic induction and surgery. Surgical biopsies of the affected area, fecal samples, as well as duodenal and jejunal aspirates are evaluated for evidence of parasites.

86 i. Emergency laboratory database should include PCV/TS, electrolyte/blood gas analysis, glucose, and BUN. Additional bloodwork includes full CBC, biochemistry analysis, and clotting times. Obtain thoracic radiographs +/- FAST assessment of the chest and abdomen for free fluid and air.
ii. Skin wounds, infections and FBs, subcutaneous emphysema, rib fractures, hemorrhage (into the chest, SC space, or outside of the body), hemothorax, pneumothorax, injury to the esophagus, pulmonary parenchymal hemorrhage, pneumomediastinum, arrhythmias, diaphragm and abdominal organ damage. Acute death is possible with injuries to major vessels or the heart.
iii. The bullet passes first through skin and hair; this may result in transfer of bacteria and hair into the body cavity causing infections, draining tracts, migrating or implantation of foreign objects (including fragments of the bullet). Many bullets 'tumble' (turn end over end) or fragment to maximize injury/damage to tissue; as this occurs, the direction of the projectile(s) is altered as it travels through tissues of varying densities. Therefore, bullets DO NOT travel in straight lines, so even though an entrance and exit wound may be found, the bullet is likely to have caused significant internal injury at sites outside of that direct path. Bullets transfer their energy to surrounding tissue as their energy dissipates, causing injury to surrounding tissues that the bullet or fragments did not pass through (disruption of blood supply, rupture/cavitation of organs). Life-threatening internal injuries are likely (severe hemorrhage or a ruptured hollow viscus), many of which may not be evident on initial examination.

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87 i. Fill in the following chart listing analgesic medication pertaining to the effects of the drug on the GI tract.

Analgesic medication	Effects on GI tract
Pure agonist opioids	
Benzodiazepine	
NSAIDs	
Lidocaine	
Ketamine	


87

ii. Surgery on the dog in case 85 reveals a jejunal intussusception (87). The affected segment is purple in color. How do you determine the viability of the tissue? What are the limitations to visual inspection?
iii. Why should this segment be removed *en bloc* and not reduced?
iv. What is the holding layer of the ventral abdominal incision closure? What size and type of suture do you select for abdominal wall closure in this 25 kg dog?


88

88 A 3-year-old male neutered Shepherd Dog-cross presents for a skin problem. The dog has a history of ear infections in the past, and was successfully treated 3 months ago with a topical antibiotic/antifungal/anti-inflammatory medication as well as oral cephalexin and an ear cleaner. The same signs started about 7 days ago, and the owners re-started the same leftover medications. They brought the dog in as the owner noted some crusty red lesions (88) that the dog was licking. Physical abnormalities are limited to the ventral abdominal skin. A similar lesion is noted on the lip fold.
i. Describe your diagnostic plan.
ii. What is your differential diagnoses list for these lesions?
iii. What is your initial therapeutic plan?

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87 **i.**

Analgesic medication	Effects on GI tract
Pure agonist opioids	May reduce motility, but may counteract pain-associated ileus
Benzodiazepine	Not an analgesic
NSAIDs	Reduces prostaglandin protection of gastric and proximal duodenal blood flow, whch can result in ulceration
Lidocaine	No direct effect, but may improve motility with pain-associated ileus
Ketamine	May modulate effects of ischemia–reperfusion injury of the mesentery

ii. The mesenteric vessels providing blood flow are palpated for pulses. The affected segment is observed for evidence of peristalsis. Marginal arteries in the serosa can be incised and observed for bleeding. However, the dark color may be due to transient venous congestion, and the bowel could appear to have normal perfusion in early arterial occlusion. Hypotension and vasospasm could also result in temporary lack of blood flow. Remember that peristalsis can be observed in ischemic bowel.
iii. Reducing the intussusceptions can result in release of mediators of inflammation and ischemia–reperfusion injury into the general circulation, leading to shock and potential cardiac arrest.
iv. External fascia of the rectus abdominus muscle. The linea is opposed using a 2-0 monofilament non-absorbable suture in a simple continuous or interrupted pattern. The subcutaneous layer is opposed using a 2-0 absorbable monofilament suture in a simple continuous pattern. The cutaneous layer is opposed with either a subcuticular 2-0 monofilament absorbable in a simple continuous pattern or a cutaneous closure using 2-0 or 3-0 monofilament non-absorbable suture in a continuous or interrupted pattern.

88 **i.** Skin scraping and tape preparation are easily performed and examined under the microscope. A systemic workup (CBC, serum biochemistry, urinalysis) and tick-borne disease titers may help determine if there is underlying disease present that may be a contributing factor. Biopsy and skin cultures may also be performed.
ii. Infectious disease (bacterial, fungal, parasitic), inflammatory disease (immune mediated such as systemic lupus erythematous, cutaneous drug reaction), neoplastic disease (cutaneous lymphoma or mast cell disease), trauma to the skin (abrasions), coagulopathy (thrombocytopenia, less likely), vascular disease (vasculitis, potentially secondary to tick-borne disease).
iii. The previous medications should be discontinued since cutaneous drug reaction is possible. An Elizabethan collar is placed to prevent further self-inflicted injury. Therapy is based on diagnostic findings and may include treatment for parasites, fungal organisms or bacteria; steroids and/or other immunosuppressive agents may be necessary if an inflammatory or immune-mediated disease is diagnosed.

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89

89 A 5-year-old male Terrier-cross presents 12 hours after having a seizure (**89**). The dog had urinated and was walking 'funny' before stumbling, falling on his side, and shaking. The owner tried to 'soothe' the dog, and the dog bit his hand, breaking skin and causing some bleeding. The dog seems a little disoriented and is aggressive towards you. RR is normal and his gums are pink, but that is as much of a physical examination as you are able to perform.

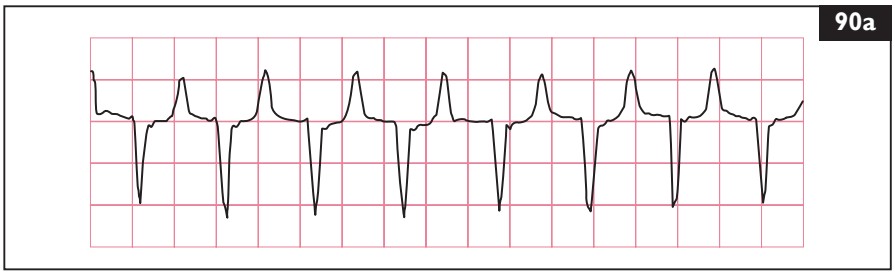
i. List major organ systems that may account for the dog's reported signs, and give at least two differentials for each.

ii. What questions and answers revealed during the history support seizure activity versus a syncopal episode?

iii. The owner elects to euthanize this dog. What must you discuss with the owner at this time?

iv. What sample must be collected, and how is it stored prior to testing?

v. What other instruction(s) do you give the owner?


90a

90 A 5-year-old male neutered cat presents for vomiting twice and is unable to walk. The cat was not eating and had been hiding for 3 days. There are no known past medical problems. One of the four household cats is urinating outside of the litter box. The cat was conscious but obtunded. T = 32.5°C (90.6°F); HR = 140 bpm; RR = 20 bpm; CRT = 1 sec; MM pink; perfusion decreased; 7% dehydrated. A very firm, non-expressible and painful urinary bladder is found on abdominal palpation. An IVC is placed, blood collected, and a lead II ECG (25 mm/sec paper speed) obtained (**90a**).

i. What is your ECG diagnosis?

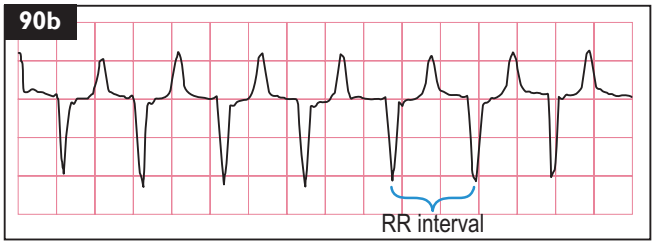
ii. Given a paper speed of 25 mm/sec, calculate the cat's HR.

iii. What is the most likely cause of this arrhythmia?

iv. What is your emergency treatment of this arrhythmia?

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89 i. Primary neurologic disease (neoplasia, inflammatory or infectious meningitis–encephalitis); severe metabolic disease (renal, liver, endocrine, hypoglycemia, electrolyte disorder); cardiovascular disease (arrhythmias, cardiomyopathy, hypertension).
ii. Was the pet acting abnormal PRIOR to the event (evidence of pre-ictal stage); was the pet acting abnormal AFTER the event (post-ictal stage); did the pet lose control of bowels or bladder; was there 'jaw chomping' or paddling (tonic/clonic) of the limbs; did the pet appear unconscious; does the dog have any prior medical history of seizures? However, the history can be identical for seizures and syncope.
iii. It is important to know the laws of your state regarding protocols for reporting and testing for rabies. In many regions, when an animal demonstrating abnormal neurologic signs bites a person, it can be a requirment to report to the health department and test the animal for rabies regardless of the animal's rabies vaccination status.
iv. The brain. Depending on regional law, the entire pet or the head separated from the rest of the animal must be prepared. The sample must be refrigerated (not frozen nor in formalin) until it can be shipped on ice to the state testing facility.
v. Instruct the person who was bitten to visit their family physician and/or an emergency care facility immediately to have the bite wound treated and to discuss possible treatment for rabies. Depending on regional law, full details pertaining to the owner of the dog that inflicted the bite may need to be reported.



90 i. Atrial standstill (absence of P waves and slow HR) with a widened QRS complex and 'tented' T waves (**90b**).
ii. (1) Measure the R-R interval (number of small boxes between two R waves) and divide 1,500 by the number of boxes. Above: 1,500/11 = 136 bpm. (2) Calculate the number of beats in 1 second (5 large boxes = 1 second). Count the number of R waves in 3 seconds (15 large boxes) and multiply by 20. There are 7 complete beats in 15 boxes, making the HR 140 bpm.
iii. Hyperkalemia is likely present secondary to the urethral obstruction.
iv. Emergency treatment of hyperkalemia includes administration of 10% calcium gluconate (0.5–1.5 ml/kg [50–150 mg/kg]) to stabilize the myosin/actin filaments and regular insulin (0.25–0.5 U/kg) and dextrose (0.5–1 g/kg) to shift potassium into non-myocardial cells. Occasionally, sodium bicarbonate (1–2 mEq/kg slow IV) is administered when severe acidosis is present as well (may cause metabolic alkalosis and hypernatremia). ECG, BP, and perfusion parameters should be monitored while giving these medications. Calcium gluconate should have an effect within minutes. Should bradycardia occur, infusion is discontinued. Dextrose and insulin will have an immediate effect, with their maximum effect in 30–60 minutes. The cat should be given opioid analgesia, IV fluids, and urethral catheterization to relieve the urethral obstruction. Cautious cystocentesis is an alternative if unable to place a urethral catheter.

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91 A 9-year-old female neutered Golden-doodle presented for a few hours of acting restless (**91**). T = 39.1°C (102.3°F); HR = 210 bpm; RR = panting; CRT = 3 sec; MM pale and dry; poor pulse quality with pulse deficits; poor perfusion (early decompensatory shock); 6–8% dehydrated (skin turgor/dry MM). Lung auscultation normal and slight upper airway stridor. Hunched posture and non-productive retching. Abdomen is normal size but very tense on palpation and tympanic on percussion.

i. What is the most likely diagnosis?

ii. When, during the initial diagnostic and therapeutic plan, should a radiograph be taken?

iii. Present the initial resuscitation plan for this dog.

iv. What are the options to relieve the cause of tympany in dogs with this syndrome? List the benefits and complications of each technique.

v. What is the initial monitoring plan?

vi. What tests are requested for the initial laboratory database for this dog?



92 A 1-year-old female neutered Yorkhire Terrier comes in for lethargy and facial swelling 5 days after playing in the dog park. T = 40°C (104°F); rest of the general physical examination normal. There is swelling and erythema ventral to the lower left eyelid, with an open puncture wound. There is no fluorescein stain uptake by the cornea. Using a transilluminator, you see a black-tipped larva moving below the puncture (**92**).

i. What is this parasite called, and how was it acquired?

ii. What is your therapeutic plan?

iii. What concerns do you relay to the owner about the process of extraction?

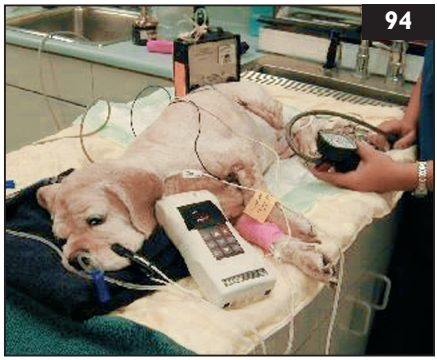
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91 i. GDV syndrome with a distended stomach completely under the caudal ribcage.
ii. Fluid resuscitation, gastric decompression, and analgesia are carried out prior to radiography, which showed a displaced pylorus and compartmentalization of the gas-filled stomach typical of GDV.
iii. Place 1–2 large-bore cephalic catheters; collect emergency database; IV isotonic balanced buffered crystalloids and HES using large volume technique to high end end-points (SIRS disease); IV analgesia using full agonist opioids. Lidocaine (2 mg/kg slow IV administered prior to fluid infusion, followed by a 24-hour 0.05 mg/kg/min infusion) has been shown to decrease hospital stay, arrhythmias, and AKI. Decompression prior to fluid resuscitation is only done when severe gastric distension is causing life-threatening hypoventilation.
iv. Percutaneous decompression of the stomach percussed beyond the caudal ribs is well tolerated with minimal restraint. Orogastric intubation relieves the stomach of large volumes of thick, tenacious material. This is best accomplished after GA and orogastric intubation to protect the airway. Complications of orogastric intubation include aspiration of gastric contents, esophageal trauma, and gastric rupture.
v. Lead II ECG, BP, pulse oximetry, serial blood lactate, level of pain, and physical perfusion parameters.
vi. PCV/TS (potential hemorrhage), glucose (hypoglycemia due to sepsis, underlying disorders), electrolyte panel, venous blood gas (acidemia, hypoventilation), coagulation profile, and blood lactate (reflects organ perfusion). Hyperlactatemia unresponsive to aggressive resuscitation can be an indication of a poor prognosis.

92 i. It is the larval stage of a *Cuterebra* fly (also called botfly). *Cuterebra* flies commonly lay their eggs on objects around animal burrows. The egg attaches to the animal's skin and body heat causes the larva to hatch. The larva enters the body through the mouth (while grooming) or a break in the skin. The presence of an air hole is common in the skin when the larva is subcutaneous. The larva can migrate through organs (e.g. brain, eye, lungs), resulting in organ-specific clinical signs.
ii. The larva needs to be extracted carefully and, because of the proximity to the eye, sedation may be required. Pain medication and systemic antibiotics are warranted. The wound is then treated as an open wound – cool compresses will decrease pain/inflammation.
iii. The larva should be extracted intact. Because it is larger than the hole, the hole may need to be incised to facilitate removal without crushing the larva. If the larva breaks open, it can result in chronic infection or an anaphylactoid reaction that can lead to multiple organ dysfunction. There are reports of dogs, especially Yorkies, who have had severe reactions that have resulted in death.

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93 The dog in case **91** is prepared for anesthesia and surgery to reposition the stomach, evaluate the integrity of the gastric wall and other organs, and assess the degree of hemorrhage.
i. What vessels are most commonly torn during a GDV episode, and where are these located?
ii. What surgical findings would indicate that a splenectomy is required?
iii. How is a splenectomy performed with an actively bleeding spleen?
iv. What are the criteria for a gastric resection in a GDV patient? How is this done?
v. List some surgical procedures that can be performed to prevent GDV in the future.



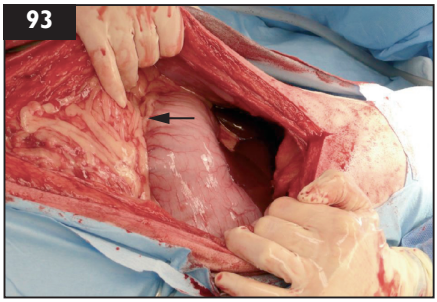
94 A 9-year-old male neutered mixed-breed dog presents for intermittent vomiting (yellow foam) for 1 week (**94**). T = 38.1°C (100.5°F); HR = 156 bpm; RR = 50 bpm; CRT = 2 sec; MM pale pink and dry; femoral pulses bounding; perfusion compensatory shock; 8% dehydrated. Thoracic auscultation is normal. Discomfort on deep palpation of cranial abdomen. Emergency database: PCV = 0.6 l/l (60%); TS = 90 g/l (9.0 g/dl); lactate = 6.2 mmol/l (55.8 mg/dl); venous blood gas: pH = 7.30; HCO_3 = 11 mEq/l; $PvCO_2$ = 28 mmHg; SaO_2 = 94% with PvO_2 = 48 mmHg.
i. Use the 5-Step Blood Gas Interpretation for the venous blood gas of this dog at entry.
ii. Make a problems list in order of priority and an initial stabilization and diagnostic plan.

An intestinal FB was removed by an anastomosis and resection of the affected bowel. The dog began exhibiting labored breathing 24 hours later. Arterial blood gas (FiO_2 = 0.4) at that time: pH = 7.23; HCO_3 = 26 mEq/l; $PaCO_2$ = 58 mmHg; PaO_2 = 63 mmHg with SaO_2 of 92%.

iii. Use the 5-Step Blood Gas Interpretation for the arterial blood gas values at this time.
iv. The PaO_2/FiO_2 ratio can be calculated as an index of oxygenation. By definition, what is the difference between the PaO_2/FiO_2 ratio in veterinary patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS)? What is likely in this dog?
v. List pulmonary and non-pulmonary causes of ALI and ARDS.

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Answers: 93, 94

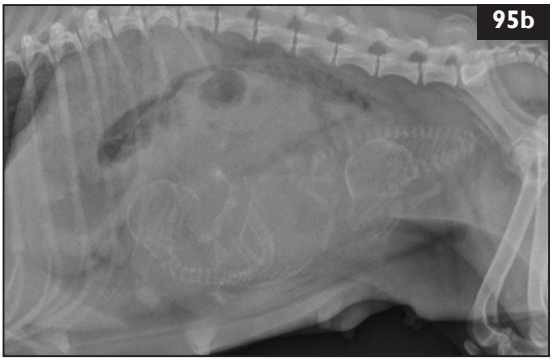


93 i. The short gastric arteries and the left epiploic artery along the greater curvature of the fundus (**93**). The site of the incisional gastropexy attaching the right pyloric antrum to the right body wall (arrow) is shown.
ii. Dark/black areas suggesting infarction/ischemia, lack of palpable pulses in the splenic hilus suggesting arterial thrombosis, disseminated masses possibly neoplastic, bleeding mass, uncontrolled splenic hemorrhage.
iii. Active splenic hemorrhage requires immediate clamping of the major vessels supplying and draining the spleen using hemostatic or Carmalt clamps. The spleen is removed followed by ligation of individual splenic vessels.
iv. Include ischemia (gray or black color of gastric wall) and lack of pulsatile blood flow when incised. Gastric resection is performed by excision of devitalized tissue and resection or by using a thoracoabdominal stapling device. Inversion of devitalized tissue leaves necrotic tissue and, possibly, uncontrollable hemorrhage. Discoloration so extensive that viable tissue cannot be incorporated in the closure line requires the stomach be left alone. A closed suction drain is placed over the area prior to closure. Fluid can be collected to analyze for gastric leakage postoperatively.
v. A gastropexy attaching the pyloric antrum to the right body wall is typically performed using non-absorbable suture. Other good options include an incisional, circumcostal, tube gastrostomy or belt-loop technique.

94 i. (1) Not acute; systemic problem with hypoxic tissues (shock, hyperlactatemia); (2) pH low – acidemia; (3) HCO_3 low – metabolic acidosis; (4) $PaCO_2$ low – compensated (using 35 mmHg as normal); (5) low normal SaO_2 – consider oxygen supplementation.
ii. Poor oxygenation (SpO_2 94%), poor perfusion (peripheral physical perfusion parameters); hyperlactatemia; compensated metabolic acidosis; dehydration (increased PCV/TS); hyperviscous blood (increased PCV/TS); vomiting yellow foam; cranial abdominal pain. Initial plan: flow-by oxygen; IVC placed; draw blood for CBC and biochemical profile; crystalloids/HES infusion large volume technique to high end end-points (SIRS dog); opioid analgesics; monitor BP; physical perfusion parameters; repeat PCV/TS, lactate; abdominal radiographs, ultrasound.
iii. (1) Acute, respiratory; (2) pH low – acidemia; (3) $PaCO_2$ high – respiratory acidosis; (4) HCO_3 high – compensated (acute respiratory – HCO_3 increases 0.1–0.15 mEq/l for each 1 mmHg increase $PaCO_2$); (5) hypoxemia. Diagnosis: acute compensated respiratory acidosis with hypoxemia.
iv. PaO_2/FiO_2 ratio for ALI is <300 and for ARDS <200. This dog has a PaO_2/FiO_2 ratio of 63/0.4 = 156; likely ARDS.
v. Pulmonary: hematogenous or aspiration pneumonia, trauma, inhalation of noxious gases, volutrauma or barotrauma during assisted ventilation. Non-pulmonary: SIRS, sepsis, heat stroke, envenomation, asphyxiation, electrocution, head trauma.

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95 A 2-year-old female Chihuahua has been straining for 4 hours in an attempt to deliver her pup (**95a**). A small amount of green discharge is coming from her vulva and a portion of a puppy can be palpated (not head or back feet). Blood calcium and glucose concentrations are normal. A right lateral radiograph is obtained (**95b**).
i. Describe the abnormal presentation of the pup in the radiograph.
ii. How may this puppy be helped without surgery?
iii. What percentage of puppies are born with the hindlimbs exiting first?
iv. Which anesthetic medications have been associated with increased fetal mortality and should be avoided during anesthesia?
v. What are the advantages/disadvantages of ovariohysterectomy at the time of cesarean section?
vi. What are the advantages/disadvantages of '*en bloc*' removal of the ovaries and uterus with the puppies inside?
vii. Describe care of the immediate postpartum neonate.
viii. What parameters are assessed for canine neonate 'APGAR' score? What is a normal score?

96 A 13-year-old male neutered DSH cat presents after sustaining a wound when his tail was accidently caught in a closing door, avulsing 3 cm of skin off the tip of the tail. He has a history of losing weight despite a voracious appetite. On presentation he is highly agitated and has open-mouth breathing. T = 39.6°C (103.4°F); HR = >300 bpm; RR = >60 bpm; CRT = 1 sec; MM bright pink; approximately 4% dehydrated based on sticky MM. You feel an enlarged thyroid gland. The midazolam administered to calm the cat had little effect. Indirect SABP = 250 mmHg. BCS = 3/9.
i. What are this cat's most significant problems?
ii. What do you believe is causing his cardiovascular signs?
iii. What are the most immediate risks?
iv. What is your immediate plan to treat the most life-threatening problems?

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95 i. Lateral deviation of the head +/- forelimb.
ii. If an open cervix and no fetal distress (fetal HR >160 bpm), rectal or vaginal manipulation can push the puppy back into the uterus to straighten the head/neck/forelimb(s) for natural delivery.
iii. 40% (considered normal in dogs).
iv. Ketamine, alpha2 agonists (dexmedetomidine, xylazine), barbiturates (thiopental, thiamylal).
v. Advantages: prevent future pregnancies; eliminate postpartum metritis. Disadvantages: longer surgical/anesthesia time; increased blood loss (from engorged uterus).
vi. Advantages: decreased surgical/anesthesia time and decreased placental fluid contamination of the abdomen. Disadvantage: puppies have increased risk for hypoxia and mortality.
vii. An assistant will immediately suction the airway and rub the puppy to dry and stimulate it. DO NOT swing the puppy. Keep the puppy warm, give an APGAR score, and identify (i.e. colored collar). A drop of naloxone under the tongue can reverse narcotics used in the bitch. A 25 gauge needle placed in the nasal philtrum (GV26 acupuncture point) or doxapram can stimulate respiration; flow-by oxygen, mask ventilation or intubation, and manual ventilation may be needed. Ligate the umbilical cord WITHOUT traction and swab stump with tincture of iodine. Start nutrition (and colostrum ingestion) within hours of birth. CPR requires intratracheal or intraosseous drugs after starting cardiac compressions.
viii. Activity/muscle tone, pulse or HR, reflexes when stimulated, MM color, RR. Scoring of each: 0 (absent), 1 (decreased), or 2 (normal) with normal a total score of 7–10. Lower scores are associated with lower survival rates and more intensive care.

96 i. Tachycardia, tachypnea with open-mouth breathing, and hypertension.
ii. Most likely a hyperthyroid storm. Acute, excessive release of thyroid hormone is causing beta adrenergic overstimulation, leading to increased HR and vasoconstriction. There could also be a component of pain from the trauma sustained.
iii. Myocardial hypoxia, since there is reduced cardiac filling time. Spontaneous bleeding into an essential organ (retinas, brain, heart) can occur as a result of the hypertension.
iv. Place an IVC and administer analgesia (e.g. methadone, 0.1–0.5 mg/kg), followed by administration of a beta-blocker (e.g. short acting esmolol, 50–100 µg/kg bolus every 5 minutes [up to 500 µg/kg/min], then 50–200 µg/kg/min CRI; or long-acting propranolol 20–60 µg/kg over 5–10 minutes) with continuous ECG and BP monitoring for reduction in HR and BP into acceptable ranges (HR <240 bpm, SABP <180 mmHg).

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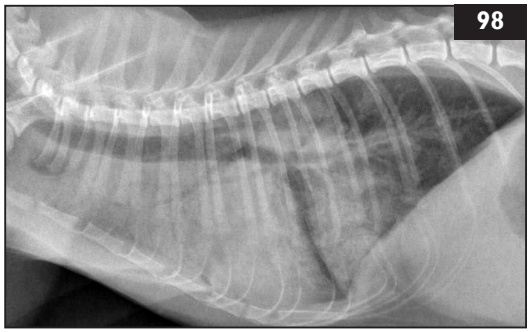
97 On Monday morning, after a busy weekend, a 3-year-old male neutered Pointer is brought in to see you. The owners have just returned from a 6-day vacation. They left the dog with a sitter, who accidentally let him into the garage where there was rat poison. The dog has bounding pulses, pale gums, and is extremely lethargic. He is in marked respiratory distress with dull, muffled lung sounds ausculted bilaterally. T = 38.3°C (101°F); P = 180 bpm; RR = 50 bpm.

i. You suspect this dog is bleeding into the thoracic cavity because of an anticoagulant rodenticide toxicity. What is your immediate therapeutic plan?

ii. The busy weekend has left you without any hemoglobin/RBC-containing blood products, but you determine this dog requires immediate intravascular volume and oxygen carrying capacity. Describe how you could perform an autologous blood transfusion.

iii. What other therapy would you institute immediately?

iv. How can you confirm the suspected anti-coagulant rodenticide toxicity?



98 A 9-year-old male neutered Sphinx cat presents for labored breathing. He has a history of heart murmur, but has never had a cardiac evaluation. T = 35°C (95°F); HR = 120 bpm; RR = 60 bpm; CRT = 2 sec; MM pale; perfusion assessed as poor; 5% dehydrated based on dry MM. The cat has a labored inspiratory effort with a choppy, asynchronous breathing pattern and an occasional gag. Thoracic auscultation finds the lung sounds muffled in all fields; cardiac auscultation is not possible.

i. What is the cat's most life-threatening problem, and what is the tentative diagnosis?

ii. What is your immediate treatment plan?

iii. The cat begins to cough and gag, and respiratory arrest appears imminent. What is your immediate response?

iv. A large volume of pink foamy fluid was suctioned from the trachea. The therapeutic intervention is productive. What is the working diagnosis and the next diagnostic step?

v. Evaluate the right lateral thoracic radiograph shown (**98**).

vi. An echocardiogram is performed. Fractional shortening is low (0.14), the left ventricular walls are thin, and the left and right atrial and ventricular chambers are dilated. What is your diagnosis?

vii. What medications might improve this cat's immediate outcome?

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97 i. Mask oxygen; IVC placed; a mild sedative (0.2–0.4 mg/kg butorphanol IV); 4-Step Fluid Resuscitation Plan: (1) perfusion deficit; (2) combination of isotonic balanced crystalloid and colloid (whole blood ideal); (3) low normal end-point resuscitation goals because of bleeding and lung fluid; (4) small volume infusion technique. Perfusion may not improve until pleural fluid drained and RBCs/hemoglobin given. Bilateral thoracocentesis can evacuate the pleural space until breathing effort and oxygenation have improved.
ii. Clip and aspectic preparation of thoracocentesis site; local block with lidocaine; pleurocentesis with 16–20 gauge needle or catheter, ensuring tip does not damage lung; aspirate blood through an extension set and 3-way stop-cock into a syringe (**97**). The blood is then transferred into an empty sterile bag or a commercial blood donation bag. A blood filter is attached to the bag and the blood given IV for resuscitation.



iii. Oral or injectable vitamin K_1. If whole blood is not available, administer plasma (frozen, fresh frozen, or stored) to immediately provide coagulation factors (from anti-coagulant rodenticide toxicity).
iv. Prolonged PT, history, response to therapy, and lack of other disease are suggestive. Blood samples may be saved for measurement of anti-coagulant levels. Proteins inhibited by vitamin K antagonist test.

98 i. Pleural space disease, either fluid or air.
ii. Oxygen support, sedation (e.g. butorphanol, 0.4 mg/kg IV or IM) to reduce the work of breathing and oxygen demand, injectable furosemide (2–4 mg/kg IV or IM or 0.75 mg/kg/hr × 6 hr IV) to reduce preload. An IVC is placed. Thoracocentesis is planned (with ultrasound guidance if available).
iii. Imminent respiratory arrest: administer a sedative and rapid acting anesthetic with minimal cardiovascular effects (e.g. etomidate); intubate the trachea; rapidly suction the trachea and ventilate with 100% oxygen by Ambu bag. Thoracocentesis is done immediately and prior to any imaging.
iv. The cat is most likely suffering from CHF. The echocardiogram will characterize the cardiac changes and direct treatment.
v. Heavy ventral soft tissue infiltrate with air bronchograms (alveolar pattern); cardiac silhouette obscured by summation effect caused by the lung infiltration. Supportive of pulmonary edema, inflammation, or hemorrhage.
vi. Dilated cardiomyopathy.
vii. Dobutamine CRI to improve inotropy via beta1 adrenergic activity, cardiac output, and reduce ventricular diastolic pressure; preload altered with injectable furosemide; afterload by nitroprusside CRI (if adequate BP) or an ACEI. Pimobendan can be administered to improve inotropy and vasodilate as the cat is weaned from dobutamine.

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99

99 A 5-year-old male German Shepherd Dog presented approximately 10 minutes after being stabbed in the chest. The owner had tied the dog outside a mini market for 5 minutes and returned to find the dog standing with a knife in his side (**99**). Small drops of blood were found on the dog's hairs and and on the sidewalk. T = 38.4°C (101.2°F); HR = 160 bpm; RR = panting; CRT = 1 sec; MM dark pink, dry; skin turgor normal; femoral pulses bounding. The entire knife blade is firmly embedded in the chest. No other external wounds visible.

i. Provide general guidelines for the transport of an animal with a penetrating foreign body.

ii. Provide an initial diagnostic and therapeutic plan for this dog.

iii. The knife blade is totally embedded within the paravertebral muscles with no penetration into the pulmonary cavity. How do you remove the blade?

iv. What complications are anticipated?


100

100 A 3-year-old male Labrador Retriever presented for skin 'lumps' that occurred 30 minutes after the dog was digging in the flower garden. T = 39.4°C (103°F); HR = 168 bpm; RR = 38 bpm; CRT = 1 sec; MM bright red; femoral pulses bounding; thoracic auscultation and abdominal palpation findings normal. There are large urticaria over the body, with facial edema and swelling (**100**).

i. What is the mechanism for the formation of urticaria?

ii. List at least four causes of acute urticaria.

iii. Provide a problems list for this dog.

iv. Provide a treatment plan.

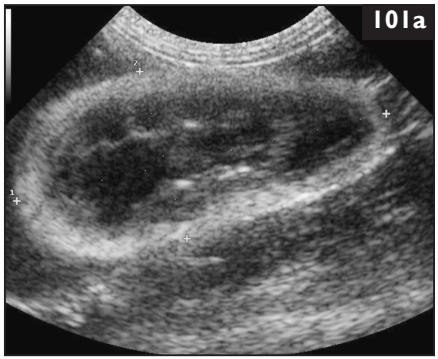
v. What follow-up is required after initial treatment?

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99 i. The owners should be instructed NOT to remove the foreign object. If the handle portion of the object is excessively long (e.g. an arrow) a portion may be clipped to prevent further damage. The dog should be gently restrained to prevent the object moving and entering the body further.
ii. Should include oxygen therapy, placement of an IVC, IV opioid analgesia administration, +/- mild sedation and fluid resuscitation following the 4-Step Plan. Initial diagnostics include an emergency database and pulse oximetry with indirect BP measurement. Following stabilization, a FAST scan is used to examine for fluid and air. Eventually, CBC, serum biochemical analysis, and thoracic radiography should be done.
iii. The entire thorax should be clipped free of hair and prepared for surgery, as a large approach may be necessary to control hemorrhage. The dog, when stable, should be induced with rapid-acting injectable medications (propofol and/or ketamine/benzodiazepine), orotracheally intubated, and maintained on an inhalant anesthetic agent. Anesthetic monitoring should include BP, ECG, SpO_2, and $ETCO_2$. A surgical approach to identify the deepest portion of the blade is necessary. It should be slowly removed, controlling hemorrhage with ligatures and electrocautery as necessary. The wound may be closed primarily or a drain may be necessary. Broad-spectrum antibiotics should be administered.
iv. The chest cavity may need to be entered. Bleeding is the primary concern while removing the blade and for the first 12 hours after its removal. Infection is possible with a deep penetrating wound. Seroma formation is possible if a large amount of dead space is present.

100 i. An inflammatory reaction in the skin causes release of histamine and cytokines from cells, resulting in leakage of the capillaries in the dermis. The interstitial fluid accumulation persists until absorbed by surrounding cells.
ii. Allergic, immune-mediated, drug-related, infectious, cold exposure.
iii. Compensatory stage shock, fever, facial edema, urticaria.
iv. 4-Step Fluid Resuscitation Plan. Step 1: perfusion abnormality. Step 2: isotonic balanced crystalloid and HES (hetastarch, tetrastarch). Step 3: high end resuscitation end-points. Step 4: large volume fluid infusion techniques (allergic reaction and anaphylaxis are SIRS problems); IV glucocorticosteroids (e.g. dexamethasone, prednisolone). Diphenhydramine can be administered if continued histamine release is anticipated. It is unknown whether this 'allergic reaction' might become 'anaphylactic', justifying aggressive restoration of intravascular volume at this stage of therapy.
v. A second exposure to the inciting allergen could result in more severe and even life-threatening problems. The owners should search the backyard for bees and other potential allergens and make every effort to protect the dog from future exposure. The owners may be instructed on the use of epinephrine should a second exposure result in anaphylaxis at home.

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101 A 4-year-old intact male Cockapoo presented for increased drinking and urination, anorexia, and vomiting white foam for 1 day. The owner added antifreeze (ethylene glycol [EG]) to his car a few days ago. TPR normal; femoral pulses strong; perfusion adequate, estimated 8% dehydrated (skin turgor/dry MM). Mild pain on kidney palpation. PCV = 0.54 l/l (54%); TS = 90 g/l (9.0 g/dl); remainder of CBC normal. Biochemical profile abnormalities: BUN >46.4 mmol/l (>130 mg/dl); creatinine >1,326 µmmol/l (>15 mg/dl); PO_4 >5.2 mmol/l (>16 mg/dl). Venous blood gas showed metabolic acidosis. Abdominal radiographs normal. Ultrasonography found a small amount of free fluid around the kidneys and bladder and abnormal renal images bilaterally (**101a**, right kidney). Urinalysis: SG = 1.008; 2+ proteinuria; sediment: occasional coarse granular cast, occasional calcium oxalate crystal.

i. What abnormalities are present in the ultrasound image of the kidney, and what is the significance?

ii. What additional tests are recommended to aid the diagnosis and treatment of this dog?

iii. Discuss the mechanism of renal toxicity from EG and the clinical signs anticipated after ingestion.

iv. Discuss the mechanism of action of ethanol and 4-methylpyrazole in the treatment of EG ingestion. Give pros and cons for each.

v. Discuss any adjuncts to antidotal therapy, and include the pros and cons of hemodialysis (HD) and peritoneal dialysis (PD) in the treatment of EG.

102 A 5-year-old male neutered Bichon Frise presents for difficulty eating after playing with a stick in the backyard. The dog has a problem with prehension and mastication of the food. General physical examination is normal. Neurologic examination findings: normal mentation; normal pupillary light responses, direct and consensual, normal facial sensation; normal movement of the lips, eyelids, ears; normal sensation to cornea; normal eye movements; normal gag reflex and tongue movement; bilateral jaw drop. The gait and limbs are normal.

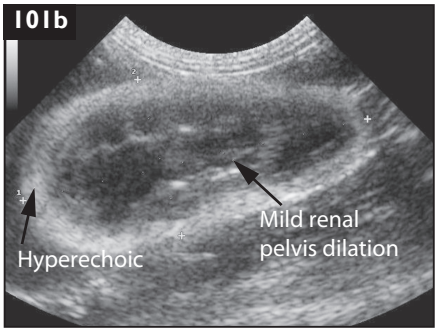
i. Localize the lesion within the nervous system.

ii. Provide a list of possible causes for this problem.

iii. What therapy is recommended specifically for this problem?

iv. What supportive care is likely necessary?

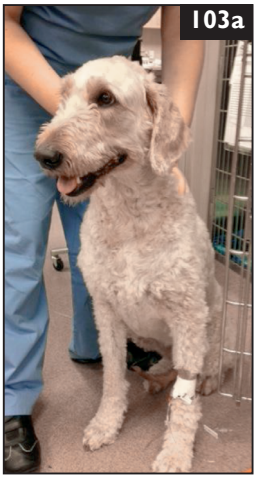
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101 i. Hyperechoic (bright) cortex associated with acute tubular necrosis and renal mineralization (e.g. EG toxicosis) and mild renal pelvis dilation (**101b**) associated with diuresis, pyelonephritis, or hydronephrosis.
ii. Bilateral renal problem suggests renal toxin, infectious disease, or lymphoma. Many renal toxins (e.g. lilies, raisins, grapes) do not have specific tests. With AKI already present, cageside EG tests may no longer be positive.
iii. EG causes gastric irritation and CNS depression; the byproducts of EG metabolism are responsible for most of the signs. Glycoaldehyde causes CNS dysfunction, glycolic acid is responsible for acidosis, and glycoaldehydate and glycoxylate have a direct cytotoxic effect on renal cells. The end-product is calcium oxalate, which deposits into renal and other tissues causing AKI. EG and its metabolites are osmotic agents causing increased fluid loss and, potentially, hypotension. Three stages of clinical signs are described. Stage 1 (0–12 hours): neurologic and GI signs (dementia, stupor, coma, vomiting, diarrhea, anorexia); stage 2 (12–36 hours): hypocalcemia, acidosis, muscular and cardiac signs; stage 3 (24–72 hours): AKI with oliguria.
iv. Both inhibit alcohol dehydrogenase metabolism of EG: 4-MP inhibits the enzyme; alcohol is a competitive inhibitor. Both are effective when EG is still present and do not eliminate EG metabolites.
v. Balanced isotonic crystalloids, anti-emetics, parenteral thiamine, and pyridoxine decrease oxalic acid formation. HD and PD remove EG, glycolic acid, oxalic acid, and other products of EG metabolism from the blood.

102 i. Bilateral peripheral nerve pathology of the mandibular branches of the 5th cranial nerves.
ii. Trauma, inflammation, fracture, and idiopathic trigeminal neuropathy (demyelination and degeneration) affecting the mandibular branches of CN5 bilaterally. Bilateral trauma of peripheral CN5 likely occurred in this dog from chewing on the stick. However, other causes of peripheral neuropathies (e.g. rabies and tetanus) must be ruled out.
iii. There is no therapy specific for this problem. Trigeminal neuritis usually resolves within 2–8 weeks. There is little evidence to support the use of steroids.
iv. Nutritional support and maintenance of hydration are key elements of therapy. Hand or syringe feeding may be adequate, but if not, an esophagostomy, nasoesophageal, or gastrostomy tube can be placed and maintained for many weeks. Physical therapy and, potentially, acupuncture may be recommended adjuncts to therapy.

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103 A 5-year-old female neutered Golden Labradoodle presents for tachypnea and difficulty breathing (**103a**). Two days ago, the owners noticed she seemed uncomfortable when jumping and has been lethargic since. She tried to vomit twice but only a small amount of clear fluid came up. T = 40.2°C (104.4°F); P = 128; RR = 84; MM light pink. There are muffled lung sounds ventrally on the left. Perfusion and hydration appear normal. A ventrodorsal thoracic radiograph is obtained (**103b**).
i. What is your radiographic interpretation?
ii. What is your differential diagnosis?
iii. What further tests can be performed to confirm your diagnosis?
iv. What are the five causes (general categories) of hypoxemia? Define each, and discuss which is/are affecting this dog.
v. Discuss how you would monitor the dog after surgery.
vi. How can you provide continued pain relief to this dog (assuming normal renal and liver function)?

104 i. How should a CSF sample be handled? What parameters are evaluated? Provide normal values for the dog and cat.
ii. CSF results for a dog with altered mentation and neck pain are suggestive of steroid-responsive meningoencephalitis. What is this, and how is it treated?

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103 i. There is a soft tissue density in the region of the caudal portion of the left cranial lung lobe; the heart appears to have normal size and position.
ii. Includes lung neoplasia, pneumonia, lung lobe torsion, granuloma, atelectasis.
iii. Ultrasound for fluid and to evaluate the structure of the mass, CT scan, bronchoscopy, thoracocentesis, or surgical exploratory; additional diagnostics may include CBC, coagulation profile, and urinalysis as a preanesthetic screen. This dog had a lung lobe torsion and was taken to surgery for a lung lobectomy
iv. (1) Low FiO_2 – environmental oxygen level is low. (2) Hypoventilation – not moving air in and out of the lungs. (3) V/Q mismatch – air flow through the lungs does not match blood flow through the lungs. (4) Shunt – anatomic shunt of blood from the right side to the left side or when V/Q mismatch is complete. (5) Increased diffusion barrier; relatively rare in veterinary medicine and occurs when pulmonary interstitial space is increased. This dog is suffering from V/Q mismatch with blood flow through the lungs, but no ventilation (some may consider this a shunt as well).
v. RR and effort, pulse oximetry, thoracostomy tube suction (decrease frequency as patient's condition dictates), level of pain q1–2h during immediate postoperative period. Consider checking arterial blood gas, lactate, electrolytes, and PCV/TS approximately q2–6h after surgery and BP/ECG q4–6h.
vi. Perioperative opioid injections or continuous infusions are appropriate (with or without ketamine and/or lidocaine infusion); regional lidocaine/bupivacaine block at the caudal aspect of the ribs associated with the thoracotomy and chest tube sites. NSAIDs may be administered via injection or by mouth. Adjuvant analgesia (tramadol, gabapentin, or amantadine) may be administered.

104 i. Gently, and processed within 30 minutes of collection. Cell count, cytologic examination, and TP are done. Add a preservative or autologous serum protein (patient plasma: 30–100 µl autologous serum to 250 µl of CSF) to a portion of the sample to extend cell life. In-house cell counts are done with a hemocytometer owing to the low cell numbers in CSF. To preserve cell architecture, use cytocentrifugation for slide preparation. Sedimentation techniques are described if cytocentrifuge is not available. TP is quantitated from a sample without added serum. Additional cultures, PCR testing, or titers for infectious agents can be performed to find a diagnosis. Dog: normal nucleated cell count = 0–2 cells/µl (>4 cells/µl abnormal); cat: <3 cells/µl. Normal for both dogs and cats: TP <30 mg/dl (300 g/l); unreactive macrophages (monocytic type cells) predominate with fewer small mature lymphocytes; neutrophils <1–2% of non-blood contaminated sample cells.
ii. Can occur in dogs of any age and breed and might represent mild cases of steroid-responsive meningitis/arteritis, viral infection, immune-mediated disorder, or other form of meningoencephalitis. Suspect when CSF shows leukocytic pleocytosis and/or elevated protein. Glucocorticosteroids are given and often either trimethoprim–sulfa and/or doxycycline pending culture or other infectious agent titers.

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105 A 2-year-old female Yorkshire Terrier presents for onset of tremors starting this evening (**105**). T = 40°C (104°F); HR = 160 bpm; RR = 60 bpm; CRT = 1.5 sec; MM pink, moist; perfusion and hydration adequate. She is mentally alert and appropriate, but is having whole body tremors. It is difficult to perform a peripheral neurologic examination, but cranial nerve examination is normal.

i. Provide a differential diagnosis for acute onset of whole body tremors.

ii. Tremors can present life-threatening problems for this dog. Why?

iii. Provide a plan for immediate stabilization and treatment.

iv. After careful questioning, the owner remembered that she had dropped her child's baclofen tablets at home, which the dog could have ingested. How is this intoxication treated?



106 A 3-year-old male neutered Golden Retriever presents for acute breathing difficulty after falling from the porch while playing with another dog (**106**). T = 38.7°C (101.6°F); HR = 130 bpm; RR = 48 bpm; CRT = 1–2 sec: MM blue-tinged; pulses synchronous with heart but weak; perfusion poor; not clinically dehydrated. The dog is open-mouth breathing with an asynchronous (chest/abdomen moving in opposition) breathing pattern. Thoracic auscultation reveals no air movement over lung fields bilaterally and quiet heart sounds. The dog appears barrel chested.

i. Localize the lesion. Provide a differential diagnosis for the clinical signs.

ii. What single test can make the diagnosis?

iii. The dog is sedated with 0.4 mg/kg butorphanol, an IVC placed, and a pleurocentesis procedure performed. Using an 18 gauge needle, you have been aspirating air and have not reached a negative pressure after 5 minutes; the dog becomes more agitated, gasping for air. What is likely occurring, and what must be done immediately?

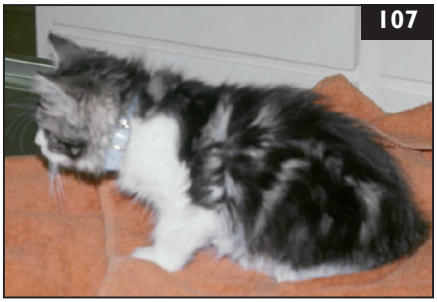
iv. Discuss the advantage of using injectable versus mask inhalant anesthetic induction to place a thoracostomy tube.

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105 i. Includes: hypocalcemia, hypoglycemia, white shaker dog syndrome, toxin ingestion (e.g. mold, chocolate, organophosphates, bromethalin, permethrin/pyrethrin, strychnine, illegal drugs such as amphetamines and cocaine, and some toxic plants), medication ingestion (e.g. pseudephedrine, baclofen, antidepressants, ADHD medication, metronidazole, theophylline, aminophylline, ivermectin, local anesthetic toxicity), and, less likely, bacterial and viral encephalitis, seizures, and other neuromuscular disorders. Fear, pain, and anxiety are considered.
ii. Secondary problems include severe hyperthermia with protein denaturation, coagulopathies, brain damage, poor fluid intake and increased losses, inability to guard the airway, and hypoglycemia.
iii. Place an IVC and begin maintenance fluid infusion with balanced isotonic crystalloids. Mild to moderate tremors may be controlled with parenteral administration of muscle relaxants (e.g. benzodiazepines, methocarbamol); severe generalized tremors can require GA (e.g. propofol or barbiturates). Blood glucose, potassium, and calcium are supplemented as needed and light, sound, and touch stimuli minimized. Consider GI decontamination if toxin or medication is a possibility.
iv. GI decontamination by gastric lavage with anesthesia, intubation, and ventilation. Oxygen support and ECG monitoring as diazepam (0.5–1.0 mg/kg slow IV, to effect) is given as drug of choice for baclofen-induced seizures. Cyproheptadine hydrochloride (1.1 mg/kg PO or rectally, as needed) can reduce vocalization or disorientation. Additional sedation (propofol) may be necessary. Anecdotal use of 20% IV lipid solutions has been reported as well (1.5 ml/kg bolus then 0.25 ml/kg/hr for 1 hour).

106 i. The breathing pattern and lack of lung sounds on auscultation support pleural space disease. The barrel chested appearance and sudden onset bring concern for a traumatic tension pneumothorax with air from blunt thoracic trauma and a ruptured airway. Blood from a coagulopathy or blunt trauma, fluid from right heart failure, neoplasia, or infection, and diaphragmatic hernia are other possibilities.
ii. Diagnostic and therapeutic pleurocentesis. Taking radiographs of this dog now will stress him, increasing oxygen demand during an oxygen depleted state.
iii. Tension pneumothorax (a large tear in the lung or airway acting as one-way valve letting air in but not out): make a mini-thoracotomy incision to immediately relieve tension and insert a thoracostomy tube the diameter of the mainstem bronchus through the mini-thoracotomy site. This must be continuously aspirated or attached to an underwater suction system for continuous aspiration.
iv. Immediate control of the airway can only be facilitated with rapid, injectable anesthesia. Mask induction requires time with the anesthetic promoting apnea and hypoxemia without adequate anesthesia for intubation and assisted ventilation. The initial excitatory phase of inhaled anesthesia as well as the pleural space disease may result in inadequate ventilation for induction. Personnel will also be exposed to the gas anesthetic.

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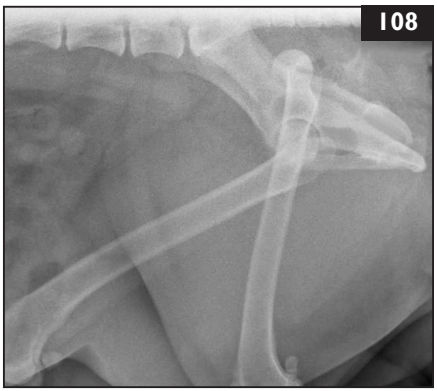
107 A 12-week-old male DSH kitten presented for sudden onset of blindness, seizures, and vocalization (**107**). The kitten was normally fed a high-quality canned organic kitten food, but 4 hours prior to presentation he was fed cooked liver from a free-range organic chicken. Neurologic findings were the only abnormalities on physical examination: fixed dilated pupils, no menace or dazzle response, vocalizing continuously, altered mentation, and head pressing on a kennel wall. Two severe generalized seizures occurred within an hour of presentation. Laboratory emergency database: PCV = 0.3 l/l (30%); TS = 50 g/l (5.0 g/dl); glucose = 6.1 mmol/l (110 mg/dl); BUN = 5.4 mmol/l (15 mg/dl). Electrolytes and venous blood gas normal. The owners had stomach cramps and had to leave to go to the human emergency room.

i. Provide a differential diagnosis for the acute onset of the neurologic signs in a young kitten.

ii. What is significant in the history to provide clues to a diagnosis?

iii. Based on the differential diagnosis, what therapy may be administered and have significant clinical improvement expected within hours?

iv. What treatment could be given that is specific for the suspected toxin?



108 A 1-year-old male neutered Labrador-cross presents after being struck in the hind end by a car travelling at 40 kph (25 mph). The only abnormality on physical examination is a non-weight-bearing lameness of the right hindlimb with internal rotation of the paw. You obtain radiographs (**108**, lateral view).

i. What is your radiographic diagnosis?

ii. What treatment options are available for this problem?

iii. What is the success of a non-surgical option?

iv. Describe how to perform the non-surgical procedure.

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Answers: 107, 108

107 i. Metabolic: hypoglycemia, hepatic encephalopathy; nutritional: thiamine deficiency; infectious, inflammatory: encephalitis (e.g. toxoplasmosis, viral, parasitic). Toxic: lead, drug toxicity, ethylene glycol; trauma; vascular accident (e.g. coagulopathy).
ii. Sudden onset of dramatic signs warrants initial concern for toxicity, trauma, or hypoglycemia. High lead levels have been found in some range-fed chickens because of lead shot in water sources and chickens pecking around lead pipes and paint chips. Highest lead concentrations will be found in the liver and kidneys and this kitten ate the chicken liver. The owners ate the meat and had stomach cramping, potentially from lead exposure.
iii. Glucose and thiamine can be administered IV; lactulose (orally and by enema) can be given if encephalopathy is suspected; chelation therapy for lead toxicity (see below); steroid and antibiotic that crosses blood–brain barrier for encephalitis.
iv. Calcium-disodium ethylenediaminetetraacetic acid (EDTA) IV or succimer (DMSA) PO for chelation of lead.

108 i. Dorsal (and slightly cranial) luxation of the coxofemoral joint.
ii. Closed reduction, open reduction, femoral head ostectomy, limb amputation.
iii. About 50% of closed reduction attempts are unsuccessful and will reluxate. Success can depend on concurrent injuries and anatomy of the coxofemoral joint of the injured dog.
iv. Stabilize with an IVC, crystalloid fluids, an opioid analgesic, and, possibly, a muscle relaxant (e.g. benzodiazepine, methocarbamol). Once stable, place the patient under general anesthesia (ideally within the first 12 hours), affected side up. One person applies countertraction on the pelvis while the person reducing the hip applies traction directed ventrally (+/- caudal) to the leg. The femoral head should have external (outward) rotation to place the head of the femur over the acetabulum, and then internal (inward) rotation to seat the head into the acetabulum. Lateral pressure directly over the coxofemoral joint is exerted while flexing and extending the hip to displace any hematoma in the joint and help seat the femoral head. Radiographs confirm placement. An Ehmer sling may be applied to the leg to maintain flexion and internal rotation for a minimum of 10 days.

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109 A 10-year-old female neutered Clumber Spaniel presents for tetraparesis. The dog had been weak in the hindlimbs for several days. Physical examination: T = 101°F (38.3°C); HR = 150 bpm; RR = 48 bpm, synchronous but shallow; CRT = 1–2 sec; MM pink; pulses strong; perfusion hyperdynamic; hydration normal; thoracic and abdominal examination normal. Neurologic examination findings: no cranial nerve deficits; unable to stand; decreased tone and weakness in all four limbs; voluntary movement and pain perception present in all limbs; conscious proprioception (CP) deficits in all limbs. Spinal reflexes: withdrawal normal in all limbs; patellar, 3+ R & L; cranial gluteal and anterior tibial, 2+ R & L; perineal and anal reflexes normal; biceps, 3+ R & L; triceps, 2–3+ R & L; panniculus normal; pain on deep cervical palpation.

i. Is the lesion above the foramen magnum, spinal cord, peripheral, or multi-origin?

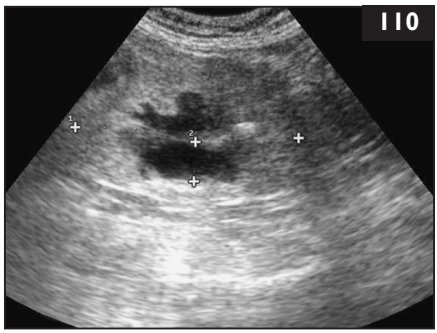
ii. How severe is the lesion(s)? Where is the lesion(s)?

iii. You are told that the dog had a ventral slot surgical procedure at C6–C7 2 years ago. Explain why you believe the lesion(s) is or is not at the C6–C7 location at this time.

iv. Several hours after admission, the dog became cyanotic with very shallow breathing efforts. Arterial blood gas revealed: pH – 7.136; $PaCO_2$ = 91.4 mmHg; HCO_3 = 30.1 mEq/l; PaO_2 = 92.1 mmHg; SaO_2 = 93.4%. Use the 5-Step Blood Gas Interpretation on these results. What is likely to be occurring?

v. What is the ideal stabilization plan for the respiratory distress?

110 A 7-year-old female neutered DSH presents with a 2-week history of reduced appetite, weight loss, and vomiting yellow foam 3 times in 3 days. Blood work by referring veterinarian 1 week ago: BUN = 17.9 mmol/l (50 mg/dl) and creatinine = 244 µmol/l (2.76 mg/dl). At presentation: T = 36.1°C (97°F); HR = 160 bpm; RR = 24; CRT = 2 sec; MM pink, dry; perfusion normal; 6% dehydrated with poor skin turgor; 6-months weight loss of ~ 1.5 kg. Abdominal palpation found pain around the right kidney. BUN = 26.8 mmol/l (75 mg/dl); creatinine = 283 µmol/l (3.2 mg/dl). Indirect systolic BP = 90 mmHg.



i. What factors could be causing the BUN and creatinine values to increase?

ii. What additional laboratory tests are necessary to further evaluate urinary tract health?

iii. Urinary tract ultrasound (**110**, right kidney) shows hydronephrosis and dilation of its proximal ureter that tapers at the point of a hyperechoic shadowing focus. You diagnose a partial ureteral obstruction of the right kidney and calculi. The cat is adequately hydrated, has an indirect systolic BP of 110 mmHg and is producing adequate urine volumes. After fluid therapy: BUN = 20 mmol/l (56 mg/dl); creatinine = 212 µmol/l (2.4 mg/dl). What do these results tell you about kidney function? What is your recommended course of treatment?

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109 i. The lesion is within the spinal cord. There are no changes in mentation, seizures, or cranial nerve deficits in this dog, suggesting that the CNS above the foramen magnum is normal. Peripheral disease typically shows slow or absent spinal reflexes.
ii. Profound weakness suggests compromise of the ventral/lateral extensor tracks of the spinal cord. Lack of CP suggests involvement of the dorsal horns of the cord. The dog still has pain perception and voluntary motor movement, suggesting that the deeper cord tracts are functional. The nerves from the brachial plexus (C6–T2, forelimbs) and the lumbosacral plexus (L5/6–S1, hindlimbs) are working for normal withdrawal. The lesion is likely anterior to C6 (C1–C5) for +3 reflexes in all four limbs. A higher cervical lesion (C1–C4) is anticipated due to the rapid and shallow breathing.
iii. The dog should have depressed withdrawal and slow to absent forelimb reflexes with a lesion within the brachial intumescence.
iv. (1) Respiratory; acute decline; (2) pH low – acidemia; (3) $PaCO_2$ very high – respiratory acidosis; (4) HCO_3 high – metabolic compensation adequate for acute, partial if chronic; (5) normal PaO_2. Diagnosis: acute respiratory acidosis with metabolic compensation. The dog most likely has a high cervical lesion impairing his ability to ventilate adequately.
v. Provide flow-by oxygen; rapid anesthetic induction (propofol, or ketamine or etomidate combined with a benzodiazepine) and endotracheal intubation; hand ventilation with Ambu bag/100% oxygen to bring down $PaCO_2$; the dog requires mechanical ventilation until diagnostics, possibly surgery, and adequate postoperative recovery.

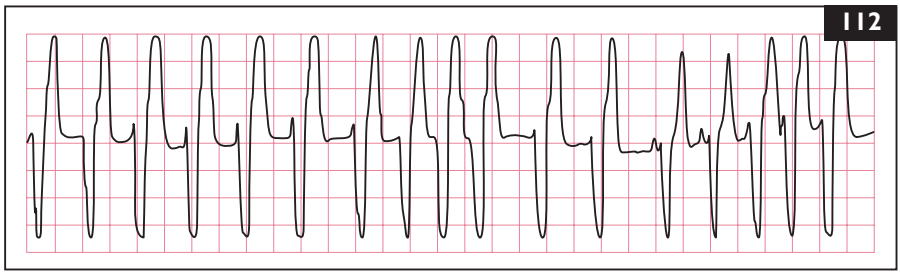
110 i. Pre-renal causes include dehydration and reduced renal blood flow. BUN could also increase if there is any GI bleeding due to uremia. Renal causes include: progressive loss of renal function due to inherent factors; damage from reduced renal blood flow; infection or toxicity due to medication. Post-renal causes could be due to urine outflow obstruction from calculi or mass lesions.
ii. A urinalysis and urine culture and susceptibility will show urine concentrating ability, presence of blood and protein, cellular evidence of underlying infection or inflammation, casts indicating damage to the glomerulus and tubules, evidence of crystals that may support the presence of calculi, and abnormal epithelial cells that may suggest neoplasia.
iii. The persistent renal enzyme elevation (today and 1 week ago) indicates reduced function of both kidneys, not just the kidney with partial obstruction. Fluid diuresis may promote urine flow and carry the obstruction out of the ureter. If the right ureter remains obstructed and continues to expand, damaging the right kidney, surgery (with or without ureteral stenting) or lithotripsy may be necessary. This cat will likely always have chronic kidney disease.

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111 A 9-year-old female intact Shih Tzu presents for a declining appetite and vomiting first undigested food and then yellow foam multiple times today. Her stools were reported as small and black in color. She is not on any medications. T = 38.3°C (101°F); P = 120 bpm; RR = 28 bpm; CRT = 2 sec; MM pale, slightly dry; pulses strong; perfusion adequate; estimated 6% dehydrated. Abdominal palpation is normal with borborygmi ausculted. Rectal examination (**111**) finds melena. The following abnormalities were returned from the initial laboratory testing: stress leukogram; microcytic anemia (PCV = 0.2 l/l [20%]); low albumin, cholesterol, and BUN; glucose low end of normal. Fecal testing revealed hookworm and whipworm eggs.

i. Define melena and explain the significance.
ii. Provide a diagnostic plan for the melena.
iii. Provide an assessment of the initial laboratory abnormalities.
iv. Explain the pathophysiology of melena in dogs with the organ dysfunction suggested by the laboratory abnormalities.
v. How is this treated?



112 i. Which of the following ECG diagnoses best fits the ECG shown (**112**): supraventricular tachycardia; atrial fibrillation; 3rd-degree heart block; left bundle branch block; ventricular tachycardia.
ii. Which of the following are important when determining the effect that an arrhythmia is having on the critical patient and your decision to specifically treat an arrhythmia: HR, effect on cardiac output; electrical instability; physical peripheral perfusion parameters; impending procedures and anesthesia; electrolyte and acid–base status?
iii. Which of the following drugs are indicated to treat this arrhythmia: diltiazem; lidocaine; atenolol; digoxin; procainamide. What is the mechanism of action of each drug?
iv. You have chosen to treat the arrhythmia and the medication has not worked. Create a checklist of at least four items to evaluate to explain the poor response to therapy.

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Answers: 111, 112

111 i. Melena is a black coloration of the stool because of the presence of significant quantities of digested blood, typically from the upper GI tract. Common causes include bleeding due to upper GI tract ulceration, heavy parasite burden, coagulopathy (typically platelet disorder), ingestion of blood (e.g. licking a bleeding wound, nosebleed).
ii. Initially: CBC, biochemical and coagulation profiles, urinalysis, fecal examination for parasites. Additional testing: fasting blood ammonia, pre- and post-prandial bile acids, endoscopy, rhinoscopy, buccal mucosal bleeding time.
iii. Low normal glucose, hypoalbuminemia, hypocholesterolemia, decreased BUN level, and microcytic anemia suggest inadequate hepatic synthetic function, likely due to hepatic insufficiency or failure. Causes include cirrhosis, portosystemic shunt, toxicity, autoimmune process, infectious agents, adverse drug reaction, thrombosis of major hepatic vessels, heartworm postcaval syndrome, chronic active hepatitis, hereditary disorders. The parasite load is likely exacerbating the bleeding and melena.
iv. GI ulceration occurs when there is an excess of acids or pepsin and/or a breakdown in local protective forces. Hepatic disease is associated with increased gastric acid secretion and alterations in GI mucosal blood flow. The parasites are contributing to the breakdown of local protective forces.
v. Treat the underlying pathology. Administer drugs to reduce gastric acid secretion (proton pump inhibitors or H2-blockers) and support/enhance the local protective forces (gastroprotectants). If ongoing blood loss from upper GI bleeding becomes significant, blood transfusion may be necessary. An ice water gastric lavage may reduce the rate of any gastric bleeding until definitive therapy becomes effective.

112 i. Ventricular tachycardia.
ii. All the listed considerations should be assessed.
iii. Lidocaine and procainamide.
- Diltiazem: class IV antiarrhythmic; calcium channel blocker; negative inotrope and chronotrope; vasodilator.
- Lidocaine: class 1b antiarrhythmic; blocks the fast voltage gated Na+ channels.
- Atenolol: selective β_1 receptor antagonist; negative chronotrope.
- Digoxin: cardiac glycoside; competes with K+ ions for binding sites on Na+/K+ ATPase pump; positive inotrope and negative chronotrope.
- Procainamide: class 1a antiarrhythmic agent; blocks open Na+ channels and prolongs the cardiac action potential (outward movement of K+).

iv. Incorrect ECG diagnosis; electrolyte disorders: K+, Ca++, Mg++; severe acid–base disorder; expired medication, incorrect dose; IV line problems; associated hypovolemia; pain; cardiac tamponade.

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113 A dog is being prepared for abdominal exploratory for FB retrieval.
i. In the Table below, indicate if the monitor is used for identifying problems with oxygenation, ventilation, and/or cardiovascular status.

Monitor	Oxygenation	Ventilation	Cardiovascular
ECG			
BP			
Pulse oximetry			
Capnography			
High-definition oscillometric pulse wave			
Esophageal stethoscope			
$ETCO_2$			

ii. The owner had agreed to a prophylactic gastropexy. Match the gastropexy technique with the procedure and provide any pros or cons for the procedure:
Technique: (a) belt-loop; (b) incisional; (c) ventral midline; (d) circumcostal; (e) tube gastropexy.
Procedure: (i) the stomach wall is included in the linea alba closure; (ii) a mushroom-tipped tube is passed through the abdominal wall and into the gastric lumen; (iii) performed by making a seromuscular flap from the stomach and wrapping it around the last rib and securing it back to the stomach wall; (iv) involves tunneling a seromuscular flap through the abdominal wall; (v) fast, simple procedure that involves apposing the muscular layer of the gastric wall and the right transverse abdominis muscle.

114 A 4-year-old male neutered Dachshund presents several hours after a hot acrylic liquid was accidentally spilled on his skin (**114**). T = 40.2°C (104.3°F); HR = 160 bpm; RR = 60 bpm; CRT = <1 sec; MM red; femoral pulses bounding; estimated 5% dehydrated based on MM moisture. Thoracic auscultation and abdominal palpation revealed normal findings. The dog has multiple burns on the right hindlimb, lower back, and right ear pinna.



i. How is the burned total body surface area (TBSA) estimated?
ii. Discuss your concerns regarding fluid resuscitation in this burn patient.
iii. Provide recommendations for fluid resuscitation in this dog.
iv. Discuss wound care goals for this patient.

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113 i.

Monitor	Oxygenation	Ventilation	Cardiovascular
ECG			x
BP			x
Pulse oximetry	x		
Capnography		x	
High-definition oscillometric pulse wave			x
Esophageal stethoscope			x
$ETCO_2$		x	

ii. a, iv. Can be performed quickly and results in a strong adhesion without entering the gastric lumen. Pneumothorax can occur.
b, v. Forms strong, long-term adhesions and results in few postoperative complications.
c, i. Rapid, but not recommended because gastric perforation can occur when another midline celiotomy is performed and because the stomach may become abnormally positioned.
d, iii. Does not penetrate the stomach lumen and creates a strong adhesion. Iatrogenic rib fracture, pneumothorax, and increased surgical time are risks.
e, ii. Results in a permanent adhesion after 14 days and permits postoperative decompression and direct access to the GI tract. Requires more intensive postoperative management and has decreased holding strength compared with other gastropexy techniques.

114 i. The 'Rule of 9s'. Head and neck together = 9% TBSA, each forelimb = 9%, each hindlimb (from hip to toe) = 18%, and thorax and abdomen = 18% each.
ii. Disruption of the capillary barrier will leak fluid and proteins into the subcutaneous tissues. Reports of >50% of crystalloids given IV leaking into burned tissues, peaking at 6–12 hours after injury. Heat-induced denatured collagen increases the size of the interstitial space, favoring fluid extravasation.
iii. The 4-Step Fluid Resuscitation Plan is modified for burn patients. Fluid overload can be devastating. Step 1: both perfusion and hydration deficits are present. Step 2: isotonic balanced crystalloids are the primary resuscitation fluid for the first 24–48 hours. Steps 3 and 4: recommendations (human) for total fluid volumes for the first 24 hours; 4 ml/kg body weight per % TBSA burned. One-half is given during the first 8 hours post injury (not post presentation) with the remaining over the following 16 hours. Adjustments are made to ensure urine output is >0.5 ml/kg/hr. Reserve colloid usage for non-responsive hypotension during the first 24 hours and added after to reduce fluid volumes required as capillary healing progresses.
iv. Goals: (1) prevent wound desiccation, (2) control pain, (3) reduce wound infection, and (4) prevent added trauma. Vacuum-assisted wound care used early can reduce progression of hyperemic skin areas. Early excision with or without grafting of full-thickness wounds can reduce occurrence of wound sepsis in people.

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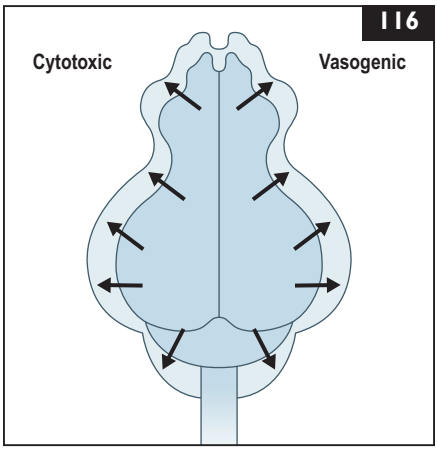

115a

115 A 3-year-old female neutered Pomeranian presents to you 30 minutes after being struck in the back end by a car travelling at 32 kph (20 mph). After the incident, she was walking with a left hindlimb limp (grade III/VI lameness) and was reluctant to stand on the right hindlimb unless supported. T = 38.6°C (101.5°F); HR = 130 bpm; RR = 30 bpm; CRT = 1.5 sec; MM pink; femoral pulses strong. Rectal examination evokes a painful response and demonstrates an irregular pelvic margin and formed feces with a few flecks of frank blood. After administering opioid analgesia, you perform a ventrodorsal radiograph of the pelvis (**115a**).

i. What is your radiographic assessment?

ii. What is the best option for treating these fractures?

iii. What concurrent injuries/complications associated with the pelvic canal may be present with pelvic fractures (short term and long term)? How do you evaluate the patient for these complications?



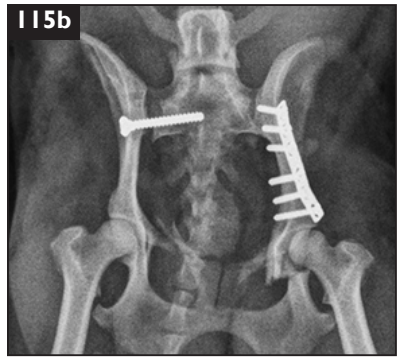
116 i. The cranium is a box with only three normal components. What are these components?

ii. When there is swelling of the brain tissue and/or excessive blood or CSF, there will be an increase in ICP. As pressure mounts, brain tissue can herniate. What are the two most common types of brain herniation in the dog and cat?

iii. Managing a patient with head injury requires a fine balance between supporting cerebral perfusion pressure (CPP) and minimizing ICP. What are the two components that make up CPP?

iv. Cerebral edema is a common cause of elevations in ICP and therefore a reduction of CPP. Two main forms of edema have been found in the brain after trauma: vasogenic and cytotoxic (**116**). Which of the following criteria/influences are typical for each type of edema: interstitial edema, BP, increased blood flow, vascular integrity, tissue osmolality, hypoxia/ischemia, serum glucose, head position, PCO_2, blood–brain barrier integrity.

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115 i. There are left-sided ilial, ischial, and pubic fractures, with medial displacement of the left coxofemoral joint and fracture components. There is also a right sacroiliac luxation.
ii. Re-establish a stable platform to allow adequate support for weight bearing by the left hindlimb (**115b**). In addition, it is best to open the compromised pelvic canal diameter to reduce injury to the lumbosacral trunk. The ileal fracture may involve the cranial coxofemoral joint, which is the weight-bearing part of the joint. Since the right hindlimb is unstable because of the sacroiliac luxation, it will be difficult for the dog to bear weight while the left hindlimb heals. If it does not reduce with fixation of the left hemipelvis, fixation may be needed.
iii. Neurologic injury to the sacral nerve roots and lumbosacral trunk, sciatic nerve entrapment, and damage to the lower urinary tract or colon. A thorough neurologic examination should be performed prior to analgesia and monitored. Urinary catheter placement may be necessary to monitor urine output and keep the dog clean. Diagnostic imaging of the bladder and urethra using contrast can identify a leak. If a colonic injury is suspected, a contrast study of the colon may be needed to reach a definitive diagnosis. If the pelvic canal is not adequately opened, a partial colonic obstruction may result in painful defecation or constipation and/or difficult parturition. Abnormal gait, chronic pain, and osteoarthritis are more likely to occur when appropriate fracture repair is not performed.

116 i. Brain tissue, blood, CSF.
ii. Tentorial (at the tentorium cerebelli) and cerebellar (through the foramen magnum).
iii. CPP is the net pressure gradient causing cerebral blood flow to the brain. CPP = MAP – ICP.
iv. Vasogenic: increased blood flow, BP, PCO_2, head position, blood–brain barrier integrity. Cytotoxic: interstitial edema, tissue osmolality, hypoxia/ischemia, serum glucose, vascular integrity.

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117a

117 A 5-year-old male neutered DSH cat presents for vomiting blood (**117a**). He was last normal 2 nights ago. Vomitus was pink tinged fluid 12 hours ago, which became a large volume of blood 1 hour prior to presentation. He has been known to eat and defecate drier sheets. The cat was mentally dull and his lips and forelimbs were coated in hemorrhagic fluid. T = 36.7°C (98°F); HR = 160 bpm; RR = 25 bpm; CRT = >3 sec; MM pale pink, dry; significant skin tent over shoulders. Emergency laboratory database: glucose = 5.3 mmol/l (95 mg/dl); PCV = 0.71 l/l (71%); TS = 95 g/l (9.7 g/dl); Na^- = 122.7 mEq/l; Cl^- = 90.1 mEq/l; K- = 2.81 mEq/l; iCa^- = 0.807 mmol/l (1.6 mEq/l); pH = 7.589; HCO_3 = 39 mmol/l; PCO_2 = 50 mmHg. Abdominal radiographs unremarkable.

i. What are the essential concepts for treating this hypovolemic, dehydrated, hyponatremic patient with a hypochloremic metabolic alkalosis?
ii. List possible causes of the ionized hypocalcemia in this cat?
iii. List potential causes of hemoptysis.
iv. What is the medical management of gastric erosion/ulceration?
v. What methods are used for controlling ongoing gastric bleeding due to severe ulceration?
vi. What are the indications for nasogastric tube placement in this cat?
vii. A pneumogastrogram at the time of nasogastric tube placement outlines a foreign object in the stomach. What non-surgical procedure can be done to remove this foreign object?


118

118 A 7-year-old Terrier-cross presents after being hit by a bicycle. T = 38.5°C (101.3°F); HR = 140 bpm; RR = 48 bpm with normal effort; CRT = 1 sec; MM pink; femoral pulses normal; perfusion and hydration normal. Auscultation and palpation provide normal results. There is a proptosis of the right eye (**118**).

i. What is the immediate treatment for the proptosis?
ii. What pre-procedural evaluations of the eye should be performed?
iii. What factors determine whether an enucleation is preferred over globe replacement?

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Answers: 117, 118

117 i. The 4-Step Fluid Resuscitation Plan corrects perfusion and hydration deficits using 0.9% NaCl and HES to reach high end end-point goals (possible SIRS, third-body spacing) using small volume infusion techniques. Potassium and calcium supplementation may be needed in maintenance fluids.
ii. Alkalosis increases the negative charge on albumin. The albumin binds more calcium, causing an ionized hypocalcemia. Pancreatitis, intestinal malabsorption, laboratory error, AKI or chronic kidney injury, and ethylene glycol intoxication are other causes.


117b

iii. Gastric ulceration, gastric neoplasia, coagulopathy, excessive vomiting, esophageal or oro-nasal bleeding.
iv. Adequate gastric perfusion, acid reducer (antacid, H2-blocker, or proton pump inhibitor), coating agent (e.g. sucralfate), enteral nutrition.
v. Gastric cold water lavage +/- topical epinephrine, endoscopic hemostatic therapy, surgical resection, correction of consumptive coagulopathy (if present).
vi. Provide enteral nutritional support, decompress stomach of excess fluid/air, administer medication and additional fluids, monitor for continued bleeding and residual gastric volumes.
vii. Endoscopy discovers a laundry softener drier sheet stuck in the pyloric outflow tract (**117b**). There was significant diffuse gastric and duodenal ulceration.

118 i. Replace the eye into the orbit, protect the globe, and treat soft tissue wounds.
ii. Systemic and ophthalmic topical anesthetic drugs are administered. The lid and conjunctiva are examined for lacerations and cleaned free of debris using sterile eye wash solution. The cornea is evaluated for injury using fluorescein stain and direct ophthalmoscopy. If the cornea is penetrated, fluorescein may bleed, indicating need for corneal repair. If the pupil can be seen, a direct and consensual light response may indicate that vision can be preserved.
iii. Less than 20% of proptosed globes regain functional vision. Signs that vision may be preserved in the affected eye include a menace or dazzle response, direct and consensual PLR. A decision to replace the globe may be for cosmetic reasons. Frequent re-evaluation of the healing eye can identify infection, blindness, strabismus, lagophthalmos, corneal sensory deficit, keratoconjunctivitis sicca, exposure keratitis, glaucoma, and phthisis bulbi. It may be more economical to enucleate.

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119 i. Describe the surgical procedure for replacing a proptosed globe.
ii. How is the proptosed globe protected during the 2-week healing phase?



120 A 5-year-old male Cavalier King Charles Spaniel presents for not wanting to move and crying when scratching at his ears (**120**). He is able to stand only with assistance. General physical examination is normal. Neurologic examination is as follows:

Cranial nerves and mentation	Normal
Retinal examination	Normal
Spinal palpation	Significant guarding and vocalization when the cervical spine is palpated
Panniculus reflex	Normal
Posture	Laterally recumbent
Gait	Requires encouragement to move; slow and ataxic gait
Proprioception	Delayed to absent x 4
Spinal reflexes	Increased (hyperreflexia) x 4
Withdrawal	Normal x 4
Muscle mass	Normal
Orthopedic examination	Normal x 4 with normal pain perception
Anal and tail tone/mobility	Normal

i. Localize the lesion from the neurologic findings.
ii. Provide a list of possible causes for this dog's problem(s).
iii. Given the breed and clinical signs, what is a likely diagnosis?
iv. What is the ideal imaging procedure(s) for this problem?
v. What treatment options are presented to the owner should this problem be confirmed?

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119 i. Perfusion parameters are stabilized and the animal prepared for anesthesia. Copious sterile lubrication is applied to the cornea. The skin around the eye is clipped free of hair and disinfected using a dilute betadine solution (chlorhexidine is caustic to the cornea and should not be used). The globe is gently replaced into the orbit with digital pressure or using the handle of a scalpel blade, applying gentle pressure across the cornea. If this is too difficult, a lateral canthotomy is performed by making a 1 cm incision through the skin and subcutaneous tissue of the lateral canthus to widen the orbital fissure. The globe is thoroughly lavaged with sterile saline, and any lateral canthotomy incision closed with a figure-of-8 suture through the skin at the fissure and simple interrupted skin sutures along the remaining lateral wound.
ii. A temporary tarsorrhaphy is performed by placing interrupted horizontal mattress sutures using 4-0 nonabsorbable suture material. The sutures are placed approximately 3 mm from the eyelid margin with suture placement through skin (partial thickness through the eyelid), not penetrating the conjunctival surface and avoiding openings of the meibomian glands. Individual sutures are placed approximately 5 mm apart. Tension devices (stents) may be used. Small openings are left at either end of the tarsorrhaphy or a subpalpebral lavage system is placed for applying topical ophthalmic antibiotic to the cornea.

120 i. Presence of withdrawal in all limbs suggests intact brachial and lumbosacral intumescents. Hyperreflexia in all four limbs supports pathology within the C1–C6 spinal cord area.
ii. Intervertebral disc disease, vascular event (hemorrhage, thromboembolus), neoplasia, inflammatory or infectious meningitis, trauma, atlantoaxial subluxation, syringomyelia (SM), hydromyelia.
iii. Breed and clinical signs make SM a likely diagnosis. This condition results in the development of fluid-containing cavities within the parenchyma of the spinal cord as a consequence of abnormal CSF movement through the foramen magnum. Other breeds reported to develop SM include Pekingese, Maltese, Miniature Dachshunds, Fox Terriers, Lhasa Apsos, Pomeranians, Yorkshire Terriers, and a Samoyed dog.
iv. MRI (with contrast) would allow visualization of the spinal cord and brain. It is important to assess the posterior fossa and foramen magnum, known to have anatomic abnormalities and obstructing CSF flow and causing SM. MRI contrast characteristics may be able to distinguish the type of cystic fluid if it is present.
v. Treatment consists of medical and surgical options. Analgesics, drugs targeted to decrease CSF production, and corticosteroids provide medical options. Gabapentin (5–10 mg/kg PO q8–12h) has been recommended to control neurogenic pain. A surgical option (referral to neurosurgeon) for dogs unresponsive to medical management is suboccipital decompression.

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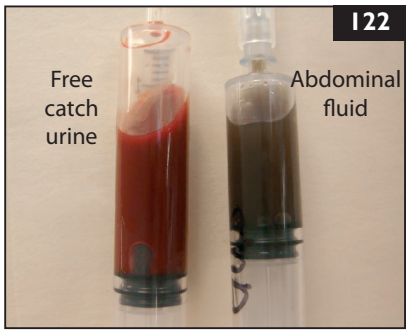
121 A 10-year-old female neutered Border Collie-cross presents 30 minutes after being struck by a car. She has a history of arthritis but has been otherwise healthy. She was walking on three legs after the injury. T = 39.1°C (102.4°F); HR = 150 bpm; RR = 50 bpm; CRT = 1 sec; MM pink. She has some mild abrasions on her muzzle, and a 1 cm full-thickness wound along the medial distal radius and ulna over an area of crepitus and instability of the antebrachium. You diagnose a mild pneumothorax and an open fracture of the right distal radius and ulna (**121a, b**).

i. Critique the technique of these radiographs.

ii. Describe your radiographic findings.

iii. What is your emergency treatment of the fractured limb?

iv. What are the principles of stabilizing a radius/ulna fracture compared with a fracture above the elbow or below the carpus?



122 A 7.5-year-old male neutered Golden Retriever-cross presents for abdominal pain and urinating blood after jumping from a boat onto the dock and landing on his abdomen. The dog fell into the water but was not submerged. T = 39.4°C (103.0°F); HR = 150 bpm; RR = panting; CRT = 1 sec; MM pink, dry; perfusion reflects pain and/or compensatory shock; 6–8% dehydrated (dry MM/corneas). Caudal abdomen painful, with normal penile and rectal examination. Urine is red and there is free fluid in the abdomen.

i. Provide a differential diagnosis for this dog given the history, physical examination findings, and character of the fluids.

ii. What should be done to analyze the fluids shown (**122**)?

iii. The free abdominal fluid was characterized as urine. What radiographic techniques can be used to localize the site of pathology?

iv. Provide a plan for the initial stabilization of this dog.

v. What should be done for definitive treatment of this dog's pathology?

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121 i. Neither radiograph has the affected site centered in the film. There is insufficient columnation, which increases potential radiation exposure. The joint above and below the affected site should also be included.
ii. Type I open, transverse, comminuted fracture of the distal third of the diaphysis of the radius and ulna, with dorsal angulation and lateral displacement.
iii. An opioid analgesic (e.g. hydromorphone 0.05–0.2 mg/kg IV or methadone 0.3 mg/kg IV) should be administered. Multimodal analgesia using additional medications such as lidocaine and/or ketamine infusions and/or a radial ulnar block may be considered. Broad-spectrum IV antibiotics should be immediately administered (e.g. ampicillin/sulbactam at 30 mg/kg IV) as well as wound care (clip, flush, and clean), bandaging, and stabilization of the fracture. External coaptation using a Robert Jones bandage, splint, or cast is used until definitive fracture management can be achieved.
iv. For this radial/ulnar fracture, temporary external coaptation with a sterile dressing is used to protect the open wound from contamination, reduce swelling, and immobilize the fracture to reduce pain and additional trauma to the surrounding soft tissue. The bandage must incorporate the joint above and below the fracture. Options include a Robert Jones bandage with or without reinforcement, a bivalve cast, or a Thermoplast splint. Fractures above the elbow are difficult to immobilize with external coaptation. The muscles around the humerus and shoulder do provide some protection and immobilization. If immobilization is necessary, a Spica splint is placed. Fractures below the radius may be temporarily immobilized using a splint.

122 i. Trauma to the lower urinary tract (ureter, urinary bladder, or urethra) is most likely. Free abdominal fluid brings concern for a ruptured urinary bladder and/or ureter. The color of the abdominal fluid warrants consideration for other injuries such as a ruptured gallbladder or GI tract.
ii. Abdominal fluid creatinine or bilirubin >2–2.5 times the blood levels suggests a diagnosis of urinary tract or biliary tract leakage. Abdominal fluid glucose concentration that is less than serum concentration by more than 1.11 mmol/l (>20 mg/dl) indicates septic peritonitis. Cytology of abdominal fluid can identify microorganisms, plant and other fibers, and toxic neutrophils compatible with bowel perforation, as well as neoplastic cells.
iii. A single- or double-contrast retrograde cystourethrogram can isolate injuries to the bladder and urethra. An IV pyelogram will identify injury to the kidneys and ureters.
iv. IV isotonic balanced crystalloids with HES to restore perfusion to high end end-points using large volume infusion techniques (possible SIRS); rehydrate over 4 hours. Opioid analgesics after initial fluid bolus. Indwelling urinary catheter and sterile collection set to empty bladder and monitor output. Monitor electrolyte and blood gas (potassium, acidosis). Abdominal (dialysis) catheter for continuous abdominal drainage (available for lavage if needed). Aerobic and anaerobic culture and susceptibility of abdominal fluid; bacteriocidal antibiotics may be indicated.
v. Some injuries to the bladder and urethra can be conservatively managed with a urinary catheter. Many require surgical debridement and repair. Perfusion, hydration, acid–base, and electrolyte abnormalities must be corrected prior to anesthesia.

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123 A 3-month-old female intact Pitbull puppy presents for 2 days of anorexia, lethargy, vomiting clear fluid, and watery, fetid diarrhea. Radiographs were reported as normal. The puppy has received 3 of her puppy vaccination series. T = 39.6°C (103.3°F); HR = 165 bpm; RR = 25 bpm; CRT = 3 sec; MM pale and dry; femoral pulses bounding; perfusion hyperdynamic; 10% dehydration based on skin turgor and dry MM/corneas. Shortly after presentation the dog passed a large amount of liquid bloody stool (**123**).

i. A parvovirus CITE (Snap) test is positive. What additional diagnostics are recommended for a patient with parvovirus?

ii. PCV = 0.6 l/l (60%); TS = 21 g/l (2.1 g/dl); glucose = 2.28 mmol/l (41 mg/dl). Interpret these results for this dog.

iii. Discuss the treatment recommendations for an in-hospital dog with parvovirus infection.



124 A 7-year-old male neutered Labrador-cross presents for what the owners call a 'stroke' (**124**). On examination, an initial diagnosis of vestibular disease is made.

i. Describe how to differentiate peripheral vestibular disease (often caused by ear infections or idiopathic/geriatric vestibular syndrome) from central vestibular disease.

ii. After closer examination, the pet is diagnosed with central vestibular disease. What diagnostic recommendations are made to define the cause?

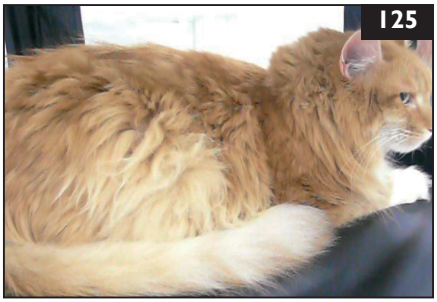
iii. What is the mechanism of action of meclizine?

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123 i. Should include emergency data base (venous blood gas, electrolyte panel, PCV, TS, glucose, BUN), CBC and serum biochemistries, and a routine fecal examination. Abdominal radiographs and/or ultrasound are examined if there is suspicion for intussusception.
ii. The dog is markedly dehydrated (elevated PCV) and likely has some significant protein losses (primarily GI loss). Albumin is likely low due to decreased production (an acute-phase protein), decreased intake, and loss due to capillary leakage (SIRS). Hypoglycemia is from decreased intake with poor glycogen reserves and increased metabolic rate, possibly due to SIRS and sepsis.
iii. The dog is immediately placed in isolation and all exposed surfaces disinfected. Personnel must wear gowns, gloves, and shoe covers when handling this dog. An IVC is placed; emergency database collected and blood drawn for CBC, biochemistries; IV isotonic balanced buffered crystalloids and HES using large-volume technique to high end end-points; reassess perfusion and correct hydration over 4–6 hours with crystalloids, continuing to account for dehydration, maintenance, and ongoing losses; CRI of HES at 0.5–2 ml/kg/hr to supplement COP; IV antibiotics effective against gram-positive/gram-negative organisms as well as anaerobes are recommended; anti-emetics; motility modifier such as metoclopramide or cisapride; and gastroprotectants (H2-blockers or proton pump inhibitors, sucralfate); nasogastric tube gastric decompression and trickle enteral feeding. Many dogs require dextrose and potassium supplementation.

124 i. A finding of a cranial nerve deficit present outside of the vestibular system warrants concern for a central neurologic disease. Abnormal findings may include, but are not limited to, a head TURN rather than a head TILT, inappropriate mentation, decreased facial sensation/movement. However, signs of facial nerve paralysis on the same side as the vestibular pathology could be due to a middle ear problem. Nystagmus changing direction with a change in body position (positional nystagmus) is suspicious for central disease. In addition, ipsilateral hemiparesis and onset of conscious proprioception deficit with the vestibular signs indicate central disease. Neurologic signs of cerebellar pathology (hypermetria and intension tremors of the head) indicate cerebellar involvement and central disease.
ii. Otoscopic and retinal examination, arterial BP, CBC, biochemical profile, electrolytes, blood gas, thyroid panel, blood ammonia levels, and urinalysis. Bile acids may be of value if there is evidence of hepatic disease. Thoracic and abdominal radiographs or ultrasound may identify neoplasia suggestive of metastatic brain disease. Toxoplasmosis and *Neospora* titers and blood lead levels are considered. Ultimately, MRI and/or CT and CSF analysis may define and diagnose the inciting cause.
iii. This is an antihistaminergic anti-emetic; in dogs it decreases the histamine-based signaling from the vestibular system to the emetic center that initiates vomiting. There may also be some anticholinergic effects of this drug.

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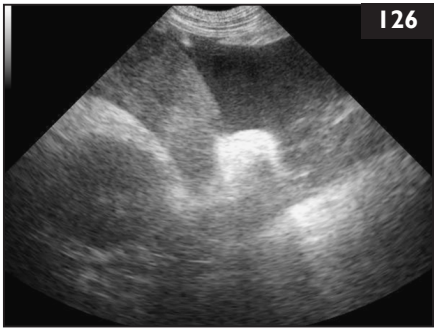
125 A 5-year-old male neutered Maine Coon cat presents because of labored breathing (**125**). He has had a history of a heart murmur. T = 36.1°C (97°F); HR = 210 bpm; RR = 45 bpm; CRT = 3 sec; MM pale pink. There is marked inspiratory effort and thoracic auscultation finds moist crackles ventrally in all lung fields and a III/VI systolic heart murmur localized over the right parasternal region. The cat's perfusion is poor and hydration is adequate.

i. What is your immediate treatment plan?

ii. What is your diagnostic plan, and how do you stage testing?

iii. Thoracic radiographs and an echocardiogram are eventually performed, and a diagnosis of CHF caused by hypertrophic cardiomyopathy is made. What are the hallmark echocardiographic findings of the left side of the heart with feline hypertrophic cardiomyopathy?

iv. Recommendations are to continue loop diuretic therapy and administer an ACEI and a calcium channel blocker. State whether each drug affects preload, afterload, rate, or contractility. What is the mechanism of action of each drug?



126 A 14-year-old female spayed Labrador presents for lethargy, shaking, and weakness. The dog has vomited yellow foam daily for 3 days. She is on pain medications for hip arthritis. T = 37.8°C (100°F); HR = 178 bpm; RR = 33 bpm; CRT >3 sec; MM very pale and dry; perfusion is poor; dehydration estimated at 10%. Abdomen slightly distended and painful on palpation. Abdominal radiographs show loss of serosal detail. A FAST abdominal scan from the left mid-abdominal region is shown (**126**).

i. How do you perform an abdominal FAST examination?

ii. Abdominocentesis produces serosanguineous fluid. How do you determine whether the effusion is septic?

iii. The fluid is determined to be a septic effusion. How would you stabilize this dog prior to surgery?

iv. The dog has a duodenual perforation (possibly from the NSAID medications) diagnosed at surgery. Much of the bowel is discolored. How do you determine whether or not the bowel is viable?

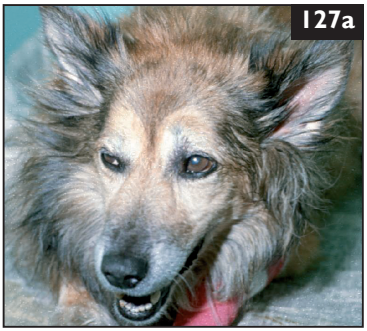
iv. You have successfully resected the damaged bowel. What is done prior to closing the abdominal cavity?

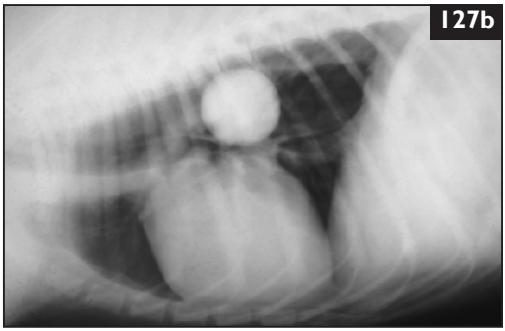
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125 i. Provide oxygen support, administer a sedative (e.g butorphanol, 0.4 mg/kg IV or IM) to reduce the work of breathing and oxygen demand, followed by furosemide (2–4 mg/kg IV or IM or 0.75 mg/kg/hr × 6h IV) to promote diuresis (decrease preload). An IVC is placed using minimal restraint.
ii. An echocardiogram, thoracic radiographs, indirect BP, and ECG are needed for complete cardiac evaluation. Obtaining BP and ECG can be performed with minimal restraint, although stress from respiratory difficulty can increase BP and HR. Imaging should not be performed until the cat has less effort breathing and is more tolerant of restraint. Next, a comprehensive evaluation of the organ systems with a CBC, serum chemistry panel including electrolytes, thyroid panel, and urinalysis is obtained.
iii. Concentric or segmental ventricular wall thickening, left atrial enlargement, decreased left ventricular internal dimensions, normal to elevated fractional shortening, +/– mitral regurgitation.
iv. Loop diuretics reduce preload by inhibiting sodium and water resorption in the thick ascending limb of the loop of Henle. They also cause venodilation. The ACEI reduces angiotensin II production and is a balanced vasodilator, resulting in decreased afterload. The ACEI also reduces vascular and myocardial remodeling over time. The calcium channel blocker acts by reducing HR and it has a positive lusitrophic effect, thereby reducing myocardial work and increasing myocardial perfusion.

126 i. The ultrasound probe examines four specific locations for free abdominal fluid: diaphragmaticohepatic area (midline caudal to xiphoid); splenorenal view (left lateral mid-abdomen); cystocolic region (midline cranial to pubis/bladder); and hepatorenal view (right lateral side mid-abdominal region).
ii. Low abdominal fluid glucose or fluid glucose 1.11 mmol/l (20 mg/dl) lower than blood glucose suggests septic effusion. Fluid cytology demonstrating bacteria and toxic neutrophils. A fluid protein >30 g/l (3 mg/dl) suggests an exudate, but is not specific for sepsis. Aerobic and anaerobic culture and susceptibility of fluid are submitted.
iii. Flow-by or nasal oxygen; IVC; emergency database and blood/urine drawn for profiles and coagulation panel; IV isotonic, balanced crystalloid and HES using large-volume technique to high normal end-points; opioid analgesics; supplement blood glucose and potassium as needed; evaluate ECG and BP prior to anesthetic induction.
iv. Arterial pulsations indicate blood flow; bowel coloration: if pink, red, or purple may be viable, if black or white not viable; bleeding when cut is less reliable.
v. (1) Leak test: mechanically occlude the intestine and inject saline into the lumen, observing for leakage. (2) Lavage the area local to bowel repair. (3) Change surgical gloves and use another set of sterile instruments for abdominal closure. (4) Complete a full abdominal exploratory. (5) Copious abdominal lavage and suction. (6) Swab abdominal peritoneal surfaces for bacterial culture and susceptibilty. (7) Placement of closed suction abdominal drains, a feeding tube, and an epidural catheter for analgesia are considered.

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127a


127b

127 A 10-year-old male neutered Sheltie presented for coughing and choking for the past hour (**127a**). The dog had been playing with his ball prior to the onset of signs. Primary survey: open-mouth breathing; labored inspiration and expiration; cyanotic MM; HR = 180 bpm; RR = 30 bpm; femoral pulses bounding.
i. Provide your plan for immediate stabilization.
ii. A lateral radiograph was obtained (**127b**). Provide a radiographic interpretation.
iii. Describe your treatment plan based on the radiographic findings.
iv. What complications should be anticipated?
v. Provide a plan for treatment and monitoring.

128 i. List at least three reasons why the ICU patient is susceptible to hospital acquired (nosocomial) infections.
ii. Veterinary facilities need to design a protocol for antibiotic selection and use in hospitalized patients. Select from the following list important considerations when creating a hospital antibiotic protocol: (a) Surveillance of past culture and susceptibility results at that specific hospital to detect resistance patterns; (b) spectrum, side-effects, bioavailability, and cost of specific antibiotics; (c) guidelines for empiric and targeted antibiotic treatment to include antibiotic choices, dosage, and duration of treatment; (d) periodic audit of compliance to the protocol.
iii. Provide at least four reasons why a patient fails to respond to antibiotic therapy.

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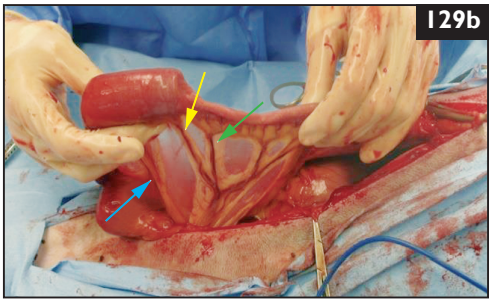
Answers: 127, 128

127 i. Immediate oxygen therapy, an IVC, crystalloid fluid therapy, mild sedation (e.g. butorphanol). If this does not improve oxygenation, may need to sedate the dog to secure the airway and provide 100% oxygen with manual ventilation.
ii. The radiograph is underexposed, but well positioned. There is a round mineral density object dorsal to the heart, and a dilated gas-filled esophagus caudal to the object. There is also compression of the mainstem bronchi. This is consistent with an esophageal FB.
iii. The foreign object needs to be removed. Given its size, retrieving the object with endoscopy would be difficult. It may be possible to force the object into the stomach, where it can be removed via gastrotomy. Alternatively, a lateral thoracotomy and esophagotomy may be required.
iv. With obstruction of the mainstem bronchi, it is possible this dog may develop postobstructive pulmonary edema. Injury to the esophagus may result in esophagitis and poor esophageal motility in the short term and, potentially, esophageal stricture in the long term
v. Perioperative IV opioid medications are indicated. A nasogastric tube should be placed to allow nutritional support if the dog is not eating and minimize aspiration of gastric contents should gastric paresis develop postoperatively. Gastroprotectant medications (e.g. sucralfate and/or H2-blockers or proton pump inhibitors) will decrease gastric acid and subsequent esophagitis from reflux. If a thoracotomy was performed, a chest tube should be placed and suctioned intermittently (most can be removed within 24–36 hours). Soft food should be fed for the next week. Monitoring vital signs (TPR, BP) along with RR, effort, and pulse oximetry will be necessary.

128 i. The critical patient is more likely to have or be exposed to: (1) indwelling devices (e.g. IV and urinary catheters); (2) invasive diagnostic procedures (e.g. transtracheal wash, abdomino- or thoracocentesis, diagnostic lavage); (3) surgical procedures; (4) invasive non-surgical procedures (e.g. feeding or oxygen tubes, mechanical ventilation); (5) immunity that is suppressed; (6) exposure to other animals; (7) broad-spectrum antibiotic usage; (8) inappropriate 'barrier nursing' personnel and contaminated equipment (e.g. clippers) moving from patient to patient; (9) incomplete surface sanitation.
ii. a, b, c, d.
iii. Disease is not bacterial; incorrect drug; incorrect dose or frequency of administration; improper (route of?) administration; drainage inadequate or not provided; poorly diffusing drug (poor bioavailability or volume of distribution); development of new or nosocomial infection; fast emerging drug-resistant strain of bacteria; more than one pathogen present; complicating problems (e.g. immune deficiency, diabetes); and finally, bacteria resistant to drug class.

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129 A 3-year-old male neutered Afghan hound presents for persistent vomiting over the past 2 days, not eating, and looking at his abdomen (**129a**). He has a history of eating things out of the trash and then developing diarrhea, but he has never been hospitalized. T = 39.2°C (102.6°F); HR = 165 bpm; RR = 30 bpm; CRT = 3 sec; MM pale pink, dry; femoral pulses weak. Abdominal palpation demonstrates a firm 3 cm × 2 cm mass within the small intestines in the mid-abdominal region. Thoracic auscultation findings normal. Radiographs show evidence of an intestinal obstruction. The dog is volume replaced and prepared for anesthesia.

i. During surgery, the mid jejunum containing a FB is exteriorized and an intestinal resection–anastomosis performed without an enterotomy. Which arrow points to the vessel that will be ligated during the resection (**129b**)?

ii. Which intestinal anastomosis suturing technique (interrupted or continuous) provides better appositional closure and less leakage?

iii. What suture pattern can reduce eversion of mucosal tissue during intestinal anastamosis?

iv. How can the anastomosis site be checked for leaks?

v. What are the risk factors associated with the complication of leakage following anastamosis?

130 A 3-year-old female neutered DSH cat presented for left hindlimb lameness. Physical examination was normal except for bilateral facial edema and brown coloration to all MM. There was a broken toe on the left hindlimb. Further questioning revealed that the owner had given the cat an extra strength (500 mg) capsule of acetaminophen (APAP).

i. What is the mechanism of APAP toxicity in the liver and RBCs in the cat?

ii. What are the clinical signs of APAP toxicity in the cat?

iii. How is this toxicity treated?

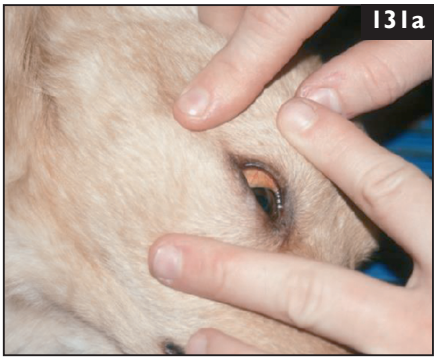
iv. What are the toxic effects of APAP in the dog?

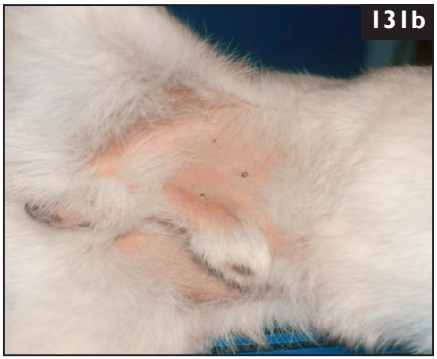
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129 i. The green one.
ii. Simple continuous is better. Anastomotic leakage is reported in 3% of animals undergoing continuous sutured anastomosis and up to 11% of animals undergoing interrupted sutured anastomosis.
iii. A modified Gambee suture pattern: the needle is passed full thickness through the intestinal wall and then back through the mucosa on the near side. Then the needle is placed into the mucosa–submucosa border on the far side, pushing the mucosa into the lumen, and then passed full thickness back out that side.
iv. Distend the segment with sterile saline injected into the lumen while continuing to occlude the intestinal segments on both sides distal to the anastomotic site.
v. FB removal or resection of traumatized intestines, pre-existing peritonitis, hypoalbuminemia, reduced blood supply.

130 i. A toxic metabolite, N-acetyl-para-benzoquinone imine (NAPQI), is produced through the cytochrome P450 pathway. NAPQI binds to cellular proteins and membranes, leading to cell injury and death. NAPQI also causes oxidation of ferrous iron (Fe^{2+}) to ferric iron (Fe^{3+}), converting hemoglobin to methemoglobin. A relative lack of methemoglobin reductase in the erythrocytes of cats makes methemoglobinemia an earlier and more prominent feature. Oxidation of hemoglobin causes Heinz bodies, leading to hemolytic anemia.
ii. Include: discoloration of MM (may appear cyanotic, muddy/brown or pale); subsequent respiratory distress (increased RR or effort) due to poor oxygen carrying capacity of the blood; edema of the face and paws along with lacrimation and pruritus.
iii. Activated charcoal adsorbs APAP and may need to be repeated. N-acetylcysteine (NAC) provides sulfhydryl groups that bind with APAP metabolites to enhance elimination. An initial oral loading dose of 140 mg/kg (dilute 1:4 in 5% dextrose) is given, followed by 70 mg/kg PO q6h for 7 treatments, or longer if still symptomatic. For symptomatic cats, a loading dose of 280 mg/kg is given. Wait 2–3 hours between activated charcoal and PO NAC administration. Patients with respiratory distress require oxygen, and whole blood transfusion may be necessary to increase oxygen carrying capacity. Ascorbic acid provides a reserve system for the reduction of methemoglobin back to hemoglobin. Cimetidine is no longer recommended.
iv. Similar to those in cats, but at much higher APAP doses (150–200 mg/kg compared with 10–50 mg/kg).

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131a


131b

131 i. Where is icterus (jaundice) detected first (select one) (**131a, b**): scleral/conjunctival membranes, oral mucous membranes, plasma, skin?
ii. What causes the yellow coloration in the conjunctival membranes overlying the sclera?
iii. Provide three general categories for the causes of icterus, and give a possible cause for each.
iv. Answer the following. (a) In which species can low levels of bilirubin in the urine be normal – dog or cat? (b) The metabolism of bilirubin in the intestine results in which of the following – urobilinogen or stercobilin? (c) What is the major molecule that binds to bilirubin in the plasma – transferrin or albumin?

132 i. List at least four indications for the use of peritoneal dialysis or hemodialysis.
ii. List potential contraindications for peritoneal dialysis.
iii. What are the contents of the peritoneal dialysis infusion fluid?
iv. What are the three basic steps to peritoneal dialysis set-up?
v. What are the three basic steps for performing peritoneal dialysis?
vi. What complications should be anticipated during peritoneal dialysis?

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131 i. Plasma.
ii. A pathologic process interferes with the normal metabolism or excretion of bilirubin. Hyperbilirubinemia results, with high bilirubin levels in the extracellular fluids depositing in the tissues.
iii. (1) Pre-hepatic: hemolysis of RBCs; (2) hepatic: cholangiohepatitis, hepatic neoplasia, liver cirrhosis, hepatic lipidosis; (3) post-hepatic: gallstones, gallbladder disease, pancreatitis, neoplasia.
iv. (a) The dog. (b) Both are correct; bilirubin is metabolized to urobilinogen in the intestines; if not absorbed, it is then metabolized to stercobilin in the intestines. (c) Albumin.

132 i. AKI; control of volume overload states; critical electrolyte imbalances; treatment of hypothermia; removal of drugs or toxins from blood; repeated lavage for non-septic peritonitis (e.g. hemorrhagic pancreatitis).
ii. Recent abdominal surgery with drains; fecal or fungal peritonitis; pleural–peritoneal fistulas, abdominal wall cellulitis; adynamic ileus; abdominal adhesions; underlying respiratory failure (could interfere with adequate ventilation).
iii. The dialysate is typically an isotonic buffered (e.g. lactate, bicarbonate, citrate) crystalloid with dextrose at selected concentrations (e.g. 1.5%, 2%, 4.25 %). Additives include heparin, antibiotics, KCl, and regular insulin.
iv. Every step is done with strict aseptic protocols using sterile infusion devices (**132**). (1) Heavy sedation, empty urinary bladder, and aseptic placement of peritoneal dialysis catheter. (2) Attach dialysate solution to administration set and wrap dialysate solution in warming device to maintain at close to body temperature. (3) Attach one prong of 3-way administration stop-cock to dialysate, one to the peritoneal catheter, and one to the outflow collection line and bag.
v. (1) The warmed dialysate is infused into the peritoneal cavity (10–20 ml/kg volume). (2) The dialysate is allowed to remain in the peritoneal cavity for 45 minutes (dwell time). (3) The peritoneal fluid is allowed to drain into the drainage bag until the peritoneal cavity is empty (drainage time) – usually 15 minutes.
vi. Obstruction of peritoneal dialysis catheter, leakage, peritonitis, disruption or kinking of administration/outflow apparatus, increased intra-abdominal pressure, peritoneal pain, herniation, fluid overload, dehydration, bleeding, perforation of urinary bladder or GI tract, hyper- or hypoglycemia, hypokalemia, dialysis dysequilibrium syndrome (cerebral edema from rapid decline in urea).

132

Peritoneal dialysis 'set-up'



Isotonic balanced cystalloid with dextrose

Warm dialysate





Aseptic connections

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133a


133b

133 An 8-year-old male neutered DSH cat presents for acute vomiting of yellow fluid, adipsia, and lethargy of 24 hours duration (**133a**). He was diagnosed 2 years ago with inflammatory bowel disease, but is not medicated. He is fed a commercial raw food diet. T = 36.1°C (97°F); HR = 140 bpm; RR = 32 bpm; CRT = 3 sec; MM very pale and dry; perfusion poor (early to late decompensatory shock); 8% dehydration (skin turgor and MM/corneal moisture). The cat is painful on cranial abdominal palpation.

i. Interpret the lateral abdominal radiograph (**133b**) and provide a radiographic impression.

ii. What are the sonographic characteristics of an intestinal FB?

iii. In the case of septic peritonitis, when is abdominal drainage indicated? List three methods for drainage.


134

134 A 2-year-old femle neutered Australian Shepherd Dog-cross presents with an acute onset of right forelimb lameness. The dog was running in the park and tripped while chasing a ball 1 hour ago. The only abnormality on physical examination is right forelimb non-weight-bearing lameness, marked swelling around the elbow region, pain during palpation of the distal humerus and proximal radius/ulna, and difficulty flexing/extending the leg. You obtain a radiograph of the limb (**134**, lateral view).

i. What is your radiographic diagnosis?

ii. Discuss the short-term and long-term treatment of this dog.

iii. Describe how the procedure for non-surgical management is done.

iv. What is the success rate of this therapy?

v. What complications may occur after the non-surgical procedure?

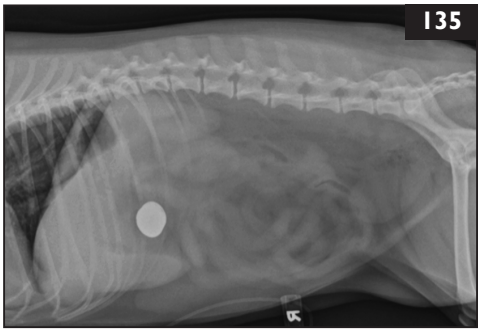
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Answers: 133, 134

133 i. Diffuse loss of contrast suggests abdominal fluid. The corrugated small bowel in the ventral abdomen suggests segmental inflammation or a linear FB. The gas distended loop of bowel in the dorsocranial abdomen supports intestinal obstruction. Free gas in the dorsocaudal region of the abdomen suggests either perforated bowel or gas-forming bacterial peritonitis. Radiographic impression: probable linear FB with bowel perforation.
ii. Sonographic details depend on the size, shape, material, surface characteristics, and location of the object. Echogenicity of surrounding luminal contents is important. Dense objects and partial gas-trapping fabrics show a hyperechoic surface with distal acoustic shadowing. Metallic or mineralized objects are highly echogenic, causing characteristic reverberation and comet tail artifacts. Plastics produce a reflective double-surface layer and rubber toys produce acoustic shadowing without a hyperechoic near surface. Less dense objects may be difficult to identify. Small intestinal obstructions from a FB can cause accumulation of fluid in the intestinal segment orad to the object, with no dilation aborad; the stomach may be distended with gas or mixed echogenic contents.
iii. Continuous postoperative abdominal drainage is used when surgical treatment and peritoneal lavage cannot remove the source of septic peritonitis or sufficiently reduce contamination. Methods include open abdominal drainage, closed abdominal drainage with a bulb drain, and vacuum-assisted drainage.

134 i. Traumatic dorsal (+/- caudal) luxation of the elbow joint.
ii. Short term: pure agonist opioid pain medication is given and closed reduction of the elbow joint attempted. After reduction, the leg should be splinted in extension (spica splint) for 5–7 days, followed by physical therapy to maximize joint mobility. Long-term therapy with oral pain medications and/or NSAIDS is warranted provided the dog has normal liver/GI/renal function.
iii. For closed reduction of the elbow joint, a pure agonist opioid (analgesia) and a benzodiazepine (muscle relaxant) are given. Traction is employed on the limb by tethering the distal limb to a stationary pole or frame to elongate and relax the muscles and tendons connected with the elbow joint. The anconeal process is 'hooked' into the fossa of the olecranon by abducting and rotating the antebrachium medially (if luxated laterally), with pressure on the proximal radius and ulna directed medially; >90 degree flexion of the joint will help reduction. Radiographs should confirm reduction.
iv. >75% in dogs.
v. Pain medication, icing, and enforced rest will treat the pain and swelling for several days after the injury. Injury to the supporting ligaments can leave the dog at risk for recurrent luxation (necessitating further immobilization or surgical correction); placement of the limb in an extension splint may help reduce reluxation. Arthritis may occur.

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135 A 6-year-old female neutered Beagle presented for decreased appetite and vomiting of yellow fluid twice after getting into the owner's purse. Physical examination: T = 39.3°C (101°F), HR = 160 bpm, RR = 50 bpm; CRT = 3 sec; MM pale, icteric, dry; weak femoral pulses; perfusion poor; 6% dehydrated. There is a grade 3/6 holosystolic left-sided heart murmur. Emergency laboratory database: PCV = 0.14 l/l (14%), TS = 70 g/l (7 g/dl); red colored serum; glucose, BUN, electrolytes, lactate, and venous blood gas are within normal ranges. CBC demonstrated a neutrophilic left shift, regenerative anemia, and low-normal platelet number. The urine is red in color with SG = 1.028; 3+ protein; 4+ blood; negative glucose and ketones. Systolic BP = 80 mmHg.

i. Discuss the 4-Step Fluid Resuscitation Plan for this dog.

ii. What are the major 'diagnostic' problems? What further test(s) should be performed to better define the cause?

iii. The radiograph shown (**135**) is obtained. Provide an assessment.

iv. Perfusion and hydration are stabilized and the PCV raised to 0.2 l/l (20%) by giving pRBCs. What therapeutic step(s) are indicated at this time?



136 A 6-year-old male neutered Chihuahua presents 30 minutes after being sideswiped in the back end by a truck going at 65 kph (40 mph). T = 38.4°C (101.2°F); P = 170 bpm; R = 50 bpm; CRT = <1 sec; MM injected, dry; femoral pulses bounding. Thoracic auscultation and abdominal and rectal examination normal. There is an open fracture of the right femur with bone exposed (**136**).

i. Create an initial problems list in order of priority. List the stage of shock with justification.

ii. Provide a 4-Step Fluid Resuscitation Plan for this dog, and justify the choices.

iii. Perfusion is now stable. How is the fracture now treated?

iv. What additional diagnostics are now indicated?

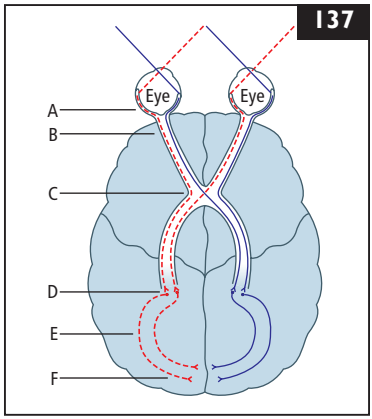
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Answers: 135, 136

135 i. The poor perfusion is associated with a severe anemia. TS will be lower once fluid balance is restored. (1) perfusion and dehydration; (2) istotonic balanced crystalloid (e.g. Normosol-R, Plasmalyte-A) and HES; (3) low end resuscitation end-points because of acute anemia; (4) small volume infusions titrating only the amount necessary to bring down HR and improve systolic BP (may require transfusion before parameters improve). Packed RBCs should be given once blood typing and/or cross-match done. Could use whole blood (WB) instead of HES during initial fluid resuscitation, but slower initial infusion of WB could delay intravascular volume expansion.
ii. Red serum, red urine, and anemia suggest intravascular hemolysis. Slide test for auto-agglutination, abdominal radiographs for FB ingestion, ± Coombs testing can be done. A blood smear to investigate for red cell parasites/infection and questioning the owner about hemolytic toxins (onions/garlic, pennies). Blood chemistry analysis (hypophosphatemia can cause hemolysis).
iii. The circular metal density in the stomach suggests ingestion of a coin. Pennies after 1982 contain zinc, which can cause hemolytic anemia. The owner should also be questioned if calcium carbonate tablets were administered, which are also radiopaque.
iv. The dog can now be anesthetized, intubated, and ventilated and the pennies removed from the stomach. Endoscopic removal is the fastest with minimal complications. Induction of emesis may be unrewarding since pennies often adhere to the gastric mucosa.

136 i. Compensatory shock (tachycardia, bounding pulses, rapid CRT, injected MM); pain (assumed with injuries); history of trauma, dehydration (estimated 6–8% with dry MM); open fracture of right femur.
ii. Step 1: both perfusion and hydration problems. Step 2: balanced isotonic crystalloids (e.g. Normosol-R, Plasmalyte-A) to address interstitial deficits and HES (e.g. tetrastarch or hetastarch) to promote fluid retention within blood vessels to treat perfusion deficits. Step 3: low end resuscitation end-points due to history of trauma and unknown if there is internal hemorrhage. Step 4: small volume technique to titrate to low end end-points and prevent sudden and dramatic increase in intravascular HP.
iii. An open fracture is a true orthopedic emergency. Analgesics (e.g. opioid, benzodiazepine combination; consider epidural) are crucial prior to treating the fracture. The hair is clipped and the skin aseptically prepared around the fracture site. The protruding bone fragment is flushed copiously with warm, sterile saline. Collect a sample for culture/susceptibility. Cover exposed bone with sterile moist dressing and splint limb. Administer parenteral antibiotics against gram-positive and gram-negative aerobes (first-generation cephalosporins or ampicillin).
iv. Lateral chest and abdominal trauma films to quickly identify potential traumatic injuries and a FAST ultrasound for abdominal hemorrhage; emergency database (PCV, TS, glucose, BUN, electrolytes, venous blood gas); coagulation profile, CBC, biochemical profile, and urinalysis for preoperative evaluation; monitor urine output for urinary bladder integrity and kidney function; radiographs of right hindlimb and pelvis.

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137 A 10-year-old femle neutered cat presents because of excessive blinking of her eyes, holding them shut. Perfusion and hydration parameters are normal and the cat has no signs of respiratory difficulty. The cat may have lost a kilogram of body weight over the past few months. She is indoor only and not current on her vaccinations. She is the only pet in the house.

i. Match the structures listed below to the appropriate structure (A to F) in the visual pathway drawing (**137**): lateral geniculate nucleus; retina; visual cortex; optic radiations; optic nerve; optic chiasm.

ii. Describe the pathway for vision.

iii. What are clinical signs of blindness?

PLRs are equal and responsive to direct and indirect light in both eyes, with the pupils slightly miotic. The anterior chamber has gravity-dependent pink cloudy contents (aqueous flare). What can be seen in the posterior chamber appears normal. There is no fluorescein stain uptake by the corneas. Intraocular pressures are as follows: 5 mmHg OS and 7 mmHg OD.

iv. List the differential diagnoses and highlight the most likely diagnosis.

v. What are the anticipated complications, and what is the ocular treatment?

vi. What would be a complete diagnostic evaluation for this cat to determine the cause of the problem?



138 A 12-year-old female neutered Golden Retriever presents for walking unsteadily and falling down three stairs (**138**). There is no known toxin exposure. The dog is weak and lethargic. T = 38.3°C (101°F); HR = 120 bpm; RR = panting; perfusion and hydration adequate. Routine initial blood test finds a mild stress leukogram and a low blood glucose (1.78 mmol/l [32 mg/dl]).

i. What are the differential diagnoses for the problem of hypoglycemia?

ii. How is the diagnosis of insulinoma made?

iii. Hypoglycemia can cause neuronal cell injury and death. Why does this occur?

iv. Provide treatment recommendations for emergency and continued care management of an insulinoma.

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137 i. A = retina; B = optic nerve; C = optic chiasm; D = lateral geniculate nucleus; E = optic radiations; F = visual cortex.
ii. Light must pass through a normal cornea, anterior chamber, pupil fissure, posterior chamber, detected by photoreceptors in the normal retina, transmitted by a normal optic nerve past the optic chiasm, along the optic tract around the midbrain to the lateral geniculate nucleus where the axons synapse and fan out as optic radiations into the white matter of the brain until they terminate at the occipital (visual) cortex for processing.
iii. Lack of direct and consensual PLRs and lack of a dazzle response to bright light; failure to navigate around obstacles or visually follow a falling cotton ball. Lack of menace is not a reliable sign of blindness, since facial nerve injury and reduced mentation can result in an abnormal menace response.
iv. Bilateral anterior uveitis is most likely. Other differentials include cataracts, lens luxation, uveal cysts, trauma, and systemic inflammation (e.g. immune-mediated disease, bacterial, viral, and fungal infections, neoplasia).
v. Complications include pain, synechiae, and glaucoma potentially causing blindness. Treatment consists of (1) topical anti-inflammatory agents such as prednisolone acetate, or flurbriprofen; (2) topical antibiotics such as neomycin–polymyxin–bacitracin; (3) topical atropine ophthalmic to open the pupil and promote drainage of cellular debris; (4) systemic anti-inflammatory agents such as corticosteroids or NSAIDs; (5) adjunctive analgesic medication such as oral tramadol; (6) investigation for and treatment of underlying disease
vi. CBC, serum biochemical profile, urinalysis, feline infectious panel, thoracic radiographs, blastomycosis urine antigen testing, aqueous centesis for cytologic evaluation and culture.

138 i. Sepsis, insulin overdose (iatrogenic, insulinoma), laboratory error, hypoadrenocorticism, hepatic failure, reduced glycogen stores (severe malnutrition, young or small animals), toxicity (e.g. xylitol), sustained motor activity (e.g. status epilepticus, generalized tremors).
ii. Concurrent hypoglycemia with hyperinsulinemia. The Veterinary Society of Surgical Oncology reports these diagnostic criteria: hypoglycemia (blood glucose <3.3 mmol/l [60 mg/dl]) and hyperinsulinemia (insulin concentration >139 pmol/ml [20 μU/ml]), from the same blood sample; relative hypoglycemia calculated using insulin-to-glucose ratio >0.23, glucose-to-insulin ratio <3.31, amended insulin-to-glucose ratio >30.
iii. Hypoglycemia induces neuronal depolarization, which results in high extracellular concentrations of glutamate, aspartate, and zinc. These substances cause the neuron to produce reactive oxygen species and cell death.
iv. Emergency management: IVC, dextrose administration (0.5 g/kg IV) with conservative dextrose continuous infusion (1.25–10.0% in IV maintenance crystalloids as needed). Glucagon (5–10 ng/kg/min CRI IV) or glucocorticosteroids may be required. Frequent feeding of high-protein, complex carbohydrates and a low sugar diet 4–6 times/day. Corticosteroids are often used long term; other oral antihypoglycemic agents include diazoxide, synthetic somatostatin, and streptozocin. Improved survival time has been found with insulinoma removal by partial pancreatectomy.

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139 A 5-year-old male neutered outdoor cat presents for trauma having been found at the side of the road near the owner's home (**139**). T= 39.5°C (103.1°F); HR =190 bpm; RR = 40 bpm with audible breathing sounds on inspiration and expiration. There is a moderate amount of oral and nasal hemorrhage and a II/VI systolic murmur. Hyphema, and pain on right periorbital palpation with no fractures or crepitus palpated. During examination the bleeding from the cat's nose and mouth becomes more severe, causing him to have trouble ventilating and requiring immediate control of his airway.

i. What are some options for rapid anesthetic induction and intubation in this cat with head trauma?

ii. What is the most common side-effect of propofol?

iii. Name five classes of analgesics, give at least two examples, and describe their mechanism of action.

iv. What is the mechanism of action of tramadol?

140 Match the analgesic medication with the potential complication or negative effect in the cat:

1. Transmucosal buprenorphine
2. Oral meloxicam
3. IV fentanyl
4. SC dexmedetomidine
5. IV diazepam

A. Not an analgesic
B. Loss of compensatory cardiovascular responses due to decreased HR
C. May not provide full analgesia with severe pain
D. Renal injury and GI ulceration
E. May cause euphoric response in the cat

141 A client requests additional diagnostic imaging to better determine if there is a mass lesion in the abdomen suggestive of neoplasia prior to a surgical procedure. What information can be gained from an abdominal ultrasound and abdominal CT scan?

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139 i. Propofol or etomidate IV (combined with midazolam or diazepam), while monitoring the BP. Ketamine IV can increase left atrial pressure and HR as well as ICP, and dexdomitor IV can increase cardiac afterload; both effects are undesirable in this cat with a heart murmur. Thiopental can be used, although this may have some significant cardiac effects. Alfaxalone is a neurosteroid general anesthetic that has a short half-life in dogs and cat but is not available in many countries. Preanesthetic administration of an opioid analgesic can decrease the anesthetic dose for induction and alleviate pain. Mask induction does not permit rapid control of the airway.
ii. Large volumes of propofol rapidly injected IV can cause apnea, requiring intubation and at least manual ventilation post induction. It can also cause hypotension and cardiac arrest.
iii. (1) NSAID (meloxicam, carprofen, deracoxib); blocks the cyclo-oxygenase-dependent production of prostaglandins, thromboxane, etc., which mediate pain. (2) Opioids (hydromorphone, fentanyl, methadone, morphine); bind to the mu opioid receptor to block transmission and transduction of pain signals. (3) NMDA-receptor antagonists (ketamine, amantidine, tiletamine); in low doses prevent wind up and hyperalgesia through their action on NMDA receptors. (4) Local anesthetics (lidocaine, bupivicaine); block fast voltage gated Na channels and block transmission of local pain signals. (5) Alpha2-agonists (dexmeditomidine, xylazine); sedative, analgesic, sympatholytic, and anxiolytic effects as an alpha2-receptor agonist with minimal respiratory depressent effects.
iv. Tramadol decreases reuptake of serotonin and norepinephrine in addition to mild opioid effects.

140 A i. 1, C; 2, D; 3, E; 4, B; 5, A.

141 Abdominal ultrasound: changes supportive of mass lesions, involvement of lymph nodes, intraluminal FB, organomegaly, and vascular integrity. The presence of peritoneal gas can prevent ultrasonographic interrogation. Abdominal CT: better definition of neoplastic lesions based on contrast-enhanced blood flow; gas-filled, bone (mineralized), and colonic changes are better defined with CT.

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142 A 5-month-old female Chihuahua presents with a puncture bite wound on top of her head (**142**). T = 37.8°C (100.1°F); HR = 40 bpm; RR = 10 bpm with minimal chest movement; CRT = 2 sec; MM cyanotic, dry; femoral pulses weak. The dog is in a stupor. You intubate the dog and confirm and secure the endotracheal tube in the airway without sedation. Immediate reassessment finds MM pink and HR 150 bpm.

i. Assess the needs of Airway, Breathing, Circulation, and Consciousness for this dog.
ii. Provide the initial FiO_2, bpm, tidal volume, peak inspiratory pressure, and any positive end-expiratory pressure settings for the mechanical ventilator for this dog.
iii. Create the 4-Step Fluid Resuscitation Plan for this dog.
iv. Which of these parameters should be used to monitor this dog: arterial blood gas, pulse oximetry, $ETCO_2$, rectal temperature, body weight, neurologic status, HR, ECG, blood glucose, seizure watch, PCV, TS, urine output, arterial BP?
v. Outline the nursing instructions for this dog.



143 A 10-year-old male neutered DSH cat presents for weakness, lethargy, and anorexia progressive over 3 days (**143**). The cat became 'wobbly' yesterday and today is not responsive. T = 36.1°C (97°F): HR = 180 bpm; RR = 12 bpm; CRT = 3 sec; MM very pale pink; femoral pulses weak. Peripheral perfusion is poor and dehydration is estimated at 10% (skin tenting, dry MM). Thoracic auscultation finds normal lung and heart sounds. The cat is obtunded with minimal response to touch. No cranial nerve deficits are noted. Abdominal palpation finds urinary bladder with urine, no abnormalities. Indirect Doppler SABP is too low to register. This emergency database is from blood taken prior to administering fluids: PCV = 0.48 l/l (48%); TS = 98 g/l (9.8 g/dl); BUN = 42.84 mmol/l (120 mg/dl); glucose = 54.16 mmol/l (976 mg/dl); Na+ = 176 mEq/l; K+ = 6.5 mEq/l; phosphorus = 2.19 mmol/l (6.0 mg/dl); venous blood gases: pH = 7.2, HCO_3 = 9 mEq/l, $PvCO_2$ = 50 mmHg; lactate = 3.5 mmol/l (31.5 mg/dl); urine (cysto): SG = 1.012, occasional granular cast, 3+ protein, 2+ blood, 4+ glucose, 3+ ketones.

i. List problems in order of most to least life-threatening, grouping them when possible.
ii. Give your specific choices for the four steps for creating the fluid resuscitation plan, and justify your choices.
iii. What fluid(s) are planned for maintenance? Include how to make fluid choice(s), additives, and/or medications.
iv. How would you like to monitor the fluid balance in this cat?

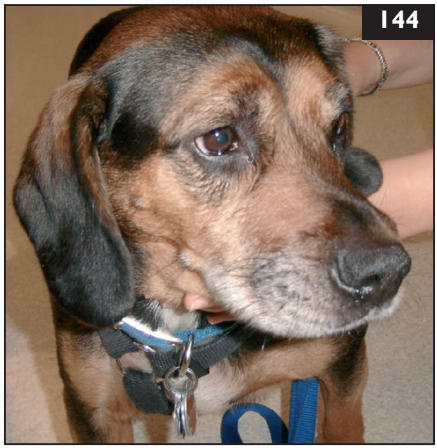
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Answers: 142, 143

142 i. Airway: control the airway for adequate ventilation. Breathing: ventilation was impaired requiring mechanical ventilation. Circulation: dehydration and poor perfusion are present. Consciousness: the dog is unconscious but arousable with noxious stimuli.
ii. FiO_2: 1.0 (100% oxygen) reducing when stable; RR = 12–15 bpm (maintain PCO_2 at 35–40 mmHg); small dog tidal volume 15 ml/kg = 60 ml; peak inspiratory pressure = 15–20 mmHg; PEEP – start at 3–5 cmH_2O.
iii. Step 1: perfusion and hydration deficits. Step 2: combination of crystalloid (i.e. normal saline due to slightly higher sodium) and HES (e.g. tetrastarch or hetastarch) to promote intravascular retention of fluids. Step 3: low end resuscitation end-points (systolic to 90 mmHg) because of likely brain edema. Step 4: small volume titration of fluids until perfusion is stable. Then use primarily crystalloids to minimize chance of colloid extravasation into brain tissue from ruptured vessel.
iv. All of them. Continuous SpO_2 and $ETCO_2$ will minimize blood sampling.
v. Lubricate corneas; elevate head/neck and shoulders 15–20 degrees; avoid moving head from normal positioning when changing body position q4h; avoid and report hyperthermia, change in head position, struggling, seizures; humidify and suction airway; reposition ET when changing tube at least q12h; maintain core body temperature >36.6°C (98°F); clean urine and feces from skin; provide sufficient padding, monitor wounds/bandages, and clean as necessary.

143 i. The order of importance can vary: poor perfusion (hypotension, bradycardia, hypothermia, high lactate); altered mentation; hyperosmolar (hyperglycemia, hypernatremia, obtunded, minimal response); metabolic acidosis (elevated lactate, urine ketones); mild hyperkalemia; kidney disease (high BUN, isosthenuria, proteinuria, granular casts); dehydration. The most life-threatening concern is restoring perfusion while preventing rapid fluid shifts into the brain because of the hyperosmolar status.
ii. Step 1: perfusion and hydration deficits (see problems list). Step 2: combination of normal saline (because of hypernatremia) and HES to maintain intravascular volume and minimize fluid extravasation. Step 3: low end end-points (because of the CNS signs of obtunded and not responsive). Step 4: small volume resuscitation with warming procedures after measurable peripheral BP/pulses to avoid volume overload and rapid drop in sodium or glucose.
iii. A combination of crystalloids (choice depends on serum Na+ after resuscitation) to replace interstitial fluid (polyuria likely to persist due to glycosuria) and promote glomerular filtration and HES for intravascular COP while slowly lowering osmolality. Therapy with regular insulin by CRI requires a separate fluid bag, pump, and line. Potassium supplementation will be in the maintenance crystalloids and based on potassium changes. The quantity of fluid to deliver the insulin is considered as part of the total maintenance crystalloids. Avoid 5% dextrose in water as the carrier in animals <8 kg because the 'free water' delivered might be harmful, and this patient is hyperglycemic.
iv. Ideal monitoring includes BP, CVP using a femoral catheter, repeated assessment of physical perfusion parameters, hydration, serial neurologic examinations, blood glucose, electrolytes, urine output; body weight.

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144

144 A 5-year-old Beagle-cross is hospitalized with a working diagnosis of acute severe pancreatitis (**144**). During the morning rounds: T = 39.4°C (103°F); HR = 140 bpm; RR = 20 bpm; CRT = 2 sec; MM pale pink and moist. The dog is anorexic and showing signs of nausea and severe abdominal pain. The dog is currently receiving fentanyl (5 µg/kg/min CRI IV) for analgesia but does not appear to be receiving adequate pain control.

i. What additional options for pain control may be used in this dog?

ii. Describe how to perform an epidural injection.

iii. What medications are commonly administered in the epidural space for pain relief?

iv. What are some possible causes of the worsened nausea and abdominal pain in this dog?


145a

145 A 3.5-year-old female neutered Collie-cross presents for an acute onset of progressive swelling of the right eye (**145a**) and reluctance to eat today. T = 39.5°C (103.1°F); P = 120 bpm; RR = 24 bpm; normal perfusion and hydration; normal auscultation and palpation findings; pain expressed when opening the mouth. Ocular examination finds significant buphthalmia OD with reddening of the conjunctiva. The pupil is slightly miotic with a normal PLR. The extraocular (retrobulbar) tissues OD are swollen and warm. The globe is firm and does not retropulse.

i. Provide differential diagnoses for an acute-onset retrobulbar swelling.

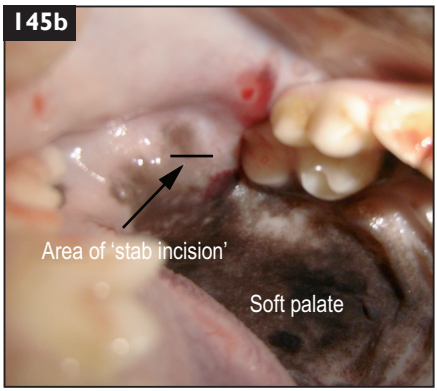
ii. Describe possible diagnostic procedures for retrobulbar swelling.

iii. Describe treatment for a retrobulbar abscess.

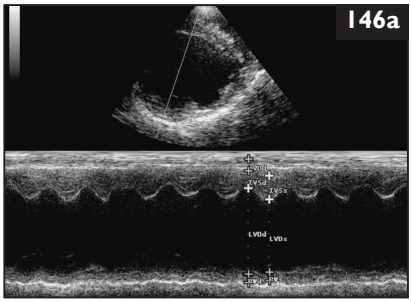
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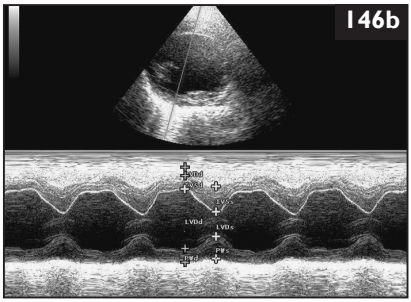
144 i. In order of preference: (a) increasing the fentanyl infusion dose (up to 10 µg/kg/min); (b) additional analgesic infusions (e.g. ketamine [0.1–1 mg/kg/hr], lidocaine [25–80 µg/kg/min] and/or dexmedetomidine [1–5 µg/kg/min]) to the fentanyl; (c) change the opioid (e.g. hydromorphine, methadone); (d) epidural local analgesia (0.5–2.0 mg/kg of 7.5% bupivacaine); (e) peritoneal lavage and infusion of local anesthetic. NSAIDs are rarely used in animals with pancreatitis.
ii. Need heavy sedation or GA. Sternal or lateral recumbency with hindlimbs extended cranially. Clip and scrub the region over spinal processes of L6–S2. Ensure midline entry of needle by palpating wings of ilium; locate the space between L7 and S1. Insert a 20 or 22 gauge spinal needle directly on the midline, caudal to the dorsal process of L7, perpendicular to the spinal column. Several small 'pops' are felt passing through the ligamentum flavum, and a more pronounced 'pop' through the interarcuate ligament. Inject the drug without resistance and over 1–5 minutes.
iii. Local anesthetics (lidocaine 2% or bupivacaine 0.5% and preservative-free morphine (0.1–0.4 mg/kg; drug volume should not exceed 6 ml).
iv. Include: increasing pancreatic inflammation, peritonitis from ruptured pancreatic abscess or other cause, GI ulceration, organ torsion, dilation or ischemia, severe ileus, gallbladder distension or rupture, insufficient analgesia.

145 i. Retrobulbar abscess (secondary to tooth root abscesses or migrating foreign body), coagulopathy (e.g. rodenticide ingestion), extraocular trauma with soft tissue swelling, granuloma (fungal or inflammatory), diseases of the globe (e.g. neoplasia).
ii. May include routine blood work (CBC, serum biochemistry) for evidence of infection or organ dysfunction, ocular ultrasound to assist in differentiating retrobulbar swelling from disease of the globe, coagulation profile, and sedated oral examination. Dental radiographs and/or advanced imaging (CT, MRI) of the head may identify migrating FB or disease of the nasal cavity/tooth roots.
iii. Heavy sedation or general anesthesia is necessary with airway protection. A vertical stab incision is made behind the last molar of the affected side (**145b**). A blunt probe is inserted to break down any adhesions and a culture swab is inserted to collect a sample for culture and susceptibility. Pain medication and antibiotics are warranted. Cold or alternating cool and warm compresses applied to the swollen retrobulbar tissues may reduce swelling and pain.



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146 A 13-year-old male neutered Shih Tzu presents with acute onset of respiratory difficulty and a soft moist cough of 3 days' duration. T = 37.5°C (99.8°F); HR = 140 bpm; RR = 64 bpm; CRT = 1–2 sec; MM pink; weak femoral pulses synchronous with heart; severe respiratory distress with synchronous breathing pattern. Thoracic auscultation reveals bilateral moderate pulmonary crackles and a grade IV/VI systolic murmur on the left side. Your working diagnosis is CHF.

i. What findings would you anticipate with CHF for the following: (a) history and signalment; (b) physical examination; (c) thoracic radiographs; (d) blood chemistries.

ii. Two echocardiograms from dogs with heart disease are shown (**146a, b**). Which is typical of dilated cardiomyopathy, and what echo findings are typical? Which is typical of mitral regurgitation, and what echo findings are typical?

iii. List other differential diagnoses for this dog in respiratory distress.



147 A 7-year-old female neutered Labrador presents for increased frequency and straining on urination and blood in the urine (**147**). She is a well-regulated diabetic receiving twice daily insulin injections. She has periodic urinary tract infections and was treated for 2 weeks with enrofloxacin 2 months ago based on culture and susceptibility results finding *Klebsiella* spp. T = 39.8°C (103.6°F); HR = 110 bpm; RR = 36 bpm; CRT = 1.5 sec; MM pink; perfusion and hydration normal. There are a few drops of serosanguineous fluid on the vaginal folds and evidence of the dog licking that area.

i. What is your differential diagnosis for these clinical signs?

ii. What would be your diagnostic plan?

iii. What are the components of the urinalysis, and what do they mean?

iv. Urinalysis results show a significant number of WBCs, RBCs, and intracellular bacteria. Would you characterize this as a simple or complicated urinary tract infection? What test may help determine what type of bacteria is present and guide antimicrobial choices?

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146 i. (a) Historical signs of cough or respiratory difficulty, exercise intolerance; signalment may help narrow differentials (although not exclusive middle-aged to older, small and toy breed dogs and Cavalier King Charles Spaniels tend to get myxomatous mitral valve disease, middle-aged Cocker Spaniels and large or giant breed dogs tend to get dilated cardiomyopathy). (b) Physical examination findings include increased RR and effort, wheezes and crackles on auscultation, heart murmurs and arrhythmias, perfusion deficits, discolored (pale or cyanotic) mucous membranes. (c) Radiographs may demonstrate cardiomegaly (vertebral heart score >10.5), enlargement of the left atrium, dorsal deviation of the trachea, and perihilar interstitial to alveolar lung pattern. (d) Laboratory work (e.g. lactate) is not specific to heart disease, just poor oxygen delivery or increased metabolic oxygen demand; cardiac troponins and natriuretic peptides are specific for heart disease, but overlap to a large degree with other disease processes.
ii. Dilated cardiomyopathy (**47a**): enlarged left atrium (LA) and LA/aorta ratio, enlargement of the left ventricular chamber size, normal or thin width of the left ventricular walls, and decreased contractility. Mitral regurgitation (**47b**): enlarged LA and LA/aorta ratio, thickening of the walls, increased contractility, thickened or prolapsed mitral valves, and visible regurgitant flow. The left ventricle chamber may be slightly enlarged
iii. Should include pneumonia (fungal, bacterial, aspiration), pulmonary contusions, non-cardiogenic pulmonary edema, pulmonary thromboembolism, acute respiratory distress syndrome, neoplasia.

147 i. Urinary tract infection, sterile cystitis/urethritis, urinary calculi, neoplasia, vaginitis, uterine stump pyometra.
ii. Urinalysis to evaluate for signs of infection, crystals, abnormal cells; urine culture to document an existing infection and susceptibility to antimicrobials; urinary tract ultrasound to determine if there are changes associated with neoplasia, calculi, or other anatomic changes indicative of renal infection. The presence of glucose would not be unexpected.
iii. Urine SG demonstrates urine concentrating ability but may be affected by the presence of inflammatory cells and glucose; urine dipstick analysis to show abnormal presence of glucose, bilirubin, ketones, protein, blood (pigmenturia from blood or hemoglobin may falsely alter dipstick results); urine sediment to document inflammatory cells, RBCs, bacteria, crystals, casts, parasites, and abnormal epithelial cells.
iv. This would be characterized as a complicated infection since it is reoccurring within a short period of time and the previous infection was resistant to commonly used antimicrobials. The presence of diabetes increases susceptibility to infection and influences response to treatment. Gram stain of the urine. Urine culture and susceptibility.

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148 The Gram stain test on the dog in case **147** showed negative-staining rods. The previous urine culture grew a *Klebsiella* species that was resistant to amoxicillin, amoxicillin–clavulanate, and cephalexin. She had been treated with enrofloxacin.
i. What is your antibiotic choice before return of culture and susceptibility (CS) results, and why?
ii. Urine CS results document a *Klebsiella* species resistant to enrofloxacin and most beta-lactams. There is susceptibility to cefovecin and trimethoprim–sulfa (TMS). What are the pros and cons of each antibiotic for the treatment of this infection? What duration of therapy would you recommend, and why?
iii. What type of follow-up would you recommend (if the dog is asymptomatic after 5 days)?



149 A 3-year-old male neutered cat presents for vomiting a clear fluid and not eating for 2 days (**149**). He is indoor–outdoor with access to an ornamental garden tended by a gardener. He is known to kill rodents. T = 37.9°C (100.2°F); HR = 120 bpm; RR = 48 bpm; CRT = 2 sec; MM pink; pulses normal, synchronous; perfusion adequate; 8% dehydrated (skin turgor and MM/corneal dryness). Thoracic auscultation normal. Abdominal palpation uncomfortable with fluid palpated in the bowels. Foul smelling watery brown diarrhea is passed when the thermometer is removed. The cat is hypersalivating, has generalized tremors, and miotic pupils. Some potential toxins the cat could be exposed to in the garden include castor bean plant, Asian lily, begonia, burning bush, brodifacoum, and diazinon.
i. List the toxic principle of each plant/product listed, and the most likely cause of the clinical signs in this cat.
ii. What primary metabolic problems cause these clinical signs?
iii. Is the diarrhea large bowel or small bowel in origin? Which typically has more consequences to the patient?
iv. When are antibiotics indicated for treating diarrhea?

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Answers: 148, 149

148 i. The previous infection was a documented *Klebsiella* species, which is a gram-negative rod. Since a similar organism was identified on Gram stain of the urine sample, it would seem reasonable to start therapy with the same antibiotic that was used previously (enrofloxacin). Urine culture and susceptibility results will provide evidence to support the use or suggest the need for a different antibiotic.
ii. Cefovecin is a long-acting antibiotic that achieves good concentration in the urine. It is primarily eliminated by renal mechanisms and should be used with caution in animals with severe renal dysfunction. Long-term (>2 weeks) use has not been evaluated in small animals. In addition, if there is an adverse reaction, the medication cannot be discontinued. TMS also achieves good concentration in the urine, but can cause side-effects such as dry eye, bone marrow suppression, and hypothyroidism. Periodic examination is necessary to monitor for side-effects. Duration = 4–8 weeks.
iii. A repeat urine CS after 1 week indicates if the current antibiotic is effective. Repeating the urine CS 1 week after stopping therapy can show if elimination of bacteria is sustained.

149 i. Castor bean: contain ricins, a toxin that inhibits protein synthesis; ingestion of an opened bean causes oral pharyngeal irritation, vomiting, diarrhea, abdominal pain, kidney failure, convulsions.
Asian lily: toxic principle is unknown; ingestion causes vomiting, inappetence, lethargy, kidney failure, and death.
Begonia: insoluble oxalates in the tubers cause oropharyngeal irritation, vomiting, difficulty swallowing when swallowed.
Burning bush: toxic principle includes alkaloids and cardenolides; ingestion in large doses can cause vomiting, diarrhea, abdominal pain, weakness, and heart rhythm abnormalities with large doses.
Brodifacoum: vitamin K epoxide reductase antagonist, anti-coagulant; causes uncontrolled hemorrhage.
Diazinon: acetylcholinesterase inhibitor that causes an increase in acetycholine at neuromuscular junctions, causing increased urination, defecation, lacrimation, tremors, miosis, and seizures. The clinical signs in this cat are consistent with ingestion of this toxin.
ii. Liver and kidney failure, pancreatitis, primary gastroenteritis (bacterial overgrowth, inflammatory bowel disease, parasitic infestation, bacterial overgrowth/enteritis), hypoadrenocorticism, sepsis.
iii. Small bowel diarrhea. More systemic consequences to small bowel diarrhea (dehydration, protein loss, electrolyte derangements, bacterial translocation) can make the animal more critical.
iv. When there are: (1) signs of sepsis, (2) a predisposition to infection, (3) documented infection as etiology, or (4) organ dysfunction resulting from or worsened by bacterial infection.

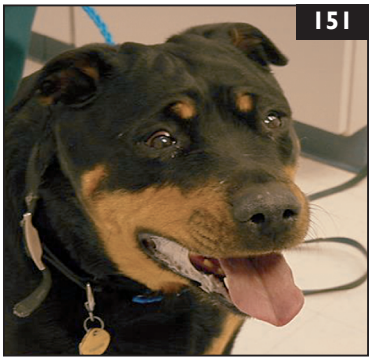
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150 After 24 hours of balanced isotonic crystalloid fluid therapy promoting diuresis, atropine, and analgesia for presumed diazinon toxicosis, the miosis and tremors in the cat in case **149** have resolved. The cat is rehydrated, but refuses to eat and continues to have watery diarrhea. Ultrasound evaluation of the abdomen shows changes consistent with pancreatitis.

i. What are some of the complications associated with lack of nutritional intake in the cat?

ii. What are the pros and cons of starting enteral feeding in this cat?

iii. What are the pros and cons of nasogastric tube (NGT) versus esophagostomy tube placement?



151 A 5-year-old female neutered Rottweiler presents for vomiting and weakness after eating expired (1 year) canned dog food (**151**). She is allowed to roam a ranch in Montana. T = 39.8°C (103.6°F); HR = 135 bpm; RR = 30 bpm; CRT = 2 sec; MM pink but dry; femoral pulses normal; perfusion adequate; 6% dehydration based on MM moisture and skin turgor. Abdominal and thoracic examinations are normal. Neurologic examination finds generalized weakness at presentation, which progresses after 12 hours of IV crystalloids and anti-emetic medication, with persistent fever. Neurologic examination done after 12 hours finds normal cranial nerves, mentation, fundic examination, muscle mass, orthopedic examination, and pain perception. The abnormalities are below.

Panniculus reflex	Absent
Posture	Cannot stand by herself; sits or lies on sternum
Gait	Requires support to stand and move; has slow, ataxic gait when supported
Proprioception	Delayed to absent x 4
Spinal reflexes	Reduced (slow) to absent x 4
Withdrawal	Reduced to absent x 4
Anal tone	Reduced

i. Localize the lesion from the neurologic examination.

ii. Provide a differential diagnosis list.

iii. CBC, biochemical profile, T4, and urinalysis results were all within normal ranges. Based on the information provided, provide an assessment of the differential diagnosis list as it relates to this dog.

iv. What is the monitoring and treatment plan for this dog?

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150 i. Hepatic lipidosis within 72 hours of no food intake. Decreased arginine and methionine can limit hepatic synthesis of proteins and phospholipids. Protein restriction leads to failure of aminotransferases and urea cycle enzymes. Lean muscle loss occurs. A negative nitrogen balance can result in GI ileus, villous atrophy, and increased risk of bacterial translocation. Deleterious effects on the renal, pulmonary, immune, cardiovascular, and musculoskeletal systems have been associated with negative nitrogen balance.
ii. Pros: reduces negative energy balance; may improve outcome and reduce hospital stay; helps maintain normal GI enterocyte health and function; generally inexpensive and easy to perform. Cons: forced oral feeding may induce nausea, aspiration, and food aversion.
iii. NGT pros: requires minimal chemical restraint; can monitor gastric residual volume (tolerance to feedings); allows decompression and removal of gastric contents, reducing vomiting and discomfort; allows continuous small volume liquid diet infusion. Cons: occasional epistaxis, rhinitis; Elizabethan collar needed. Esophagostomy tube pros: can infuse larger volumes of concentrated, thicker (blendarized) diets (less expensive); more comfortable for patient; allows administration of medications unable to pass through smaller NGT. Cons: requires a full, albeit brief anesthesia; occasional misplacement; abscess at site.

151 i. Lower motor neuron or myoneural junction pathology.
ii. Metabolic derangements (e.g. hypoglycemia, electrolyte imbalances, severe hypothyroidism), polyradiculoneuropathy, coral snake poisoning, tick paralysis, botulism, myasthenia gravis, polymyositis.
iii. Metabolic problems were not identified and coral snakes are not found in Montana. Myasthenia gravis and polymyositis typically cause normal peripheral nerve reflexes and progressive weakness with activity. Polyradiculoneuropathy and tick paralysis are possibilities. Botulism is a possibility in this dog ingesting expired dog food or exposed to a *Clostridium botulinum*-infected carcass in Montana.
iv. Careful examination for presence of ticks is indicated and a tick pesticide should be applied. Skin wounds are thoroughly cleansed with debridement. Botulinum antitoxin can stop further progression when there is strong evidence of botulism. Supportive care is the mainstay of treatment for tick paralysis, botulism, and polyradiculoneuropathy. The Rule of 20 is assessed at least twice daily for these recumbent animals. Specific areas of interest include reduced mobility and recumbency requiring physical therapy and frequent body shifting and eye lubrication. Placement of a nasogastric tube for nutritional and fluid support is important. Prokinetic drugs can offset ileus and reduce risk of aspiration pneumonia. Oxygenation and ventilation parameters are closely monitored since the respiratory muscles can become dysfunctional. Mechanical ventilation may be needed for several days until the condition improves.

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152 A 10-year-old Great Pyrenees presents for incoordination and weakness (**152**). Physical examination is normal except for tetraparesis and ataxia when gaited. The dog has not eaten for 10 hours. Emergency laboratory database: PCV = 0.45 l/l (45%); TS = 68 g/l (6.8 g/dl); glucose = 2.2 mmol/l (40 mg/dl); BUN = 8.9 mmol/l (25 mg/dl).

i. List differential diagnoses for hypoglycemia.

ii. Select the correct list of hormones that are released to counterregulate a low blood sugar (select one): (a) epinephrine, corticosteroid, glucagon, growth hormone; (b) epinephrine, glucagon, corticosteroid, thyroid hormone; (c) epinephrine, corticosteroid, gastrin, growth hormone; (d) epinephrine, corticosteroid, glucagon, testosterone.

iii. Which organ is most susceptible to the detrimental effects of hypoglycemia?

iv. Treatment for hypoglycemia may include all EXCEPT: (a) epinephrine; (b) dextrose bolus followed by CRI; (c) glucagon; (d) corticosteroid.

v. What treatments are indicated in the acute stage of this patient?

vi. What special considerations must be made when supplementing glucose in a patient with insulinoma-related hypoglycemia?

vii. What is neuroglycopenia?

153 A 4-month-old male Pitbull falls from a retaining wall and presents for labored breathing. T = 37.8°C (100°F); HR = 165 bpm; RR = 58 bpm; femoral pulses weak; perfusion poor (middle stage shock); 6% dehydrated. The breathing is labored on inspiration and expiration, with chest and abdomen movement synchronous. Thoracic auscultation reveals generalized bilateral moist crackles and normal heart sounds. Initial PCV = 0.45 l/l (45%) and TS = 45 g/l (4.5 g/dl).

i. Localize the respiratory lesion. Give a differential diagnosis, identifying the most likely.

ii. What is your initial stabilization plan?

iii. Give the pros and cons of using furosemide, antibiotics, and/or steroids in the initial treatment plan for this dog.

iv. What is your plan for continued care of this dog's pulmonary pathology?

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152 i. Sepsis, hepatic failure, neoplasia (insulinoma, sarcoma), insulin overdose, hypoadrenocorticism, xylitol intoxication, glycogen deficiency or storage disease, heavy exercise (e.g. hunting dogs), portosystemic shunt, laboratory error.
ii. a.
iii. Brain.
iv. a.
v. IV dextrose infusion and possibly glucagon. Encourage frequent meals.
vi. Bringing up the glucose level beyond the normal plasma range may stimulate additional insulin release and exacerbate the hypoglycemia.
vii. A syndrome in which hypoglycemia results in neurologic signs. The brain almost exclusively uses glucose for energy (25% of all glucose in the body) but cannot synthesize or store it. Also, the metabolic rate of brain tissue is three times that of peripheral tissues. These characteristics make the brain particularly sensitive to the effects of hypoglycemia. When protracted or severe hypoglycemia exhausts counterregulatory mechanisms, excitotoxin (e.g. glutamate, aspartate) release, apoptosis, and pseudolaminar necrosis can occur in the brain.

153 i. Lung parenchymal disease. Edema (cardiogenic, non-cardiogenic), hemorrhage, inflammation, infection, and neoplasia of the lung tissue; most likely pulmonary contusions.
ii. Flow-by oxygen; IVC; IV balanced isotonic crystalloids/HES using small volume technique to low end end-points (trauma, pulmonary pathology); analgesics early in treatment; high-flow oxygen by mask or hood until nasal cannula is placed; emergency laboratory database.
iii. Furosemide. Pathology is not due to increased HP. Pros: no advantage. Cons: can volume deplete critical patient; dry airways; will not reduce parenchymal hemorrhage.
Antibiotics. Pathology is not due to infectious agent. Pros: none at this time. Cons: can allow overgrowth of resistant bacterial organisms. Antibiotic use is reserved for specific treatment of documented bacterial complications.
Steroids. Pros: none. Cons: have been shown to be of no benefit in people and may impair bacterial clearance from pulmonary tissues.
iv. Pulmonary contusions are typically self-limiting, benefiting from oxygen support, fluids supporting perfusion, adequate analgesia, treatment of chest wall injuries, and careful pulmonary hygiene and physiotherapy if dog develops tracheal secretions or cough. Initial monitoring includes: RR and effort, BP, pulse oximetry, assessment of perfusion/hydration, rectal temperature, and CBC for signs of inflammation or infection.

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154 A 4-year-old male neutered Cocker Spaniel presents because of decreased activity and appetite. T = 39.9°C (103.9°F); HR = 170 bpm; RR = 60 bpm; CRT = 3sec; MM pale yellow and dry; femoral pulse bounding; perfusion hyperdynamic; estimated 6% dehydrated (MM moisture/skin turgor). A II/VI left systolic heart murmur with normal lung sounds are heard on auscultation. Initial database: PCV = 0.14 l/l (14%); TS = 78 g/l (7.8 g/dl); hemolyzed serum; BUN = 16 mmol/l (45 mg/dl); glucose = 5.3 mmol/l (95 mg/dl).

i. List at least two pathologic mechanisms that cause anemia.

ii. What are the RBC morphologic indicators of a regenerative process in anemia?

iii. Fill in the following chart comparing changes seen during acute hemorrhage versus hemolysis.

	Hemorrhage Acute loss	**Hemolysis Destruction**
Total protein		
Plasma color		
Reticulocyte response (brisk or less brisk)		
RBC morphology		

iv. List the broad categories of causes of RBC hemolysis.

v. How is a saline agglutination slide test performed, and what does it demonstrate?

155 A 5-year-old female neutered Beagle-cross presents for PU/PD (**155**). Past diagnoses include ascites, hypoalbuminemia, mild normocytic normochromic anemia, and proteinuria.

i. Name some diseases that can lead to the development of (secondary) glomerulonephritis (GN)?

ii. What are the general treatment considerations for GN in dogs?

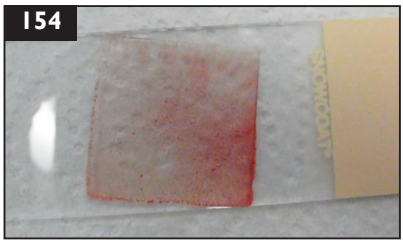


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Answers: 154, 155

154 i. Inadequate production of RBCs (e.g. selective erythropoietic depression, insufficient erythropoietin release, bone marrow failure); excessive loss of RBCs (e.g. shortened lifespan, hemorrhage); increased destruction (intravascular or extravascular hemolysis).
ii. Macrocytosis, hypochromia, polychromasia, reticulocytosis.
iii.

	Hemorrhage Acute loss	**Hemolysis Destruction**
Total protein	↓	Normal or ↑
Plasma color	Clear	Icteric or hemolyzed
Reticulocyte response (brisk or less brisk)	Less brisk (3–5 days)	Brisk
RBC morphology	Normal Polychromasia (after 2–7 days)	Spherocytes/Heinz bodies/ eccentrocytes/schistocytes/+/- auto-agglutination


154

iv. Immune-mediated hemolytic anemia; alloimmune hemolysis (also called neonatal isoerytholysis, rare in dogs); microangiopathic/fragmentation hemolysis (DIC, dirofilariasis, neoplasia); metabolic (hypophosphatemia, osmotic lysis); toxins/drugs (acetaminophen, onions, zinc, lead); infection (blood parasites, viral, rickettsial disease); hereditary enzyme deficiencies.
v. A drop of patient blood is placed on a slide and mixed with a drop of isotonic saline. Macroagglutination is indicated by visualizing clumping of red cells on the slide (**154**) and microscopic evaluation to distinguish true agglutination from rouleaux formation.

155 i. Underlying causes of GN include: infectious diseases (e.g. Lyme disease, dirofilariasis, endocarditis, pyometra, ehrlichiosis, pyoderma), neoplasia (e.g. multiple myeloma, leukemia, lymphoma), immune-mediated diseases (e.g. SLE, polyarthritis, IMHA, chronic pancreatitis), metabolic conditions (e.g. hyperadrenocorticism), and drug use (sulfa drugs).
ii. Treat the underlying condition (if present), control of protein loss in the urine (e.g. ACEI), control of hypertension (amlodipine or other vasodilating drugs), control of hypercoagulation (e.g. aspirin or other drugs), immunosuppressive therapy (e.g. cyclosporine, azathioprine; corticosteroids may worsen azotemia unless secondary to an inflammatory condition such as SLE); sodium restriction and diuretics are often prescribed to reduce ascites. If azotemia present: fluid administration; GI proctectants (sucralfate, H2-blockers, proton pump inhibitors) may help decrease GI ulceration; aluminum hydroxide if hyperphosphatemia; and prescription (kidney) diets.

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156 A 2-year-old female neutered DSH cat presents 15 minutes after jumping over a metal gate at home. T = 38.6°C (101.5°F); P = 260 bpm; RR = 36 bpm; CRT = 2 sec; MM pink, moist; perfusion and hydration normal. Thoracic auscultation and abdominal palpation are normal. There is a large inguinal wound (**156**).

i. A GDV walks in the door; you and your staff must attend to this dog quickly. What immediate emergency care can be provided to this cat to allow you and your staff to give your attention to the dog with GDV.

ii. Discuss the definitive management of this cat and the wound.

iii. There is a large subcutaneous space found during wound repair that is difficult to close. Discuss options for closure of subcutaneous dead space.

iv. What suture materials and size should be used to close this wound?



157 A 5-year-old male neutered American Eskimo dog presents for not wanting to walk, not eating, and generally painful. T = 40.1°C (104.2°F); HR = 136 bpm; RR = 36 bpm; CRT = 1 sec; MM pale pink. The dog is reluctant to walk, has a hunched gait, and mild edema of the distal forelimbs. There is gingival bleeding (**157**) and petechiation on the ventral abdomen. He is not on flea or tick prevention because he becomes very agitated after application, but he does spend time in wooded areas. Vaccinations and heartworm prevention are current. CBC shows a mature neutrophilia with a thrombocytopenia (45×10^9/l) and mild anemia (Hct = 32%).

i. Which clinical sign supports the platelet count?

ii. List at least five tick-borne pathogens.

iii. An investigation for tick-borne pathogens identifies an *Ehrlichia canis* infection. Which of these ticks is responsible for *Ehrlichia* transmission: *Rhipicephalus sanguineous* (brown dog tick); *Dermacentor variabilis* (American dog tick); *Ixodes scapularis* (deer tick)?

iv. What is the recommended treatment for ehrlichioisis?

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156 i. The cat is given pain medication and the wound clipped, cleaned, and bandaged. Broad-spectrum antibiotics should be given.
ii. Abdominal radiographs or a FAST ultrasound examination and a minimum database (PCV/TS, glucose, Azo stick) are appropriate prior to induction of GA. Primary wound closure is an appropriate option at this time because of the acute onset, healthy appearing tissues, and minimal disruption to blood supply. An IVC is placed, IV crystalloid support provided, an opioid analgesic (such as buprenorphine) administered, injectable anesthestic agent (e.g. propofol) administered to induce anesthesia, and the cat intubated and maintained/monitored under gas (e.g. isoflurane) anesthesia. The entire region is clipped and surgically prepared and the wound explored for entry into the abdominal cavity, debrided, and closed (likely with a drain).
iii. The large subcutaneous space will need to be closed with walking sutures, several layers of suture, or placement of a passive (e.g. Penrose) or active (e.g. bulb suction) drain. Subcutaneous dead space extending to a limb may be treated by bandaging as well.
iv. The subcutaneous tissues can be closed with 4-0 or 3-0 monofilament absorbable suture (e.g. PDS®, Maxon™, or Monosorb) on a taper needle. The skin can be closed with staples, intradermal sutures (4-0 monofilament absorbable suture on a cutting needle), or nylon skin sutures.

157 i. Petechiation is a sign of a primary coagulation dysfunction, including low numbers of or abnormally functioning platelets.
ii. *Anaplasma phagocytophilum*, *Anaplasma platys*, *Babesia canis*, *Bartonella henselae* or *vinsonii*, *Ehrlichia canis*, *Mycoplasma hemocanis/hemoparvum*, *Neorickettsia risticii*, *Rickettsia rickettsii*.
iii. *Rhipicephalus sanguineous*.
iv. Doxycyline, with vigorous supportive care for this SIRS disease. Fluid therapy with a combination of isotonic balanced crystalloids and HES to support intravascular volume that extravasates through the leaking capillaries. The Rule of 20 is used at least twice daily during the active phase of vasculitis.

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158

158 A 6-year-old male mixed-breed dog presents for acute hindlimb paralysis after playing fetch in the yard. Physical examination is normal except for a nervous and agitated demeanor. He is able to support weight on his forelimbs but not on his hindlimbs (**158**). Neurologic examination findings: cranial nerves, mentation, retinal examination, and spinal palpation normal; withdrawal, muscle mass, and orthopedic examination normal in all four limbs; anal tone normal. Abnormalities are noted below:

Panniculus	Exaggerated on right at L2 vertebral body; normal on left
Posture	Sitting with forelimbs supporting weight of thorax. Hindlimbs stretched out beneath abdomen, not supporting weight. When supported, the left hindlimb is able to bear weight
Gait and voluntary motor	Normal forelimbs. Reduced voluntary motor left hindlimb. Greater loss of voluntary motor on right hindlimb
Proprioception	Normal forelimbs, reduced left hindlimb, absent right hindlimb
Spinal reflexes	Normal forelimbs, normal left hindlimb, increased sciatic, patellar and cranial tibial reflexes right hindlimb

i. Localize the lesion from the neurologic examination.
ii. Provide a differential diagnosis list.
iii. What diagnosis is most likely for this dog, and how is the likely problem treated?


159a

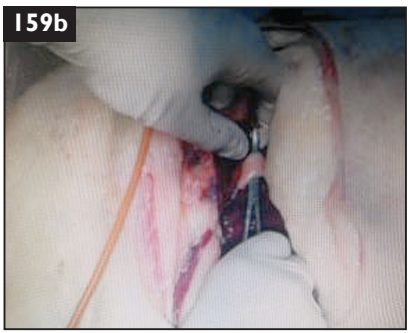
159 An 11-year-old cat presents to the clinic in cardiopulmonary arrest. She has a history of a heart murmur and a breathing difficulty for the past few hours. The owners report that the cat stopped breathing in the clinic parking lot.
i. Name indications for open chest compression CPR (**159a**).
ii. Describe rapid entry into the chest for open chest cardiac massage during CPR.
iii. How can you monitor this patient while performing CPR? How might $ETCO_2$ results alter your intervention?
iv. What is the targeted RR and HR for the patient during CPR?
v. What is a Rummel tourniquet? How is it placed? How long can it stay on, and why?

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Answers: 158, 159

158 i. The head, neck, and forelimbs are normal, suggesting that the spinal cord from C1 to T2 is normal. The hindlimb reflexes for the right limb are exaggerated and normal for the left limb, with normal withdrawal in the hindlimbs. This suggests that the lumbosacral intumescence is normal (L3/4–S1). This places the lesion between T3 and L3 spinal cord segments, with the problem more severe on the right side. The asymmetry of the panniculus response and the exaggerated reflex at vertebral body L2 narrow the focus to spinal cord segments T13–L1 – right side.
ii. Fibrocartilagenous embolus (FCE), prolapsing/ruptured disc, acute hemorrhage around or within the spinal cord, spinal fracture, neoplasia affecting spinal cord.
iii. An FCE given the acute onset, lack of spinal pain, asymmetric panniculus reflex, and lateralizing motor signs. However, intervertebral disc disease and other problems should be ruled out. Imaging and surgical consultation are recommended. Intramedullary swelling is typically the only sign seen on imaging with FCE. Physio/hydrotherapy instituted immediately after diagnostics has been shown to have a major influence on the rate of recovery from FCE.

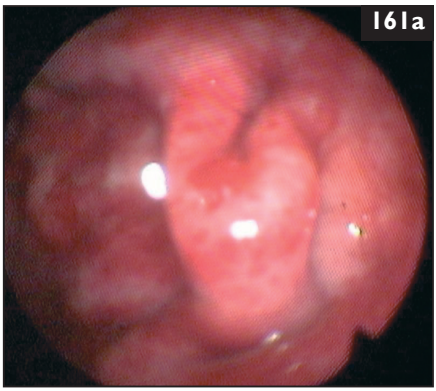
159 i. Patients >10 kg body weight; 10 minutes of unsuccessful closed chest CPR; thoracic wall fractures, pleural air or fluid, pericardial fluid; unknown arrest time; rapid access to heart through abdominal or thoracic incision; abdominal hemorrhage (cross-clamp thoracic descending aorta).
ii. Rapidly clip chest hair. Incise skin with a scalpel or mayo scissors at the 3rd, 4th, or 5th intercostal space, extending incision dorsal to paralumbar muscles and ventral to sternum. Rapidly incise corresponding soft tissues and muscles and enter the chest, briefly stopping ventilations to avoid lung injury. Avoid incising the internal thoracic artery (lateral to the sternum). Cutting the rib cranial and caudal to the incision at the costochondral junction can increase exposure. Open the pericardium with scissors, avoiding the phrenic nerve. The use of a one- or two-hand compression technique depends on heart size. Compress ventricles from apex to base for forward blood flow.
iii. ECG: assess HR/rhythm and direct antiarrhythmic therapy or use of a defibrillator. $ETCO_2$: 0 = check placement of endotracheal tube; 1 to 7 = poor pulmonary blood flow necessitating different CPR technique; 8 to 15 = adequate CPR efforts; >20 = return of spontaneous circulation.


159b

iv. Compression rate, 100–120 bpm; RR, 10 bpm.
v. A Rummel tourniquet can maximize blood flow to the heart and brain. A curved hemostat passes umbilical tape or a soft red rubber catheter around the thoracic descending aorta (**159b**). The catheter/tape is lifted and clamped to occlude aortic blood flow (do not directly clamp aorta) and loosened every 10 minutes to restore blood flow to posterior organs.

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160 i. What are the indications for dialysis?
ii. What are the similarities and differences between intermittent hemodialysis (IHD) and continuous renal replacement therapy (CRRT)?





161 A 3-year-old female spayed American Bulldog presented vomiting. This morning her appetite was decreased; she first vomited food and yellow liquid, then it turned into white foam with blood throughout the vomitus. She is now retching and producing some blood clots. T = 38.3°C (101°F); HR = 160 bpm; RR = 50 bpm; CRT = 1 sec; MM pale and dry; pulses are strong; perfusion is hyperdynamic; 8% dehydrated. Mild abdominal pain. Rectal examination found melena. PCV = 0.2 l/l (20%); TS = 42 g/l (4.2 g/dl).
i. Provide a problems list and the initial stabilization and diagnostic plan for this dog.
ii. The dog was given butorphanol for analgesia and dexmedetomidine for sedation. Initial test results did not provide a diagnosis. An endoscopic image of the gastric mucosa is shown (**161a**). Assess this image.
iii. How do these medications work: (a) sucralfate; (b) famotidine; (c) pantoprazole; (d) barium sulfate; (e) calcium carbonate; (f) misoprostol; (g) aluminum hydroxide?
iv. The dog vomits a large amount of bright red bloody liquid (**161b**). HR is now 180 bpm; CRT = >3 sec; MM very pale; femoral pulses weak; systolic BP = 80 mmHg. PCV = 0.15 l/l (15%); TS = 35 g/l (3.5 g/dl). What is the treatment plan at this time?

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Answers: 160, 161

160 i. AKI, electrolyte and acid–base imbalances, toxins removed by dialysis, and fluid overload not responsive to conventional therapy.
ii. Both modalities use diffusive and/or convective forces across a semipermeable membrane between the blood and dialysate through an extracorporeal circuit to remove small molecular weight solutes (<500 daltons) from the blood. IHD is efficient enough to normalize body fluid composition and volume during a single treatment session, which may not be well tolerated by the patient with severe AKI or a patient whose perfusion is unstable. CRRT is a slow and continuous exchange over a longer period of time (up to 24 hours) and may be better tolerated in severe AKI and patients with unstable hemodynamics.

161 i. Hyperdynamic perfusion; dehydration; upper GI bleeding (vomiting blood; melena); anemia/hypoproteinemia; lethargy; depressed appetite, abdominal pain. Stabilization and diagnostic plan: IVC; draw blood for emergency database, CBC, biochemical profile; coagulation profile, cross-match for possible transfusion; administer IV isotonic balanced crystalloids +/- HES large volume with high normal end-points (unless coagulopathy found) to restore perfusion, then rehydrate over 4 hours; analgesics (opioids); collect urine for urinalysis; plain abdominal radiographs; abdominal ultrasound. Do not start topical GI protectants (i.e. sucralfate) if endoscopy is planned. Monitor BP, physical perfusion parameters, PCV, TS.
ii. There are multiple erosions and ulcerations throughout the gastric mucosa.
iii. (a) In an acidic environment, sucrose molecules bind to the GI epithelial cells providing a barrier. (b) Reversible, competitive inhibitor of the H-2 receptor, decreasing acid secretion. (c) A proton pump inhibitor that decreases acid secretion. (d) Acts as a protectant and shown to be antisecretory in diarrhea. (e) Chemically neutralizes gastric acid (HCl). (f) A synthetic analog of prostaglandin E1, affects secretion of mucus and bicarbonate, increases mucosal blood flow, decreases HCl production. (g) Neutralizes acid, binds bile salts and pepsin, and induces production of local prostaglandins.
iv. Flow-by oxygen; fluid resuscitation with isotonic balanced crystalloids and HES – use small-volume technique to low end end-points (hemorrhage); prepare for whole blood transfusion if needed (type, cross-match, and warm transfusion if time permits); place nasogastric tube and perform ice water gastric lavage to slow or stop gastric bleeding (vasoconstricts local vessels). Begin proton pump inhibitor and sucralfate.

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162 A 4-year-old male neutered cross-breed dog presents because he is hyperexcitable, his pupils are dilated, and he is turning in circles to the right (**162**). He can turn to the left. T = 40°C (104°F); HR = 140 bpm; RR = panting; CRT = 1 sec; MM bright pink; perfusion and hydration adequate. Cranial nerves appear normal except for pupil response. He lies down periodically and trembles and still tries to turn to the right. Spinal and postural reflexes appear normal.

i. Provide a differential diagnosis list for acute hyperexcitability in the dog.

ii. After further questioning the owners, you determine there is a child on medication at home for attention deficit hyperactivity disorder (ADHD). What is the mechanism of action of most of these medications ?

iii. How is an overdose of these medications treated?



163 A 1-year-old male neutered DLH cat presented for a seizure after biting an electrical cord 30 minutes ago. The cat is mentally disoriented. T = 39.1°C (102.4°F); HR = 210 bpm; RR = 50 bpm with rapid, shallow synchronous breathing pattern; CRT = 2 sec; MM bright pink and dry; femoral pulses readily palpable. Erythema and sloughed lingual papillae are noted on the anterior edge of the tongue (**163**).

i. List the organ systems that are likely to be affected by electrocution and the changes that commonly occur.

ii. The cat has labored breathing with increased lung sounds heard in the dorsocaudal lung fields on auscultation. What is the likely mechanism for the pathology in the lungs?

iii. Provide an immediate treatment plan for this cat.

iv. Once the breathing has stabilized, the oral lesions must be addressed. Provide a plan for the continued support of this cat.

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162 i. Toxicity is the initial differential diagnosis to consider. Medications include ADHD medications (Ritalin, Concerta, Focalin, Dexadrine, Adderall), antidepressant medications (selective serotonin reuptake inhibitors and tricyclic antidepressants can result in serotonin syndrome), illicit drugs (amphetamines, cocaine, marijuana), methylxanthine intoxication (chocolate and asthma/airway medications such as terbutaline, theophylline, aminophylline, proin), and cold medications with pseudoephedrine, antihistamines, anticholinergics. Other differentials include head trauma, seizures, hypocalcemia, hypertension, hypoglycemia, primary brain disease (encephalitis, tumors), behavioral changes (fear, anxiety), and pain.
ii. The majority work by increasing neurotransmitter concentrations in the brain. Methylphenidate (Ritalin, Concerta, Focalin) increases dopamine levels; amphetamine and dextroamphetamine salts (Adderall, Dexadrin) increase dopamine and norepinephrine.
iii. Sedation with acepromazine (0.05–0.2 mg/kg IV), benzodiazepines (0.5–1 mg/kg/hr diazepam or 0.2–0.5 mg/kg/hr midazolam CRI IV) and/or propofol (2–8 mg/kg induction then 0.1–0.6 mg/kg/min infusion). Intubation +/- oxygenation and ventilation may be necessary. Benzodiazepines have been reported to worsen dysphoria in mildly affected patients. Decontamination of the GI tract can only be done under GA with tracheal intubation to guard the airway and minimize aspiration pneumonia. Some of these drugs and their active metabolites are eliminated through the kidney, making fluid diuresis important. External stimuli should be minimized. Body temperature is monitored since hyperthermia is common. ECG should be monitored and beta-blockers may be necessary to slow HR (propranolol slow IV). Some of these drugs are lipid soluble, making 20% lipid emulsion IV an option (1.5 ml/kg bolus then 0.25 ml/kg/min for 30–60 min).

163 i. CNS signs: seizures, loss of consciousness, limb rigidity, cerebral edema, potentially neuropathy. Cardiac signs: ventricular fibrillation or other rapid heart arrhythmias. Pulmonary: non-cardiogenic pulmonary edema. Oral cavity: erythema and necrosis of the lip and tongue tissue due to the heat generated in the soft tissues from the electrical current.
ii. Increased pulmonary capillary HP associated with sympathetic stimulation and an increase in pulmonary capillary permeability.
iii. Oxygen support; IVC; measure BP: if low, titrate combination of IV isotonic crystalloids and HES to low end end-points using small volume technique until BP stabilizes; if normal BP or hypertension, give IV isotonic crystalloids to replace dehydration over 2–4 hours and provide maintenance fluid support; obtain emergency database (PCV, TS, glucose, BUN, electrolytes, venous blood gas); give IV analgesics (opioid/benzodiazepine combination); use of diuretics for pulmonary edema is limited. Monitor RR and effort and SpO_2; be ready with ETs, laryngoscope, and Ambu bag if breathing worsens. A seizure watch is initiated with a benzodiazepine available.
iv. Placing a feeding tube can assure adequate intake of food and water. Antibiotics against gram-negative aerobic and anaerobic bacteria (e.g. clindamycin, attenuated beta-lactam) are administered throughout the initial healing stages. Debridement of dead tissue may be necessary. Oral chlorhexidine rinses may be used. Hard or soft palate wounds can cause an oronasal fistula.

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164 An 11-year-old male neutered Greyhound presents for a swollen paw that the owner noted a short time prior to presentation. T = 38.0°C (100.4°F); P = 88 bpm; R = 24 bpm; perfusion and hydration appear adequate. The dog is comfortable, alert, and walking normally on all four limbs. There is mild swelling of the right carpal joint, but normal orthopedic examination. You notice some ecchymotic hemorrhages on the skin of the ventral abdomen (**164**).

i. Which portion of the coagulation system results in ecchymotic hemorrhages (noted above)?

ii. Arthrocentesis of the carpal joint retrieves bloody fluid. What diagnostic tests can be performed 'in-house' to assess coagulation? Which part of the coagulation system are you assessing with each test?

iii. A bleeding 'syndrome' has been reported specific to Greyhounds. What is this? Is there any therapy effective for this problem?

iv. List differential diagnoses for prolonged aPTT in cats and dogs.

v. List differential diagnoses for prolonged PT in cats and dogs.

165 A 6-year-old Labrador Retriever presents to your colleague for a traumatic right eye wound. Physical examination is normal except for the right eye area. The dog is anesthesetized for wound repair when the veterinarian is suddenly called home. You must now perform the wound closure. The dog is blepharospastic in the right eye with a small amount of swelling of the lid margins and some blood in the fissure. There is a 1.5 cm full-thickness laceration of the lower eyelid margin with eversion of the edges of the wound.

i. What essential part of the ophthalmic examination has been left out?

ii. The right pupil is miotic compared with the left, and indirect PLRs are normal. There is no fluorescein stain uptake. Why is the right eye miotic?

iii. Describe the important aspects of lid margin closure and how complications can be minimized.

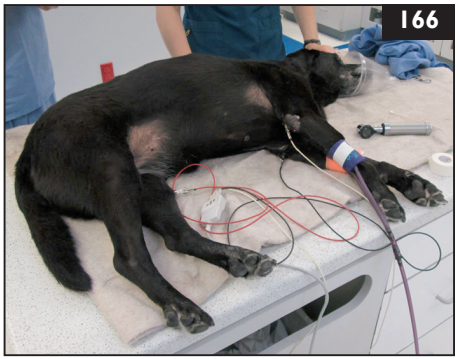
iv. What medication(s) are prescribed postoperatively?

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164 i. Ecchymosis is most commonly associated with abnormalities involving disruption of blood vessels. While less common, severe platelet defects, vascular disease (vasculitis), vascular disruption (trauma), and fibrinolytic disease are also possible.
ii. PT tests the extrinsic and common pathways (factors I, II, V, VII, X); aPTT tests the intrinsic and common pathways (factors I, II, V, VIII, IX, X, XI, XII); CBC (looking for alterations in platelet number and morphology, characterize anemia, and infectious/inflammatory disease); manual platelet estimate (as peripheral clumping may alter machine counts); buccal mucosal bleeding test (tests *in-vivo* platelet function and for von Willebrand's factor deficiency); ACT tests for factors VIII, IX, X, XI, XII.
iii. Excessive postoperative or post-traumatic bleeding, which has not been found to be due to abnormal primary or secondary hemostatic mechanisms, but may be due to altered fibrinolysis. Epsilon aminocaproic acid has been studied in Greyhounds undergoing limb amputations and appears to decrease postoperative bleeding.
iv. Hemophilia A (VIII deficiency), hemophilia B (IX deficiency), Hageman factor (XII) deficiency (cats only), vitamin K1 deficiency (anticoagulant rodenticide intoxication, severe intestinal malabsorption), severe liver disease, hypothermia, consumption of coagulation factors (through surgery, multi-trauma, DIC, SIRS diseases), iatrogenic anti-coagulant therapy (heparin), von Willebrand's disease.
v. Vitamin K1 deficiency, severe liver disease, hypothermia, consumption of coagulation factors (surgery, multi-trauma, DIC, SIRS), iatrogenic anti-coagulant therapy (heparin).

165 i. Evaluation of the PLR and symmetry; examination of the anterior chamber; fluorescein staining to look for corneal injury.
ii. The cause is most likely traumatic uveitis.
iii. The goal is to prevent complications associated with entropion or ectropion by opposing the edges of the wound as perfectly as possible without gaps or incongruous alignment. The sutures must be placed to avoid damage to the corneal surface. A figure-of-8 suture pattern using 4-0 or 5-0 suture on a cutting or micropoint needle at the lid margin is used. This is a modified horizontal mattress with the suture exiting and entering at the meibomian gland opening. The remaining part of the wound can be closed with simple interrupted sutures. The ends of the sutures closest to the eyelid margin can be caught and linked within the more proximal knots to prevent contact with the cornea.
iv. Topical ophthalmic atropine solution to dilate the pupil, open the angle for drainage, and prevent glaucoma; topical triple antibiotic ophthalmic solution with steroid; oral analgesics.

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166 A 10-year-old female neutered Labrador Retriever presents for an episode of weakness leading to collapse (**166**). T = 37.8°C (100°F); HR = 180 bpm; RR = 60 bpm; CRT = <1 sec; MM white and dry; femoral pulses bounding; 8% dehydration estimated based on MM moisture and skin turgor. Auscultation finds normal lungs and a grade II/VI left-sided murmur. The dog appears uncomfortable during abdominal palpation and a fluid wave is discovered. History does not support trauma or exposure to rodenticides.

i. Which stage of shock is this dog experiencing at presentation?

ii. What diagnostics can be performed to detect the presence of abdominal fluid?

iii. There is non-clotting whole blood free within the abdomen of this dog. What is your 4-Step Fluid Resuscitation Plan for this dog?

iv. List causes of hemoabdomen in the dog.

v. A large mid-abdominal pendulous mass has been identified. The owners have elected exploratory surgery. What pre-surgery testing is recommended?

vi. The origin of the bleeding was a splenic mass. What is the prognosis for splenic hematoma, hemangioma, and hemangiosarcoma?



167 A 3-year-old female neutered DSH cat presents for redness of the eye of 1 week duration. The cat is otherwise healthy, but did have an upper respiratory infection about 1 year ago. Physical examination is normal except for the left eye (**167**).

i. Describe the abnormalities noted in the picture.

ii. What initial diagnostics would you perform at this time?

iii. The initial diagnostics show normal results. Provide a list of differential diagnoses and the treatment for each.

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166 i. Compensatory stage (rapid CRT, bounding pulses, and tachycardia).
ii. Plain abdominal radiographs may suggest fluid (loss of serosal detail) but do not characterize the fluid; abdominal ultrasound (FAST scan) has a high sensitivity, allowing visualization during aspiration of fluid sample; single or four-quadrant abdominocentesis may provide a fluid sample but has false-negative taps; diagnostic peritoneal lavage and surgery confirm fluid and provide samples for analysis.
iii. Step 1: perfusion and hydration deficits. Step 2: isotonic balanced crystalloids and a colloid (HES if PCV >0.25 l/l [25%], whole blood if <0.25 l/l with animal going to surgery). Step 3: low end resuscitation end-point because of closed cavity hemorrhage. Step 4: small volume titration technique.
iv. Vascular injury (avulsed or ruptured vessels from trauma or torsed organs, tear in liver or spleen), coagulopathy, ruptured splenic or hepatic neoplasia or hematoma.
v. If the patient's condition permits, a CBC, biochemical and coagulation profiles, and urinalysis are evaluated; 3-view thoracic radiographs and imaging of the abdomen (ultrasound) to assess for metastatic disease.
vi. Extremely favorable for splenic hematoma or hemangioma, with surgery usually curative. Hemangiosarcoma carries a median survival time of 5–9 months with surgery and chemotherapy. Diagnosis CANNOT be made without histopathology.

167 i. There is neovascularization of the cornea from the medial canthus extending one-third of the way across the cornea, and a mild gray to white discoloration in the middle of the cornea.
ii. Should include (in order) examination with a slit lamp, indirect ophthalmic examination of the posterior eye, Schirmer tear test, fluorescein stain, and tonometry to measure intraocular pressures.
iii. (1) Chronic feline herpes virus infection: treated with topical antiviral medication (trifluridine), +/- oral lysine, famcyclovir, autologous serum, +/- topical tetracycline (if secondary infection suspected). (2) Feline eosinophilic keratitis: treated with topical steroids and cyclosporine. (3) Focal corneal necrosis (sequestrum) may be associated with viral infection (treat as 1). In addition, small superficial sequestra may detach and topical pain mediations/antibiotics may be necessary. Others require surgical removal. (4) Lymphoma (uncommon disease): enucleation may be necessary and a systemic workup is essential.

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168 A 6-year-old Golden Retriever presents for vomiting a brown fluid with blood flecks, lethargy, and inappetence for 3 days. Protein-losing nephropathy (PLN) and hypertension were diagnosed 4 years ago, and are treated with enalapril, calcitriol, and a prescription kidney diet. T = 39.4°C (102.9°F); HR = 116 bpm; RR = 32; CRT = 2 sec; MM pink but very dry; perfusion adequate; 8% dehydrated based on skin turgor, dry MM. Blood abnormalities (day 1) are shown. PO_4 = 5.8 mmol/l (18 mg/dl). Urinalysis: SG = 1.016; sediment benign; urine protein:creatinine ratio (UPC) = 1.2. The chart compares the dog's current laboratory work with his last laboratory work.

	4 months ago	Day 1
PCV (l/l; %)	0.35; 35	0.26; 26
Albumin (g/l; g/dl)	24; 2.4	22; 2.2
BUN (mmol/l; mg/dl)	20.3; 57	132.8; 372
Creatinine (µmol/l; mg/dl)	292; 3.3	>1,150; >13
UPC	0.46	1.2
BP (mmHg)	125	130
Body weight (kg; lb)	19.5; 43	19; 42

i. What are some different causes of his acute change?
ii. What additional tests are recommended?

169 A 3-year-old female neutered crossbred dog presents for coughing and gagging with a terminal retch. She acts lethargic and is eating and drinking less. She spends 3 days a week at a doggy day-care facility, and the owner reports that she is up-to-date on her vaccinations. T = 40.1°C (104.2°F); HR = 150 bpm; RR = 45 bpm; CRT = 2 sec; MM pale pink: pulses strong, synchronous with heart; perfusion adequate; 4–6% dehydrated. She is quiet but alert, with a moist cough on palpation of her cervical trachea. Thoracic auscultation finds normal heart and lung sounds with moist air movement in the trachea.
i. What are the differential diagnosis list and presumptive diagnosis for this dog?
ii. What diagnostic tests do you recommend, and why?
iii. What types of organisms might be associated with this presumptive diagnosis?
iv. List three ways to obtain a tracheal fluid sample.
v. Thoracic radiographs show normal lungs, normal cardiac size, normal vasculature, and no mass lesions. Discuss the pros and cons of antibiotic use for this case.
vi. Describe any special precautions to take if the dog is admitted for diagnostic procedures and treatment.

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Answers: 168, 169

168 i. Progressive PLN, toxicity, calictriol side-effect, infection.
ii. Urine culture and susceptibility, tick-borne disease titers, abdominal ultrasound, and radiographs.

169 i. Infectious tracheobronchitis (presumptive diagnosis), inflammatory tracheitis, collapsing trachea, disease of the oropharynx; less likely, pneumonia (fungal, viral, bacterial, aspiration), lungworm, cardiac disease, intratracheal or extratracheal mass or FB.
ii. Thoracic radiographs to evaluate the pulmonary fields. CBC for inflammatory response and the presence of a neutropenia. Tracheal fluid collection for cytology and aerobic, anaerobic, and mycoplasma cultures. Upper respiratory PCR profile for viral causes. Baermann fecal flotation for tracheal parasites such as *Oslerus osleri*, *Filaroides osleri*. Blastomycosis urine antigen test.
iii. Causative organisms of infectious tracheobronchitis include *Bordetella bronchiseptica*, canine parainfluenza, canine adenovirus, *Mycoplasma* spp., canine herpes virus, and canine distemper virus.
iv. (1) A transtracheal wash; (2) endotracheal wash under anesthesia through a sterile ET (**169**); (3) a sputum sample obtained from the oropharynx after stimulating a cough
v. Infectious tracheobronchitis (kennel cough) is self-limiting if the dog is not immunocompromised. Lungs appear normal. Because of fever, anorexia, and lethargy, trimethoprim–sulfa (15 mg/kg PO q12h), doxycycline (5 mg/kg PO q12h), or azithromycin (5–10 mg/kg PO q24h) may be considered.
vi. The possible pathogens are highly contagious, requiring patient isolation. Orders when working with the dog should include: hand washing before and after; wear gown and gloves; disinfect all surfaces and equipment in contact with patient; educate owners to isolate dog from other dogs and immunologically compromised people.



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170 The dog in case **168** is treated with four times his estimated maintenance IV fluid rate, IV ampicillin–sulbactam, proton pump inhibitors, and metoclopramide CRI. On day 5 he develops increased breathing rate and effort. Thoracic chest radiographs show a diffuse increase in bronchointerstitial opacity, pleural fissure lines, and distended caudal thoracic vena cava and pulmonary vessels. You diagnose fluid intolerance and repeat the laboratory work. You place a jugular venous catheter for monitoring CVP, and a urinary catheter with a closed collection system. You temporarily discontinue his IV fluids and administer furosemide. The monitored values the following day (day 6) are shown:

	4 months ago	Day 1	Day 5	Day 6
PCV (l/l; %)	0.35; 35	0.26; 26	0.19; 19	0.17; 17
Albumin (g/l; g/dl)	24; 2.4	22; 2.2	19; 1.9	
BUN (mmol/l; mg/dl)	20.3; 57	132.8; 372	40.3; 113	37.5; 105
Creatinine (µmol/l; mg/dl)	292; 3.3	>1,150; >13	751; 8.7	707; 8
UPC	0.46	1.2	0.6	
BP (mmHg)	125	130	215/140	150
Body weight (kg; lb)	19.5; 43	19; 42	21; 46	20.2; 44.5
CVP (cmH_20)			10	12
Urine output (ml/kg/hr)		6	4	3

i. What is your assessment of the monitored data on days 5 and 6?
ii. What options can be given for continued therapy on day 6?

171 A 3-year-old Pitbull presents shortly after running through a barbed-wire fence. The owner reports that he has a 10 cm (4 inch) long and deep laceration on the caudolateral brachial region that has been bleeding a lot. T = 36.9°C (98.5°F), P = 160 bpm, RR = panting. Gums are pale, CRT = <1 sec, pulses bounding. There are no other apparent injuries apart from the shoulder wound, which has pulsating hemorrhage. Despite direct digital pressure being applied to the bleeding area, large amounts of blood continue to ooze from the site of injury.
i. Discuss options available for immediate slowing and arresting of the hemorrhage in the shoulder region.
ii. What is your treatment for this dog in the emergency room?
iii. Discuss indications for administering a whole blood transfusion.

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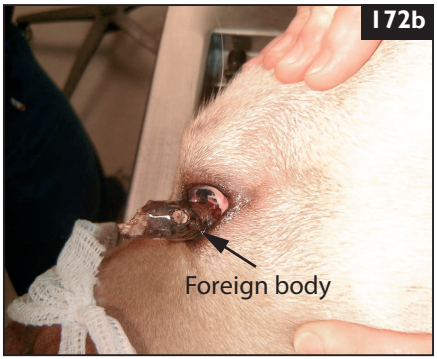
170 i. While the renal blood values have improved on day 5, the fluid intolerance suggests that GFR is less than his fluid infusion rate, with serious concern for onset of oliguria–anuria. The intravascular fluid retention has resulted in a significant increase in HP and worsening of the arterial hypertension. On day 6, the CVP is elevated, suggesting continued retention of fluid in the vascular space. Urine output shows a relative oliguria with a patent lower urinary tract. Though the renal values have improved from presentation, they are still high.
ii. Peritoneal dialysis, intermittent hemodialysis, or continuous renal replacement therapy are options for therapy at this time.

171 i. Digital pressure with bandage material can be applied (**171**), with hemostatic gauze (kaolin impregnated gauze) used as an option to speed clotting; a pressure wrap can be placed by bandaging the chest; sedation and pain medications should reduce movement of the pet and decrease mechanical disruption of clots; tourniquets CANNOT be applied to this region.
ii. Direct pressure is applied to the wound area to stop hemorrhage, an IVC placed, an IV opioid analgesic administered, and fluid resuscitation initiated following the 4-Step Fluid Resuscitation Plan. Given the arterial hemorrhage, heavy sedation or rapid-acting injectable anesthesia (e.g. propofol or ketamine/benzodiazepine combination) is likely necessary for surgical control of the hemorrhage. Surgical methods for hemostasis include hemostatic clamp placement, electrocautery, and ligatures.
iii. Whole blood (WB) is administered when RBCs and plasma components (albumin, natural colloids, and/or coagulation factors) would be of benefit to the patient. The more common reason for WB transfusion is acute hemorrhage from causes such as trauma, surgery, anti-coagulant rodenticide intoxication, or a ruptured vascular tumor. However, a patient with systemic disease that has resulted in hypoproteinemia or poor blood coagulation along with anemia may require WB transfusion(s) as well. PCV and TS results should not be the primary indicator for WB transfusion since patients with acute or active hemorrhage may initially have normal PCVvalues.



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172 A 1-year-old male Labrador presents with squinting and his left eye held shut after running around in the woods. Physical examination is normal except for the left eye (**172a**) and an anxious demeanor to the dog. Ocular examination requires heavy sedation.

i. Provide good options for sedation for ocular examination.

ii. After the dog is sedated, eye examination finds a large FB that looks like a stick (**172b**). What are recommendations for examination and treatment?

iii. List possible ocular injuries as a result of this problem, and suggest possible solutions.



173 A 4-year-old male neutered Great Dane presented for a 4-hour history of vomiting chewed food and guarding his abdomen after eating. Physical examination: T = 39.2°C (102.5°F); HR = 200 bpm; RR = 33 bpm; CRT = >3 sec; MM white, dry; femoral pulses not palpable; cold extremities. The abdomen was painful on palpation; the spleen was enlarged with sharp edges and thickened in a 'C' shape.

i. What splenic abnormality is suspected from the physical findings?

ii. What causes the spleen to be drastically enlarged with this problem?

iii. What is the anticipated mechanism(s) of vomiting with this problem?

iv. What is the 4-Step Fluid Resuscitation Plan for this dog?

v. A cranial lateral abdominal radiograph (**173**) is obtained after fluid resuscitation. Interpret the film.

vi. What abnormal finding(s) are anticipated on the CBC with this problem?

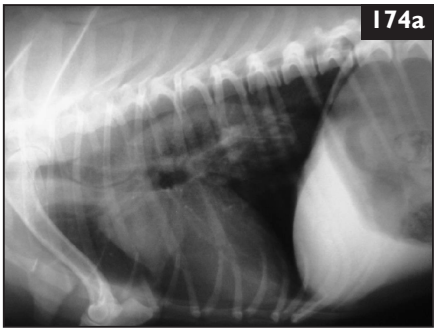
vii. An emergency splenectomy is indicated. Provide general guidelines for surgical removal of this spleen.

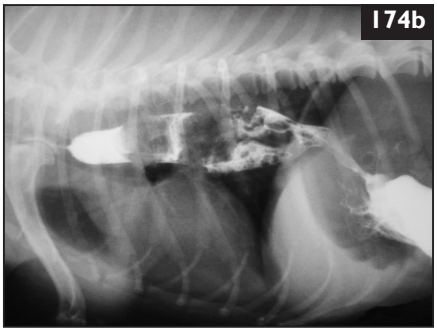
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172 i. Heavy sedation or GA will be necessary for careful and complete ocular examination. An IVC is placed and maintenance balanced crystalloids infused throughout the anesthetic procedure. A combination of an opioid (e.g. hydromorphone, fentanyl) with any of dexmedetomidine, acepromazine, benzodiazapine or propofol can be appropriate for induction. Ketamine could elevated intraocular pressure. Maintenance of anesthesia with an inhalant anesthetic (isoflurane or sevoflurane) will be necessary for prolonged procedures. The disadvantage of GA is the change in position of the eye.
ii. GA will be required for FB removal. Apply ocular lubricant generously. The globe can be protected by placing a soft, compressible material such as Styrofoam over the ocular area while the foreign object is gently removed. A complete ophthalmic examination is now performed including fluorescein stain, tonometry, and fundoscopic and slit lamp examination.
iii. Serious ocular injuries can include a ruptured globe, lens luxation, retinal detachment, conjunctival laceration, corneal ulceration, hyphema, hypopyon, ocular muscle damage, periocular abscessation, and remaining foreign material. Significant pain is anticipated and analgesics will be indicated. Treatment will depend on the ocular examination findings. Serious injuries may require referral to a ophthalmologist or enucleation of the eye.

173 i. Splenic torsion.
ii. The spleen twists about its veins and arteries. The veins collapse while the arteries (higher pressure) continue to transport blood. The amount of blood going into the spleen is greater than the blood leaving, resulting in splenic enlargement/engorgement.
iii. Splenic enlargement stretches the splenic capsule. Afferent capsular nerve fibers send signals to the vomiting center (peripheral receptor input). The engorged spleen could release cytokines and vasoactive substances, stimulating the chemoreceptor trigger zone (which stimulates the vomiting center).
iv. (1) Perfusion and hydration deficits; (2) isotonic balanced crystalloid (e.g. Normosol-R, Plasmalyte-A) and colloid (e.g. tetrastarch, HES); (3) high end resuscitation end-points, since this is an SIRS process without lung or brain edema/hemorrhage; (4) large volume infusion technique.
v. The liver may be small. The stomach is distended with food, with the axis shifted anteriorly. The spleen is ventral and greatly enlarged. There are several gas-filled loops of small bowel.
vi. Anemia (possibly hemolytic), thrombocytopenia.
vii. Perform complete CBC, biochemical profile, and coagulation panel prior to surgery. Ensure that perfusion and hydration have been restored. A routine ventral midline incision is made. The spleen is externalized and the splenic vessels clamped, ligated, or cauterized with a thermal vessel sealing unit and **without** untwisting the splenic pedicle. Standard abdominal exploratory and closure. Submit representative sample of spleen for histopathology.

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174 A 6-year-old female spayed Maltese presents for lethargy and vomiting or regurgitating a small amount of water with a piece of rawhide in it. She started howling in the car. T = 36.9°C (98.4°F); HR = 80 bpm; RR = 45 bpm; CRT = 2 sec; MM pink, slightly dry; pulses normal; perfusion normal; 5% dehydrated. Abdominal and thoracic examination normal. The dog is hypersalivating. Plain (**174a**) and barium contrast (**174b**) lateral thoracic radiographs are obtained.
i. Interpret the radiographs and provide a radiographic diagnosis.
ii. What are the pros and cons of barium administration? What are the alternative imaging options?
iii. What are the common locations for the problem identified?
iv. What are some consequences of this problem?
v. What are your treatment goals? How would you correct this problem?



175 A 10-year-old male neutered DSH cat presented for weight loss and generalized weakness of 2 weeks' duration. The cat's appetite has been declining for the past month. T = 37.4°C (99.4°F); HR = 180 bpm; RR = 25 bpm; CRT = 2 sec; MM pink, very dry; femoral pulses easily palpable. Significant skin tent (**175**) with dry, dull corneas. Cardiac auscultation reveals gallop arrhythmia. Initial emergency laboratory database: PCV = 0.35 l/l (35%); TS = 102 g/l (10.2 g/dl); glucose = 4.44 mmol/l (80 mg/dl); BUN >28.6 mmol/l (80 mg/dl); Na+ = 160 mEq/l; K+ = 4.8 mEq/l; pH = 7.25; HCO_3 = 15 mEq/l; PCO_2 = 38 mmHg; systolic Doppler BP = 80 mmHg.
i. Assess the perfusion and hydration of this cat.
ii. Create a problems list and assess the significance of the problems.
iii. Create an initial diagnostic plan.
iv. Create an initial therapeutic plan.
v. Create an initial monitoring plan.

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174 i. There is a soft tissue density between the thoracic inlet and the cranial aspect of the heart on the plain radiograph. The barium contrast highlights dilation of the esophagus along with a bi-lobed filling defect dorsal to the heart, a portion passing through the stomach and into the upper duodenum. There is gas dilation of the stomach. This is consistent with an esophageal FB causing a partial obstruction and aerophagia.
ii. Pros: barium can coat ulcers in the stomach, has anti-secretory effects, and may promote GI motility. Cons: leakage of barium into the mediastinum, trachea, or pleural cavity if esophageal perforation is present; aspiration of barium into the lungs; poor visualization if endoscopy performed after barium administration. Alternative imaging: flexible endoscopic or rigid orogastic tube evaluation; CT.
iii. Cranial to the thoracic inlet, cranial to the heart, and cranial to the diaphragm (esophageal hiatus).
iv. Esophageal erosion and ulceration are common; esophageal perforation possibly leading to pneumomediastinum or (tension) pneumothorax and pyothorax; esophageal stricture may occur long term.
v. To stabilize the patient and remove the FB obstruction while preserving the integrity of the GI tract. Treatment for the consequences of the lodged FB is planned after removal of the obstruction and examination of the esophagus. There are several methods for removal: (1) endoscopic retrograde removal (if possible); (2) endoscopic or orogastric tube-assisted normograde advancement of the FB into the stomach for digestion (if possible) or gastrotomy; or (3) surgical intervention – some caudal esophageal FBs can be surgically removed through an abdominal approach with gastrotomy; others (like this one) require a thoracotomy.

175 i. Perfusion appears mildly decreased based on the low Doppler BP and body temperature, likely associated with severe dehydration. The cat is >10% dehydrated based on significant skin tent, dry corneas and MM, elevated TS.
ii. Mild hypotension, dehydration, weight loss and decreased appetite, azotemia, hypernatremia, anemia, gallop, uncompensated metabolic acidosis. The cat has total body water depletion; careful fluid replacement with a balanced isotonic buffered crystalloid solution is needed. Once extracellular fluid is replaced, the sodium and renal values are reassessed. Blood protein analysis should determine if the increased TS is due to hemoconcentration or hyperglobulinemia. The PCV is re-evaluated after rehydration to assess for anemia.
iii. Serum biochemical panel, CBC, urinalysis (+/- culture), imaging of the abdomen (radiographs and/or ultrasound), thyroid profile, +/- echocardiogram.
iv. Placement of IVC; 4-Step Fluid Resuscitation Plan. (1) Severe dehydration, mild hypotension; (2) isotonic balanced crystalloid (e.g. Normosol-R, Plasmalyte A) would be the mainstay of initial fluid resuscitation – HES can be titrated, if needed, to bring systolic Doppler BP >90 mmHg; (3) low normal end-points until the significance of the gallop rhythm is known; (4) small volume infusion techniques to begin the rehydration process, with the whole rehydration process occurring over 4–8 hours.
v. RR and effort q2h; BP q15min during resuscitation then q4–6h; recheck PCV/TS +/- blood gas/electrolytes q6–12h; veterinarian will assess hydration q6h; HR and T q6h.

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176 A 6-year-old female neutered cross-breed dog presents for lethargy and an enlarging abdomen. T = 38.9°C (102°F); HR = 140 bpm; RR = 30 bpm; CRT = 2 sec; MM pink and dry; pulses normal; perfusion adequate; estimated 8% dehydrated (MM moisture and skin turgor). Abdominal palpation finds mild discomfort and a fluid wave. SABP = 130 mmHg. Past history reveals episodes of occasional vomiting and soft stool, and elevated liver enzymes. Ultrasound-guided abdominocentesis collects the free abdominal fluid shown (**176**).

i. Describe the fluid.

ii. What diagnostic tests are recommended to characterize the fluid?

iii. Assess the following results: bilirubin (abdominal fluid) = 327 µmol/l [19.1 mg/dl]; bilirubin (serum) = 3.5 µmol/l [0.2 mg/dl].

iv. Provide a therapeutic plan for this dog.



177 A 2-year-old female neutered Spaniel presents for ingestion of a bottle of the pet owner's heart medication (**177**). The dog is brought in by the daughter, who is not familiar with the name or type of heart medication. T = 38°C (100.4°F); HR = 110 bpm; RR = 36 bpm. Perfusion and hydration parameters are normal. Thoracic auscultation and abdominal palpation are normal.

i. What is the basic approach to accidental poisoning?

ii. How can elimination of ingested toxins be promoted?

iii. What are the risks associated with inducing emesis?

iv. When should emesis NOT be induced?

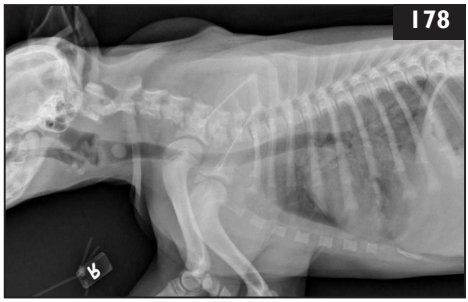
v. What substances are not adsorbed by activated charcoal?

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176 i. The fluid is yellow/orange in color and slightly turbid.
ii. Cytology of the fluid sediment; refractometer reading for protein content; biochemical tests can include: creatinine, bilirubin, glucose, lactate level as indicated; aerobic and anaerobic cultures and susceptibility.
iii. The pet has a bile peritonitis, most likely from a rupture within the biliary tract.
iv. An IVC is placed and a combination of isotonic balanced crystalloids and colloids (likely an SIRS patient) given to promote perfusion and restore hydration. Preanesthetic blood work and imaging are obtained and evaluated (include coagulation profile and thoracic and abdominal radiographs). Ultrasound or CT of the abdomen may be considered. Surgical exploration is recommended for bile peritonitis as soon as the pet has been assessed and stabilized. Copious abdominal lavage and closed abdominal drainage are employed. Antibiotics may be indicated. The Rule of 20 is utilized to monitor and treat the patient during recovery.

177 i. Assess and secure and maintain an open airway, assist ventilation if hypoxic and/or hypercarbic, support circulatory disturbances. Obtain a diagnostic database: collect blood, gastric contents or tissue samples for further testing. Eliminate further exposure (wash off topical toxins, eliminate ingested toxin). Promote toxin excretion. Administer specific antidotes. Provide supportive care.
ii. Ingested toxins: inducing emesis, gastric lavage under anesthesia with orotracheal intubation, surgical removal, adsorption using activated charcoal, and cathartics to promote intestinal motility and defecation. Systemic toxins: forced diuresis with IV fluids, alkaline diuresis with barbiturate, salicylate, or cyclic antidepressant overdoses, dialysis to rapidly remove small molecular weight particles (e.g. alcohols, amphetamines, phenobarbitol, lithium, salicylates, theophylline, ethylene glycol and its byproducts), prevention of conversion to toxic compound (e.g. fomepizole or ethanol for ethylene glycol toxicity), and/or use of IV lipid infusions with fat-soluble substances.
iii. Airway obstruction/aspiration of vomitus; vasovagal effect may result in bradycardia and hypotension. Apomorphine carries a risk of mild sedation. Oral hydrogen peroxide may cause mucosal ulceration. Prevent re-ingestion of vomitus.
iv. When caustic or sharp substances or bagged illicit substances have been ingested; when the animal has an impaired gag or swallowing reflex (e.g. neurotoxins); when there is bradycardia, severe ileus, or other severe cardiovascular, pulmonary, or GI derangements.
v. Heavy metals (iron, lithium, lead, zinc), cyanide, strong acids/bases, alcohols (e.g. ethanol, ethylene glycol, xylitol), and hydrocarbons.

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178 A 3-month-old male Boxer presents for acute breathing difficulty after playing outside with crab apples. T = 39.6°C (103.2°F); HR = 130 bpm; RR = slow; CRT = 2 sec; MM blue tinged; perfusion poor; estimated 6% dehydrated. He has marked labored breathing with noisy stridor during inhalation and a gagging cough on exhalation.

i. Localize the lesion within the respiratory tract

ii. You decide that you need to take over the dog's airway. What do you recommend to the client?

iii. Describe your radiographic findings from this lateral radiograph (**178**).

iv. Endotracheal tube placement could cause further problems in this dog. How can you support oxygenation and ventilation during the recommended procedure?

v. You have no tracheotomy tubes in your hospital. How can you improvise?

vi. What is the most likely cause of the pulmonary changes? How is this treated?



179 A 4-year-old male neutered Boxer presents with multiple injuries 45 minutes after being hit by a car (**179a**). He did not walk from the scene. Primary survey finds the dog recumbent with labored asynchronous breathing (chest and abdomen moving in opposition). T = 37.2°C (99°F); HR = 165 bpm; RR = 42 bpm; CRT = 2–3 sec; MM white; weak pulses. Comprehensive examination reveals reduced lung sounds bilaterally, bilateral epistaxis, blood in the mouth, and a frontal sinus fracture. Neurologic examination finds the dog to be conscious with altered mentation and dysphoria; anisocoria (OD constricted and minimally responsive to direct light); poor menace response; normal facial sensation and movement, jaw tone, gag and swallow, eye position, blink. The dog can stand but is weak in all four limbs. Emergency laboratory database: PCV = 0.34 l/l (34%); TS = 40 g/l (4.0g/dl); lactate = 7.3 mmol/l (65 mg/dl); glucose = 14.3 mmol/l (257 mg/dl); systolic Doppler BP = 60 mmHg; SpO_2 = 95%.

i. What is your problem list in order of priority?

ii. Discuss the challenges of resuscitation in this case with polytraumatic injuries and how you would prioritize treatment.

iii. Localize the brain lesion(s).

iv. What type of bandage would best protect the wound over the frontal sinus?

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178 i. Large airway.
ii. Initially, IV access, anesthesia, intubation, and ventilation for a tracheotomy. However, endotracheal intubation may not be possible due to tracheal or esophageal FB.
iii. The entire large airway is distended with air. A circular soft tissue density is present within the trachea caudal to the larynx. There are air bronchograms in the caudodorsal lung field and air within the stomach. Tracheal FB, non-cardiogenic pulmonary edema, and aerophagia.
iv. Transtracheal oxygen; tracheotomy with heavy sedation and oxygen supplementation through the tube; mask or flow-by oxygen is less likely to be helpful.
v. Make a tracheostomy tube from a sterile ET. Remove the plastic tube adaptor; make two cuts 180 degrees apart down the center of the tube, preserving cuff inflating mechanism (ensure length of remaining tube extends to thoracic inlet); reinsert plastic tube adaptor. Shorten the ends of the butterfly flanges as needed, placing holes in ends to attached to ties to secure around neck.
vi. Postobstructive (non-cardiogenic) pulmonary edema is likely. Recovery of edema may be spontaneous after relief of obstruction and oxygen support. Furosemide is often ineffective but can be given at 1–2 mg/kg IV if edema is not responsive to supportive care. Rarely, mechanical ventilation is required.

179 i. Abnormal, asynchronous, rapid breathing = pleural space disease (reduced SpO_2); circulatory shock with suspected blood loss (elevated lactate, low BP); brain injury (altered mentation, anisocoria); pain; open wound into sinus.
ii. Priorities are based on airway, breathing, bleeding, circulation, consciousness. Treatment plan: IVC; oxygen by mask or flow-by; analgesia (after neurologic examination and initiation of fluid infusion); pleurocentesis to stabilize breathing. 4-Step Fluid Resuscitation Plan with isotonic balanced crystalloids and HES to low normal end-points using small volume infusion technique (with or without hypertonic saline). The brain injury is best treated by increasing MAP to 90 mmHg, but care must be taken to avoid hypertension or increased intravascular HP, which can exacerbate hemorrhage. The wound is carefully cleaned and protected after breathing, bleeding, and circulation have been addressed.


179b

iii. Diffuse cerebral cortical, or subcortical.
iv. A tie-over dressing. Sterile gauze is used to cover the wound and held in place by umbilical tape fed through suture loops placed in the skin around the wound (**179b**).

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180 Match the effect(s) that alterations in systemic parameters have on the brain and cerebral edema:

Systemic alteration	Effect on brain and cerebral edema
1. Ca++	A. affects cerebral perfusion pressure
2. Na+	B. affects blood flow to the brain
3. PCO_2	C. low levels – excessive Ca++ through channels
4. Mg++	D. increases brain oxygen/glucose requirements
5. BP	E. insufficient energy production when low
6. serum glucose	F. alterations affect brain tissue water content
7. fever	G. brain excitotoxin
8. seizures	
9. hypoxia	

181 A 9-year-old female neutered Rhodesian Ridgeback presents for not eating and having back and hindlimb subcutaneous masses increasing in size. Mild anemia and thrombocytopenia were found 5 months prior, resulting in splenectomy for benign hematoma. The only abnormality on physical examination was T = 39.6°C (103.6°F), which did not resolve with fluid therapy. CBC abnormalities: PCV 0.32 l/l (32%); RBC indices = normocytic, normochromic; reticulocyte count = 45×10^9/l; platelet count= 70×10^9/l; 10 nucleated RBCs/100 WBCs. Biochemical profile and urinalysis normal. Saline agglutination negative, no spherocytes identified on blood smear, and no platelet clumping.

i. Provide a problems list and a differential diagnosis for the underlying pathology.

ii. What is the diagnostic plan for this dog?

iii. Tests performed were not diagnostic. The masses are nerve sheath tumors, unlikely to cause the hematologic problems. Repeat CBC shows a progressive nonregenerative anemia (PCV = 0.27 l/l [27%]) with normal TS and persistent thrombocytopenia. What is the next level of diagnostic testing?

iv. What are the indications for bone marrow evaluation?

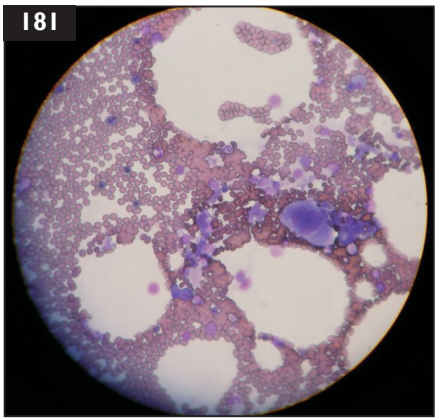
v. Why should core biopsy samples be evaluated as well as cytologic samples of the bone marrow?

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Answers: 180, 181

180 1, G; 2, F; 3, B; 4, C; 5, E, B, A; 6, B, E, F; 7, D; 8, D ± E; 9, E.

181 i. Non-regenerative normocytic, normochromic anemia; thrombocytopenia; fever; subcutaneous masses; anorexia; history of splenectomy. Differential diagnoses include infection (e.g. tick-borne diseases), inflammation, neoplasia, chronic blood loss. Hematologic infection should be high on the list given the impaired reticuloendothelial system from the previous splenectomy. Immune-mediated hemolytic anemia is not likely given the lack of hemolysis or jaundice and absence of spherocytes.
ii. Tick serology, thoracic and abdominal imaging for neoplastic lesions or evidence of internal hemorrhage, urine culture, mass excisional biopsy.
iii. Bone marrow cytology and biopsy.
iv. Any persistent depression in RBCs, neutrophils, or platelets without evidence of regeneration (i.e. reticulocytosis, band cells); unexplained, persistent elevations in peripheral WBCs; presence of abnormal cells in the peripheral blood; suspicion of bone marrow dysfunction; staging for certain hemolymphatic cancers; unexplained persistent hypercalcemia (dog); unexplained monoclonal or polyclonal gammopathy; fever of unknown origin.
v. Both will provide information on morphologic details of bone marrow cell types; however, the cytologic sample can undergo immediate examination but may not yield a specific diagnosis. Core biopsy demonstrates the architecture of the marrow and identifies inflammation, neoplasia, marrow necrosis, osteolysis, and myelofibrosis. Cytology of the bone marrow of this dog (**181**) is poorly cellular and considered inconclusive. Histopathology of the bone marrow core biopsy identified a preleukemic hemic (confined to the bone marrow) neoplasia. Chemotherapy was initiated.



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182 A 5-year-old female neutered Maltese presents after being bitten by another dog. T = 37.2°C (99°F); HR = 160 bpm; RR = 25 bpm and eupneic; CRT = 2 sec; MM pink; palpable peripheral pulses; perfusion adequate; hydration normal. The dog is recumbent. There is a wound over the right thorax, with lung occluding the hole.

i. Complete the Table below for the cardiovascular unstable emergency patient with moderate to severe pain.

Analgesic agent	Action/benefit	Adequate analgesia expected?	Potential side-effects with analgesic doses
Local anesthetic (e.g. lidocaine)			
Pure agonist opioid (e.g. hydromorphone)			
Agonist/antagonist opioid (e.g. butorphanol)			
Partial agonist opioid (e.g. buprenorphine)			
NSAID (e.g. meloxicam)			
Alpha2 agonist (e.g. dexmedetomidine)			

ii. What is the better therapeutic approach to the bite wounds over the chest: surgical exploration or topical wound care? Why?

iii. How is this wound best managed?

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Answer: 182

182 i.

Analgesic agent	Action/benefit	Adequate analgesia expected?	Potential side-effects with analgesic doses
Local anesthetic (e.g. lidocaine)	Sodium channel blocker. Blocks transduction, transmission, and modulation of pain	Yes	Minimal
Pure agonist opioid (e.g. hydromorphone)	Opioid receptor agonist. Blocks transduction, modulation, and perception of pain. Can be used as a continuous IV infusion with additional analgesic drugs for multimodal, continuous effects	Yes	Urinary retention, sedation, vomiting, hypothermia (dog), hyperthermia (cat)
Agonist/antagonist opioid (e.g. butorphanol)	Stimulates and blocks certain opioid receptors. Blocks transduction, modulation, and perception of pain. Provides some sedation. Short acting	No	Minimal
Partial agonist opioid (e.g. buprenorphine)	Binds tightly at opioid mu receptor. Blocks transduction, modulation, and perception of pain	No	May need to be completely metabolized before effects of stronger, pure agonist opioids can take effect
NSAID (e.g. meloxicam)	Cyclo-oxygenase inhibitor. Blocks transduction and modulation of pain	Yes	GI ulceration, reduced renal perfusion
Alpha2 agonist (e.g. dexmedetomidine)	Blocks transmission, modulation and perception of pain	Yes	Inhibit cardiovascular response to circulatory shock

ii. Surgical exploration. Allows visualization of the full extent of trauma, discovery of penetration into a body cavity, removal of devitalized tissue and contaminated or foreign objects (e.g. skin, hair, teeth, tartar). It facilitates adequate lavage, culture/susceptibility, and drain placement. Blindly lavaging into small skin holes can spread infection into distal tissue planes.

iii. Penetrating chest wounds are better surgically explored, debrided, and closed with a thoracostomy tube in place. GA and assisted ventilation are necessary. Large wounds communicating with the pleural space or lung injury can be addressed when necessary. Samples for culture/susceptibility are taken, contaminated sites are lavaged, and a wound drain and/or chest tube placed.

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183 A 4-year-old male neutered Bulldog presents with severe labored breathing 4 days after a laryngeal tieback for laryngeal paralysis (**183**). T = 103°F (39.4°C); HR = 167 bpm; RR = 60 bpm with synchronous breathing pattern; CRT = 2 sec; MM mild cyanosis; perfusion hyperdynamic; 6% dehydrated with slight increase in skin turgor. Thoracic auscultation found moist rales over the right ventrocaudal lung fields and normal heart sounds. The dog is working hard to breathe. Arterial blood gas after initial resuscitation: pH = 7.36; HCO_3 = 19 mEq/l; $PaCO_2$ = 27 mmHg; PaO_2 = 55 mmHg (FiO_2 = 0.4 on nasal cannula oxygen); SaO_2 = 88%.

i. Assess the blood gas using the 5-Step Blood Gas Interpretation.

ii. List at least three pathophysiological causes of hypoxemia. Which is likely in this dog?

iii. The dog is now on mechanical ventilation. Outline the plan for airway care during mechanical ventilation.

iv. Define the following as it applies to mechanical ventilation: PEEP; anatomic dead space; stacking.

v. When and how is the dog weaned from the ventilator?



184 A 6-month-old male Dachshund presents for persistent vomiting of yellow foam and lethargy (**184**). A diagnosis is made of septic peritonitis and fluid resuscitation is initiated.

i. When should antimicrobial therapy be initiated for sepsis or septic shock?

ii. What are the initial targeted bacteria?

A sample of abdominal fluid collected prior to abdominal surgery is submitted for aerobic and anaerobic culture and susceptibility. Treatment with injectable ampicillin–sulbactam and enrofloxacin was initiated immediately. A resection and anastamosis for perforated intestinal obstruction was performed with the culture results returned 2 days later. (*Escherichia coli*: sensitive to all antimicrobials tested including amoxicillin, ampicillin, and enrofloxacin; *Pasteurella* spp.: sensitive to all antibiotics tested except intermediate sensitivity to Clavamox® [amoxicillin/clavulanic acid]).

iii. Do you make any modifications to the antimicrobial treatment?

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183 i. (1) Respiratory, acute; concern for aspiration; (2) pH normal; (3) HCO_3 low – metabolic acidosis; $PaCO_2$ low – respiratory alkalosis – not compensatory with normal pH; (4) mixed, no compensation; (5) hypoxemia. Diagnosis: metabolic acidosis and respiratory alkalosis with hypoxemia. $PaO_2/FiO_2 = 136$.
ii. (1) Low inspired oxygen; (2) hypoventilation; (3) V/Q̇ mismatch; (4) diffusion impairment; (5) right-to-left pulmonary shunt. 5 and 3 are likely to occur. 4 is rare.
iii. Airway care: aseptic technique at all times; use low-pressure ET cuff; change tube ≥2 × daily with sterile tube cuff at different levels to avoid pressure necrosis; humidify and warm inspired air; supplement with oxygen by cannula and instillation of 3–10 ml of sterile saline; suction airway to bifurcation q2–6h; analyze tracheal fluid by cytology, culture/sensitivity, and TP.
iv. PEEP: A method of ventilation to increase the end-expiratory volume of gas and maintain/recruit open alveoli, thus improving gas exchange. Anatomic dead space: The air space within the ventilator tubing, ET, and patient's airways to the alveoli not participating in gas exchange. Stacking: Failure to totally exhale the ventilator-delivered tidal volume before the next machine breath is delivered. Part of each subsequent tidal volume is retained, increasing peak airway pressure.
v. Common criteria for weaning include: RR <25 bpm, tidal volume >5 ml/kg, PaO_2/FiO_2 >200, voluntarily generating an inspiratory pressure >10 cmH_2O, and resolving underlying disease. Methods: (1) Pressure supported ventilator weaning: gradually decrease the amount of pressure support and number of mechanically driven bpm until pressure support approaches 5–6 cmH_2O; and (2) spontaneous breathing trial: disconnect patient from ventilator and provide flow-by oxygen support by ET or tracheostomy tube. Trial lasts 30–90 minutes, carefully monitoring BP, RR, HR, and gas exchange.

184 i. As soon as a septic process is suspected, antimicrobial therapy should be initiated. Samples are collected for culture prior to therapy but sample collection should not delay therapy. People with signs of severe sepsis or septic shock have been reported to have a better outcome when appropriate antimicrobials are administered within an hour of triage.
ii. Since a GI perforation is a possible cause, the antimicrobial(s) chosen should be bacteriocidal and effective against both aerobic and anaerobic gram-positive cocci and rods and gram-negative cocci and rods. Once culture results are available, antimicrobial therapy is altered as indicated based on organism and susceptibility results.
iii. Because the *E. coli* has intermediate sensitivity to an ampicillin/sulbactam equivalent, Clavamox®, this drug is not effective and is discontinued. Both the *Pasturella* spp. and *E. coli* are sensitive to enrofloxacin, which is continued.

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185a


185b

185 A 10-year-old male neutered Beagle presents for a painful eye and reluctance to eat today. Physical examination abnormalities are limited to the eyes. There is blepharospasm, a mucoid ocular discharge, and episcleral injection OS. The left cornea has blue discoloration with opacity. There is no menace or dazzle response OS. PLRs can only be evaluated OD owing to the opaqueness of the left cornea: direct is present, indirect is not present OD. A tentative diagnosis of glaucoma is made.
i. How is glaucoma commonly diagnosed?
ii. What ocular tests are recommended for this dog?
iii. What are the instruments pictured (**185a, b**)?
iv. Describe how to use the instrument shown in **185a**.
v. Medical treatment of glaucoma incorporates medications to (1) reduce aqueous humor production, and (2) increase aqueous humor outflow, and (3) osmotic diuretics to reduce ocular pressure. Provide at least one type of medication for each and the mechanism of action.


186

186 A 3-year-old male neutered Dalmatian presents with a 12-hour history of lethargy, straining to urinate, and passing only small amounts of urine (**186**). T = 38.9°C (102°F); HR = 120 bpm; RR = panting; CRT = 2 sec; MM pink, moist; femoral pulses normal; perfusion and hydration normal. Abdominal palpation finds an enlarged urinary bladder. Rectal examination finds mild prostatic bilateral enlargement.
i. Name 10 structures you can palpate on rectal examination in a male dog.
ii. Describe how to perform retrograde urohydropulsion to retropulse a urethral stone back into the bladder.
iii. What type of urinary calculi are Dalmatians predisposed to developing, and why?
iv. Name a treatment for the following bladder stones, and identify whether or not the stone type is visible on plain radiographs: (a) struvite (magnesium ammonium phosphate); (b) ammonium biurate; (c) calcium oxalate; (d) cystine; (e) silica.
v. What alternative methods are available for diagnosing stones not visible on plain radiographs?

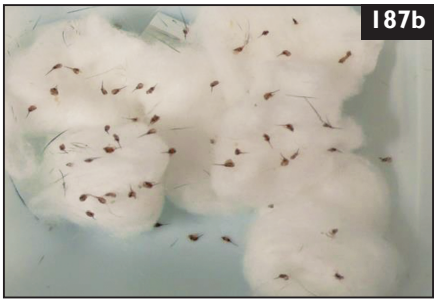
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185 i. By measuring pressures within the eye with applanation tonometry (Tonopen), reflex tonometry, or a Schiotz tonometer. Normal values in the dog are 10–20 mmHg; higher values are consistent with glaucoma.
ii. A complete ocular examination, which should include slit lamp examination of the globe and indirect examination of the retina. Schirmer tear test, tonometry, and fluorescein staining are essential.
iii. Applanation tomoter (Tonopen or Tonovet) (**68a**); Schiotz tonometer (**68b**).
iv. The pressure is measured in both eyes for comparison. Topical anesthesia (proparacaine) is applied. A new rubber applicator is applied to the tip. The tonometer button is depressed once to confirm calibration (typically two dashed lines appear); if not, the device should be calibrated. The tip is gently applied to the cornea several times until an average reading is obtained with less than 5% error.
v. (1) Beta-blockers (e.g. betaxolol, timolol); carbonic anhydrase inhibitors (e.g. dorzolamide, methazolamide). (2) Synthetic prostaglandin (latanaprost); cholinergic agents (e.g. parasympathomimetics [pilocarpine, demercarium] and alpha2 agonists [brimonodine]). (3) Mannitol, glycerine. Lack of response to medication warrants referral to an ophthalmologist for further care.

186 i. Prostate, urethra, caudal aorta, sublumbar lymph nodes, rectal mucosa, fecal material, pelvic symphysis, sacral spine, anal tissue and glands, anal tone.
ii. Heavy sedation or anesthesia and aseptic technique for urethral catheter placement. A urinary catheter is placed to the level of the urethral obstruction. The tip of the penis is manually occluded to close the urethra around the catheter. An assistant places a finger in the patient's rectum and compresses/occludes the urethra ventrally against the pubis through the rectal wall. Sterile saline with or without sterile water-soluble lubricant is injected by syringe into the urinary catheter with sufficient force to dilate and create intraluminal pressure within the urethra distal to the obstruction. The rectal urethral occlusion pressure is quickly released by easing the rectal digital pressure, with the goal to push the stones back towards the urinary bladder. This procedure may need to be repeated to get the stone(s) into the bladder for surgical retrieval. This procedure may relieve the obstruction or permit passage of the urethral catheter past the obstruction and into the urinary bladder.
iii. Some Dalmatians have a genetic mutation that prevents the liver from converting uric acid to allantoin. The resulting high uric acid concentrations predispose these dogs to urate urinary tract calculi.
iv. Struvite stones are common in alkaline urine, primarily subsequent to urinary tract infection. Medical management (antibiotics, acidification of urine, short-term moist diet lower in protein, magnesium, and phosphates) may dissolve smaller stones that are not obstructing the urinary outflow tract. The other types of calculi cannot be dissolved medically. Surgery or lithotripsy is required to remove these stones or any stone obstructing urine outflow. Cystine and urate stones are not visible on plain radiographs nor are calculi of any composition when less than a few millimeters in size.
v. Double-contrast retrograde cystourethrogram, ultrasound, CT, cystoscopy.

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187 A 9-year-old female neutered Pug is found in bushes collapsed, minimally responsive, and surrounded by ground bees (**187a**). She is transported immediately to the clinic. T = 36.1°C (97°F); HR = 190 bpm; RR = 56 bpm; CRT = >3 sec; MM pale pink and dry; femoral pulses not palpable; perfusion poor; 8% dehydration (MM/corneal moisture). Stridor is heard from the upper airway and bees crawl out of the rectum when the thermometer is removed. Multiple stingers are removed from the skin (**187b**).

i. How is anaphylactic shock different from hypovolemic shock?

ii. What is different in the pathology between anaphylaxis and an anaphylactoid reaction? Give an example of each.

iii. A peripheral cephalic catheter is immediately placed and oxygen administered by mask. What is the single best treatment for acute anaphylactic shock in the dog?

iv. Establish the 4-Step Fluid Resuscitation Plan for this dog.

v. What organ systems need to be closely monitored during the recovery period in this patient?



188 A 13-year-old male neutered Terrier-cross presents after being bitten in the head by a neighbor's dog. General physical examination is within normal limits. Ocular examination finds mature cataracts OU, a 2 cm dorsal lid laceration OD, traumatic proptosis OD (**188**), and an abrasion on the dorsum of the nose.

i. List some ocular findings that are indicators of poor prognosis for return to vision with a proptosis.

ii. List some indicators of a good prognosis for return to vision.

iii. What indicators have very little impact on prognosis for return to vision?

iv. What is the prognosis for return to vision in this dog?

v. What structures must be removed in an enucleation?

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187 i. Anaphylactic shock is characterized by peripheral vasodilation and bronchoconstriction.
ii. True anaphylaxis requires prior sensitization and is an IgE-mediated stimulation of mast cell degranulation, such as can occur with *Hymenoptera* (bee) envenomation, beta-lactam sensitivity, and many foods. An anaphylactoid reaction is non-IgE-mediated stimulation of mast cell degranulation and complement activation, such as can occur with foreign plasma protein exposure or radiographic contrast media.
iii. Epinephrine injection (0.05 μg/kg/min IV) titrated to effect. IM injection is less rapid, but can be administered at 0.01 mg/kg (up to 0.3 mg in patients <40 kg and up to 0.5 mg in patients >40 kg) repeated every 5–15 minutes as needed. The SC route is never used due to lack of reliable absorption.
iv. Step 1: this dog has both perfusion and hydration deficits. Step 2: a combination of isotonic balanced replacement crystalloid and HES is chosen to potentiate intravascular volume retention. Step 3: high end resuscitation end-point is chosen since anaphylaxis is an SIRS disease. Step 4: since there are no problems with lung or brain edema, oliguric renal failure, internal hemorrhage or trauma, large volume administration techniques can be used. The epinephrine administered for anaphylaxis will cause peripheral vasoconstriction, making it initially difficult to obtain a reliable indirect BP reading.
v. The upper respiratory and pulmonary systems for evidence of edema and bronchoconstriction. The GI and hepatic systems are affected by hypoxia/ischemia and should be monitored for signs of dysfunction. Increased vascular permeability requires close monitoring for edema, hypovolemia and third-body fluid spacing.

188 i. Ruptured globe, visualized or high index of suspicion of severed optic nerve (i.e. marked rotation or protrusion of globe), and/or retinal detachment in affected eye.
ii. Presence of PLR in affected eye.
iii. Lack of PLR, hyphema in affected eye.
iv. The eye is pointed dorsally, indicating that there is likely damage to the optic nerve. In addition, there are mature cataracts in both eyes. These findings suggest little to no chance for return of vision.
v. The globe, third eyelid with gland, eyelid margins, and conjunctiva must be removed to avoid the development of a draining tract in the orbit.

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189 An 11-year-old female spayed Daschund presents for progressive anorexia and vomiting bile twice over 2 days (**189**). The dog is currently well controlled on potassium bromide and phenobarbital for seizures. Ingestion of a toxin or foreign object is unlikely. T = 40.5°C (104.9°F); HR = 160 bpm; RR = panting; CRT = 1 sec; MM very dry and bright pink; bounding femoral pulses; perfusion hyperdynamic; estimated 8% dehydrated. Moderate discomfort on palpation of the right upper abdomen. Abdominal radiographs demonstrate loss of detail in the upper right quadrant and gas distension of the upper duodenum. FAST scan demonstrates small amount of fluid in the upper right quadrant.

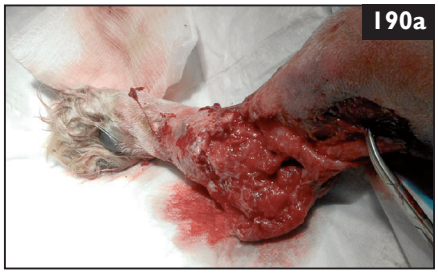
i. Describe the procedure for a four-quadrant abdominocentesis.

ii. What are other options to recover fluid from the abdomen? How is the fluid analyzed?

iii. Cytology on the abdominal fluid reveals a moderate number of neutrophils, a small number of RBCs, and rare macrophages. No bacteria are seen. TP = 15 g/l (1.5 g/dl). Which describes the nature of the recovered fluid: transudate; modified transudate; exudate? Provide options for the origin of the fluid in this dog.

iv. What tests will confirm a diagnosis of pancreatitis? What is seen on ultrasound to suggest this diagnosis?

v. Which of the following clinical problems are complications to anticipate in acute severe pancreatitis: hypoglycemia; hyperlactatemia; thrombocytopenia; DIC; hypoalbuminemia; sepsis; icterus; third-body fluid spacing; ileus.



190 A 10-year-old male neutered Lhasa Apso presents for a wound on the left hindlimb caused by a cat bite 2 days ago. The dog has a history of diabetes mellitus and is currently receiving 16 U of NPH SC q12h. T = 40.1°C (104.2°F); P = 100 bpm; RR = 24 bpm; CRT = 2 sec; MM pink slightly dry; femoral pulses normal; perfusion normal; 6% dehydration (MM moisture). Thoracic auscultation and abdominal palpation are normal. The cat has severe dental disease. The leg wound has overlying skin necrosis, erythema, and a foul odor. An opioid is given for analgesia and sedation to debride and lavage the tissue (**190a**).

i. List options for managing the wound at this time.

ii. What further diagnostics are recommended?

iii. What antibiotic would be chosen initially, and why?

iv. What is vacuum-assisted wound closure, and how does it promote healing?

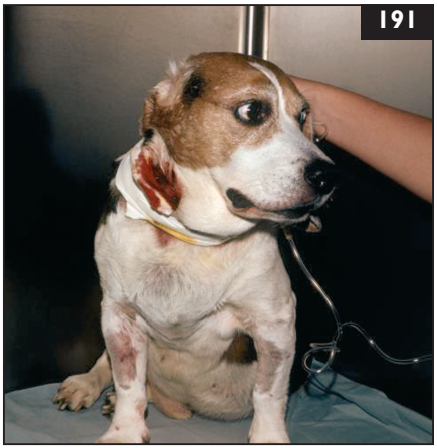
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189 i. Clip and surgically prepare the skin at the needle entry sites. Insert 20 or 22 gauge, 1 or 1.5 inch needle into each quadrant (right/left upper/lower), allowing abdominal fluid to flow from the needle by gravity. Collect the fluid for analysis.
ii. Diagnostic peritoneal lavage; ultrasound-guided aspirate; surgical collection. PCV/TS, glucose, and cytology are routine; creatinine and/or potassium, lactate, bilirubin, and triglycerides (chest fluid) as indicated by history and physical examination; samples are saved for culture and susceptibility.
iii. Modified transudate consistent with a non-septic peritonitis from causes such as severe GI inflammation, SIRS diseases (such as pancreatitis), or recent surgery.
iv. Clinical diagnosis is most frequently made using a combination of tests. History and physical examination compatible with pancreatitis; canine- and feline-specific pancreatic lipase is suggestive but not specific; CBC and biochemistry are non-specific. Pancreatic biopsy with histopathology is the 'gold standard' and rarely performed in animals. Ultrasound findings of pancreatitis include: thickened, hypoechoic pancreas with hyperechoic surrounding fat and mesenteric tissues; small amounts of free abdominal fluid may be present; dilation of the gallbladder or a tortuous common bile duct; and stomach/intestinal changes (such as mild dilation, decreased motility).
v. All can be present since pancreatitis is an SIRS disease.

190 i. Primary closure is not an option due to missing skin and infected/necrotic tissues. Good options include: wet-to-dry bandaging to debride wound for delayed primary closure; secondary closure when granulation tissue forms, or second intention healing or skin graft/flap at a later date. Honey or sugar bandages may be used initially. Alternatively, a vacuum-assisted wound closure device may help speed healing. Analgesics and antibiotics are necessary.
ii. CBC, biochemistry, blood gases, electrolytes, and urinalysis are important because of potential complications (e.g. diabetic ketoacidosis or hypoglycemia). Culture and susceptibility testing of the wound tissue is appropriate.
iii. Broad-spectrum bacteriocidal antibiotics with good tissue penetration are selected initially and adjusted based on culture and susceptibility results. The rapid progression of this wound requires concern for gram-positive organisms that cause necrotizing fasciitis. Potentiated beta-lactam antibiotics or potentiated sulfa drugs (e.g. trimethoprim/sulfamethoxazole) are appropriate. Anaerobes are a possibility, making penicillin or metronidazole important.
iv. Controlled application of sub-atmospheric pressure to the local wound environment using a sealed wound dressing connected to a vacuum pump. The continued vacuum draws out fluid/exudate/infected material from the wound and increases blood flow to the area, reduces wound edema, and promotes formation of granulation tissue. The dog's leg is shown after several days of vacuum therapy (**190b**).


190b

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191 A 9-year-old intact male Beagle (**191**) is transferred to you for continued care having a diagnosis of pancreatitis made 3 days ago. He has been NPO and received LRS therapy. He is still vomiting yellow foam several times daily. Physical examination: T = 39.4°C (103°F); HR = 194 bpm; RR = panting; CRT = 1 sec; MM bright red, dry; estimated at 8% dehydrated. Abdominal palpation finds pain in the right upper quadrant and fluid-filled intestines. Ecchymotic hemorrhages are seen on his ventral abdomen and neck region. There is bleeding from the jugular venipuncture site. Initial laboratory database: PCV = 0.54 l/l (54%); TS = 50 g/l (5.0 g/dl); glucose = 4.7 mmol/l (86 mg/dl); BUN = 21.4 mmol/l (60 mg/dl); Na+ = 148 mEq/l; K+ = 3.2 mEq/l; lactate = 3.5 mmol/l (31.5 mg/dl); platelet estimate = 0–2 platelets/oil immersion field; PT and aPTT are both not-clotting; venous blood gas: pH = 7.2; HCO_3 = 14 mEq/l; $PvCO_2$ = 28 mmHg.

i. Make a problems list prioritizing the most life-threatening problems first and grouping problems when possible.

ii. What is the likely pathology of the ecchymotic hemorrhages and abnormal coagulation parameters?

iii. What is antithrombin (AT), and why might the normal concentration be altered in pancreatitis (SIRS disease)?

192 A 3-year-old male neutered Australian Shepherd Dog-cross presents for blood coming from the prepuce after he was caught in a door slamming shut. Physical examination is normal except for blood dripping from the prepuce. An opioid was given and the penis extruded. A 0.5 cm laceration was found approximately 1 cm caudal to the tip of the penis, several millimeters deep.

i. What other penile injuries might have occurred, what diagnostics would be beneficial, and what treatment would be warranted?

ii. The laceration is aseptically prepared for primary closure. What suture material should be selected?

iii. Describe the postoperative care of this dog.

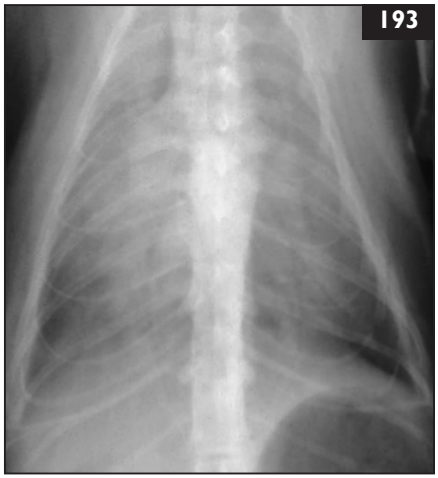
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191 i. Shock (compensatory stage), coagulopathy (bleeding venipuncture, ecchymotic hemorrhages, low platelets, prolonged PT and aPTT), severe dehydration, pain in right upper quadrant abdomen (past diagnosis of pancreatitis), hemoconcentration, hypoproteinemia (likely once rehydrated), metabolic acidosis, hyperlactatemia, azotemia, history of vomiting, no food for 3 days.
ii. The dog has an SIRS disease. Systemic cytokines will initiate four simultaneously occurring mechanisms: (1) tissue factor-mediated thrombin generation; (2) dysfunctional anti-coagulation mechanism unable to balance thrombin generation; (3) impaired fibrin removal due to suppressed fibrinolytic system; (4) inflammatory activation of coagulation proteins and platelets.
iii. AT is a natural anti-coagulant made in the liver. It binds to thrombin (II) preventing it from stimulating the conversion of fibrinogen (I) to fibrin (Ia). AT also binds to activated IX, X, and XI. The activity is accelerated in the presence of endogenous or exogenous heparin. It is 54,000 daltons in size, smaller than albumin. Low levels of AT can result from consumption or leakage and have been found to be one of the earliest indicators for risk of DIC in SIRS patients.

192 i. Fracture of the os penis – radiographs; conservative management; open reduction and fixation (wires and plates have been reported); or urethrostomy depending upon injury. Urethral tear – contrast urethrogram; indwelling urinary catheter for 24–72 hours; urethrostomy/urethral repair if does not resolve with conservative management.
ii. Monofilament absorbable is ideal so the suture can be placed under the skin/mucous membrane to minimize irritation and not have to be removed. Small size is ideal (5-0 to 3-0) depending on the size of the dog and wound (**192**).
iii. The dog should have sedation and analgesics; an Elizabethan collar to prevent self-mutilation of the surgical site; perioperative antibiotics (broad-spectrum bacteriocidal); indwelling urethral catheter until swelling is gone; monitoring urination will be important after the catheter is removed. Limiting any stimuli or behaviors that elicit sexual stimulation. Long term, there is risk of stricture development if the wound is >50% the circumference of the penis.



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193

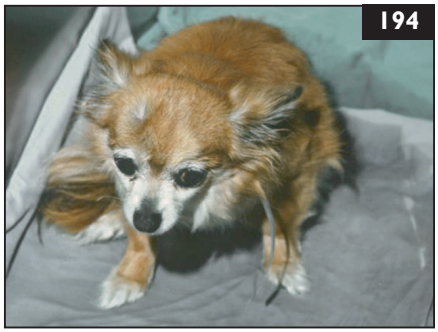
193 A 4-year-old female Golden Retriever had surgery to remove a ruptured infected uterus (pyometra). Six hours later, the dog began labored breathing with a synchronous breathing pattern. Auscultation revealed increased diffuse bronchovesicular sounds. SpO_2 = 88% with FiO_2 = 0.4–0.5 (nasal oxygen). A dorsoventral radiograph demonstrates diffuse interstitial lung infiltrates consistent with pulmonary edema, with heart and artery/vein sizes within normal limits (**193**). The dog was initially resuscitated with a combination of crystalloids/HES and is now on a maintenance infusion. Urine output has fallen (from 1.5 to 0.7 ml/kg/hr). Systolic Doppler BP = 80 mmHg; CVP = 4.0 cmH_2O.

i. What are some possible causes of the respiratory problem?

ii. What is the likely mechanism of the lung pathology in this dog?

iii. The infected uterus was removed and the dog received appropriate antibiotic type and dosage pre- and postoperatively. Explain why this problem has developed 6 hours later.

iv. What additional complications are anticipated?


194

194 An 8-year-old female Chihuahua presented for sudden onset of staggering and depression (**194**). The dog had increased drinking and urination for the past several weeks. T = 36.8°C (98.3°F); HR= 140 bpm; RR = 20 bpm; CRT = 1 sec; MM very pale, very dry; perfusion – compensatory shock; 8% dehydration estimated. Abdominal palpation and thoracic auscultation were normal. The dog has mental depression and generalized weakness. Laboratory database: PCV = 0.52 l/l (52%); TS = 102 g/g (10.2 g/dl); osmolality 355 mosmol/l; Na+ = 165 mEq/l; K+ = 3.3 mEq/l; glucose = 5 mmol/l (90 mg/dl); BUN = 14.3 mmol/l (40 mg/dl); pH = 7.31; PCO_2 = 33 mmHg; HCO_3 = 16 mmHg; urinalysis: SG = 1.003; 3+ proteinuria; WBC >10/high-power field; intracellular bacteria seen.

i. What is the formula for calculating osmolarity (US units and SI units) ?

ii. Make a problems list for this dog.

iii. What important information does the urinalysis provide in this dog?

iv. Create a diagnostic and therapeutic plan for this dog.

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193 i. Acute lung injury (ALI, also called mild ARDS), acute respiratory distress syndrome (ARDS), fluid overload (unlikely with CVP, urine output, and BP values), hematogenous pneumonia, and the following, which are not supported by radiographs: CHF, pulmonary thromboembolism, aspiration pneumonia.
ii. ALI is likely an indirect insult from systemic disease (e.g. SIRS, secondary to the pyometra in this dog). Phase 1 has leakage of protein-rich fluid into the interstitial and alveolar spaces from disruption of the capillary/alveolar border. Phase 2 occurs as fibroblast proliferation begins in a disorganized manner with collagen deposition within the basement membranes. Scarring occurs causing abnormal shaped capillaries and alveoli. Phase 3 is highlighted by remodeling of lung and vascular tissue with removal of damaged tissue and fluids.
iii. Once the production of cytokines has been initiated, newly produced cytokines can stimulate the production of additional cytokines, even when the initiating pathogen has been eliminated. This can lead to damaged tissues far from the site and at a later time than the initial insult.
iv. Thrombocytopenia, clotting abnormalities, hypoalbuminemia, ileus, malnutrition, electrolyte disorders, acid–base disorders, hypotension, poor cardiac contractility, arrhythmias, thromobosis or infarcts, AKI, hepatopathy, mentation disorders, fluid imbalance, third-body fluid spacing, anemia, peritonitis, pleuritis, aspiration pneumonia, continued pulmonary dysfunction. The Rule of 20 is used to remind the clinician to be thorough in patient evaluation and monitoring.

194 i. 2 (Na+ + K+) + [BUN/2.8] + [glucose/18] = mOsmol/l (US units). Calculated osmolarity = 2 Na + glucose + BUN (all in mmol/l) (SI units).
ii. Compensatory shock, dehydration, hemoconcentration, hyperosmolar, hypernatremia, elevated BUN, hyposthenuria, urinary tract infection (bacteria, protein, WBCs), history of PU/PD, hypothermia, generalized weakness, depression.
iii. Hyposthenuria indicates a problem with ADH and the distal tubule and collecting ducts. Diabetes insipidus (DI) can be either central (reduced production of ADH) or renal (renal cell insensitivity to ADH). If the urinary tract infection in this dog is due to endotoxin-producing bacteria (e.g. *Escherichia coli*), the endotoxin can induce renal DI. The hypernatremia and severe fluid loss are due to the loss of solute free water associated with DI.
iv. Diagnostic plan. Urine culture and susceptibility; imaging (radiographs or ultrasound to rule in/out renal disease or pyometra). Therapeutic plan. Flow-by oxygen, IVC; 4-Step Fluid Resuscitation Plan: Step 1– perfusion and hydration deficits; Step 2 – combination 0.9% NaCl (due to hypernatremia) and HES; Step 3 – high normal end resuscitation end-points because of bacterial endotoxin possibility; Step 4 – small volume titration because of sodium disorder, potential for brain edema; antibiotics IV (e.g. ampicillin/sulbactam, cephalothin, trimethoprim-sulfa). Exogenous ADH (DDAVP) is not likely to work if the DI is nephrogenic associated with endotoxin. Great attention must be paid to fluid balance and the Rule of 20.

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195 An 8-year-old male neutered Retriever-cross presents for lethargy and vomiting food and yellow liquid for 24–36 hours (**195**). There is no known exposure to toxins. He was recently in muddy waters hunting birds. T = 39°C (102.2°F); HR = 120 bpm; RR = 25 bpm; CRT = 1–2 sec; MM icteric, dry; pulses normal; perfusion normal; 8–10% dehydrated (dry MM/corneas). The dog is mentally dull. Chest and abdominal examination are normal with soft brown/yellow stool on rectal. Initial blood work: normal WBC count, with platelets = 100 × 10^9/l; PCV = 0.46 l/l (46%); TS = 76 g/l (7.6 g/dl); BUN = 32.1 mmol/l (90 mg/dl); creatinine = 1,109 µmol/l (12.5 mg/dl); serum PO_4 = 3.5 mmol/l (10.8 mg/dl); total bilirubin = 210.3 µmol/l (12.3 mg/dl). Mildly enlarged kidneys are the only abnormality seen on abdominal ultrasound. Urinalysis: SG = 1.020, 3+ proteinuria, 2+ blood, 4+ bilirubin, occasional coarse granular cast.

i. This dog lives in an area endemic for leptospirosis. Identify any clinical and physical/historical signs from this dog that are compatible with this diagnosis.

ii. How would you confirm the diagnosis of leptospirosis in this dog?

iii. What is the mechanism of renal injury from leptospirosis?

iv. What treatment is needed for leptospirosis in dogs? Are there any specific precautions for this suspected disease?



196 A 3-year-old male neutered DSH cat presents for lethargy and pain around his back end after being missing for 3 days. T = 40.3°C (104.5°F); HR = 190 bpm; RR = 40 bpm; MM slightly dry; normal perfusion; estimated 4–5% dehydrated based on history. Analgesic/sedative combination is given and the perineal region is clipped/cleaned. A large, ruptured wound with deep pocketing to the left side of his anus (likely anal sac) and extending several centimeters under the skin ventrally and caudally is noted (**196a**). Large quantities of purulent and necrotic material is removed and the wound lavaged.

i. Select the best option(s) for management of this wound after lavage: wet-to-dry bandaging; primary closure; honey bandage; vacuum-assisted wound closure; remove the anal sac.

ii. Describe how this cat's perineal region can be bandaged.

iii. What are the indications for anal sacculectomy?

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Answers: 195, 196

195 i. Laboratory support of AKI, icterus/hepatobilliary disease, fever, blood in urine, history of hunting in muddy waters, endemic area.
ii. Leptospirosis antibody microscopic agglutination test (MAT). May need to repeat in 2–3 weeks to confirm increasing titers. Other options include dark-field examination of the urine, leptospirosis-specific culture, fluorescent antibody stain, and PCR.
iii. Bacterial invasion of tissues and their products causing inflammation (i.e. edema and vasculitis); decreased renal perfusion from swelling and direct damage to blood vessels. Hemodynamic alterations can contribute to development of renal pathology. Interstitial nephritis is the basic lesion with tubular necrosis important for AKI. Jaundice typically due to cholestasis, with hyperbilirubinemia potentially contributing to renal dysfunction.
iv. Leptospirosis is a zoonotic disease requiring hospital-specific isolation to protect personnel from exposure to urine and blood. As a minimum, gloves and face masks should be worn and urine contained. General IV fluid support with isotonic crystalloids is provided to rehydrate, maintain fluid balance, and promote diuresis. Penicillin and its derivatives are the antibiotics of choice for initial treatment, which terminates leptospiremia and prevents further urinary shedding, decreasing the risk of zoonotic transfer. Doxycycline should be administered for 3 weeks to clear the infection and eliminate the carrier state. Anti-emetics, synthetic colloids, motility modifiers, and nutritional support are often required. Oliguric patients may respond to osmotic diuretics. Dialysis is occasionally indicated. The Rule of 20 should be assessed twice daily.

196 i. A wet-to-dry or honey bandage is the best option at this time. Primary closure is not an appropriate choice because of the purulent and necrotic debris; vacuum-assisted wound closure would be difficult given the proximity of the wound to the anus and prepuce. Removing the anal sac is not possible at this time.


196b

ii. The best option is an 'island bandage'. Several large suture loops of 2-0 or 3-0 nylon are placed around the wound, and sterile gauze or a laparotomy pad placed directly against the wound (with or without topical medications such as honey). Umbilical tape or gauze are used to tie the bandage in place (**196b**).
iii. Anal sac neoplasia and recurrent anal sac infections. Infection and/or inflammation must be medically managed prior to surgical intervention.

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197

197 An 8-year-old female neutered Labrador presents for collapsing during a run in the mid-afternoon heat (**197**). She was placed in a wheelbarrow filled with ice, but seizured and was unable to walk. T = 33.9°C (93°F); HR = 190 bpm; RR = 30 bpm; CRT = 3–4 sec; MM pale pink with petechiae and dry; femoral pulses weak; perfusion poor; 8–10% dehydration (skin turgor/MM). Auscultation and palpation findings within normal limits. Neurologic examination: moribund with severely depressed mentation, dilated pupils OU, unable to stand, slow spinal reflexes. Doppler arterial BP too low to register.

i. Create a problems list in order of priority.

ii. What is the end-point resuscitation goal (high end or low end) and volume infusion technique (large or small) that will be used?

iii. Interpret the emergency database results obtained before fluid therapy: PCV = 0.6 l/l (60%); TS = 90 g/l (9.0g/dl); pH = 7.253; PCO_2 = 42 mmHg; HCO_3 = 14.8 mEq/l; Na+ = 158 mEq/l; K+ = 3.2 mEq/l; Cl– = 121 mEq/l; iCa^{++} = 1.0 mmol/l (3.88 mg/dl); Mg++ = 0.61 mmol/l; lactate = 7.2 mmol/l (65 mg/dl); glucose = 2.0 mmol/l (36 mg/dl). What are the implications for treatment?

iv. The end-points of resuscitation have been reached and the dog has another seizure. What treatment should be instituted?


198a

198 A 10-year-old female neutered Poodle-cross presents for anorexia, vomiting yellow foam, and a painful abdomen (**198a**). Presumptive diagnosis of acute pancreatitis is made. Initial laboratory database: lipemic serum; PCV = 0.48 l/l (48%); TS = 50 g/l (5.0 mg/dl); glucose = 2.22 mmol/l (40 mg/dl); BUN = 19.6 mmol/l (55 mg/dl); Na+ = 132 mEq/l; K+ = 4.8 mEq/l; ACT = 60 sec (n = 80–120 sec); 3 platelets per oil immersion field.

i. List the possible causes of lipemia in the dog.

ii. What are some key historical and clinical signs compatible with acute pancreatitis in the dog?

iii. What diagnostic imaging can be done to diagnose pancreatitis?

iv. What is the pathophysiology of acute pancreatitis?

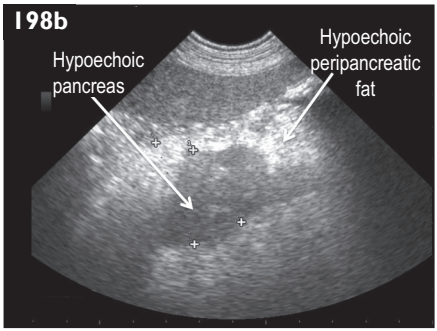
v. Explain why acute pancreatitis is an SIRS disease process.

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Answers: 197, 198

197 i. Circulatory shock, severely depressed mentation with dilated pupils and a seizure, hypothermia, petechiae, vomiting, severe dehydration, history of heat exhaustion.
ii. Low normal end-points and small volume technique are selected initially due to the likelihood of brain edema. Because heat exhaustion is an SIRS problem, titrate to high normal end-points when the neurologic signs improve.
iv. Hypoglycemia requires immediate IV supplementation. This may be caused by a severe hypermetabolic state (heat exhaustion, seizures, sepsis). Metabolic acidosis and hyperlactatemia are likely due to poor perfusion and possibly recent seizure activity. Tissue perfusion must be supported. Mild hypernatremia and hyperchloremia are likely due to solute-free water loss from the heat exhaustion. Hypocalcemia may be a result of sepsis, renal failure, hyperlactatemia, or dilution. Mild hypokalemia may be a result of dilution or GI losses, necessitating potassium supplementation of maintenance fluids.
iii. Give 0.2 mg/kg midazolam or diazepam IV, rapidly check blood glucose, and supplement if needed. Use colloids to minimize fluid extravasation and support oxygenation and BP. Institute nursing procedures for patients with ICP (see case **142**).

198 i. Postprandial, hypothyroidism, hyperadrenocorticism, diabetes, pancreatitis, altered lipid metabolism, nephrotic syndrome.
ii. Vomiting, anorexia, and depression are key clinical signs. Cats may only show anorexia and depression. Other signs include: history of pancreatitis, other endocrinopathies (diabetes mellitus, Cushing's, hypothyroidism), hepatobiliary disease, recent dietary indiscretion, abdominal pain, diarrhea, loss of appetite, fever, icterus.
iii. Radiographs showing loss of detail or ground glass appearance in the right upper quadrant and a wide angle between the gastric antrum and duodenum; ultrasound (**198b**) showing a dilated common bile duct and gall bladder, small amount of free fluid in the abdomen, and a hypoechoic, thickened pancreas with hyperechoic mesenteric tissue surrounding it with a corrugated duodenum. CT scan and surgery.
iv. Activation of pancreatic enzymes within the pancreas causes proteolysis and activation of the inflammatory cascade, producing free radicals and phospholipase. These disrupt cellular membranes and result in production of cytokines, neutrophil recruitment, and further free radical production. Local inflammation leads to increased capillary permeability, edema, necrosis, and hemorrhage of the pancreas.



v. The inflammatory mediators noted above may be transported via the lymphatics to all parts of the body, resulting in global inflammation, increased capillary permeability, and neutrophil recruitment.

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199 A 12-year-old female neutered DLH cat presented for anorexia and weight loss for 2 weeks. Blood streaks were seen in urine in the litter box. BCS = 3/9; T = 36.7°C (98°F); HR = 190 bpm; RR = 35 bpm; CRT = 1.5 sec; MM pink, dry; femoral pulses normal. Thoracic auscultation normal; pain on deep abdominal palpation; moderately distended urinary bladder. Emergency database: PCV = 0.54 l/l (54%); TS = 98 g/l (9.8 g/dl); glucose = 5.3 mmol/l (96 mg/dl); BUN >53 mmol/l (>150 mg/dl); Na+ = 154 mEq/l; K+ = 6.5 mEq/l; pH = 7.32; HCO_3 = 14 mEq/l; PCO_2 = 30 mmHg; systolic Doppler BP = 180 mmHg; creatinine = 353.6 µmol/l (4.0 mg/dl). Urinalysis: SG = 1.035, 4+ protein, 4+ blood, triple phosphate crystals, occasional coarse granular cast.

i. Create a problems list for this cat.

ii. Prepare an initial therapeutic plan.

After fluid diuresis, BUN = 30.3 mmol/l (85 mg/dl), creatinine = 185.6 µmol/l (2.1 mg/dl), K+ = 4.5 mEq/l. Abdominal ultrasound demonstrated fluid around the left kidney and a thickened urinary bladder wall with a small amount of urine. An IV pyelogram (IVP) was done to assess the urinary tract (lateral view at 15 minutes shown, **199**).

iii. What are the indications and potential complications of an IVP?

iv. What can be done to minimize complications?

v. Assess the radiograph.

vi. What recommendations are made for definitive treatment of this cat?



200 A 2-year-old female neutered Yorkshire Terrier/Shih Tzu-cross presents for 'walking funny' after eating a meal (**200**). T = 38.7°C (101.8°F); HR = 120 bpm; RR = 28 bpm; CRT = 1.5 sec; MM pink; perfusion and hydration adequate. Neurologic examination is normal except for generalized weakness and dull mentation. Hypoglycemia is reported on the emergency database. Hepatoportal shunt causing hepatic encephalopathy is suspected.

i. What is the diagnostic plan for hepatoportal shunt, and what are typical findings?

ii. What is the mechanism of weakness and mental dullness with hepatic encephalopathy?

iii. What is the recommended emergency medical treatment for portosystemic shunt?

iv. What options are available for surgical treatment of portosystemic shunts?

v. You have diagnosed this pet with a portosystemic shunt and the owners wish to pursue surgical correction. If this patient were to seizure preoperatively, what medication would you administer?

vi. What medication may help decrease postoperative seizures?

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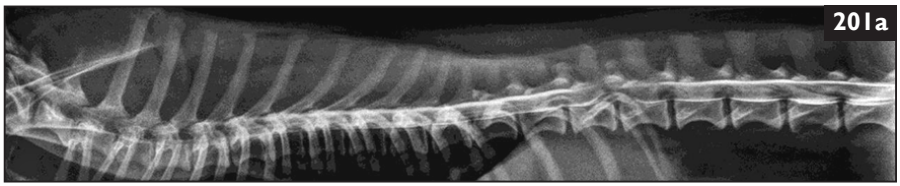
199 i. Anorexia, weight loss, blood streaks in urine, mild hypothermia, abdominal pain, dehydration (dry MM, PCV/TS 0.54/98 [54/9.8]), hyperkalemia, azotemia, hypertension, struvite crystalluria, proteinuria/hematuria with casts.
ii. Place an IVC, provide opioid analgesia, and initiate fluid therapy with a balanced isotonic crystalloid to replace hydration deficits, fluid loss with diuresis, and maintenance requirements. Gastroprotective proton pump inhibitor or H2 blocker for uremia. Persistent hypertension may require a calcium channel blocker (e.g. amlodipine). Place a urinary catheter with closed collection to monitor output.
iii. To assess the blood flow to the kidneys and filtration of contrast agent through the kidneys; assess the renal pelvis, the ureters, and flow from the kidneys to the bladder. Contrast agents are hypertonic, possibly causing significant fluid shifts, allergic reactions, and anaphylxis.
iv. Restore perfusion and hydration and improve renal values prior to administration. BP is monitored and changes immediately addressed. A urinary (bladder) catheter may help reduce leakage of contrast if the bladder is ruptured.
v. There is contrast leaking into the retroperitoneal space. There is concern for a ruptured ureter.
vi. Additional imaging (ventrodorsal radiographs, CT, and/or ultrasound) can further assess the ureter. Surgical exploration with stenting or re-routing of the ureter may be necessary.

200 i. Routine bloodwork may reveal decreased hepatic function with decreased blood glucose, BUN, cholesterol, and albumin. Other supportive findings: elevated blood ammonia, fasting bile acids >8 µmol/l with a post-prandial bile acids >30 µmol/l; ultrasound may demonstrate shunts. Portovenograms (with or without fluoroscopy), scintigraphy, and CT are advanced non-invasive methods of diagnosis. A definitive diagnosis may require exploratory surgery.
ii. Include (in the brain): (1) Increased glutamate from ammonia metabolism causing swelling. (2) Increased activity of the inhibitory γ-aminobutyric acid (GABA) system. (3) Decreased energy supply to other brain cells. (4) Effects of endogenous benzodiazepine-like compounds. (5) Aromatic and branched-chain amino acid imbalance. (6) Dysregulation of serotonin system. (7) Brain zinc and manganese abnormalities. (8) Cytokine action on astrocytes.
iii. IVC; restore perfusion and hydration with crystalloids +/- colloids; dextrose (0.5 g/kg IV titrated to effect); lactulose enemas and/or oral lactulose, oral fiber, +/- GI antibiotics such as neomycin; gastroprotectant drugs (H2 blockers or proton pump inhibitors) if GI ulceration is suspected; low-protein diets. Control of seizures and treatment of cerebral edema may be necessary.
iv. Extrahepatic shunts: ligation, ameroid ring placement, or cellophane band wrapping. Interventional radiological procedures such as coil embolization for intrahepatic shunts.
v. Propofol is a good first choice. Levetiracitam is an alternative option. Administration of benzodiazepines (midazolam, diazepam) is potentially harmful.
vi. Levetiracitam (20 mg/kg PO q8h for 24 hours preoperatively) can decrease postoperative seizures and death after ameroid ring placement.

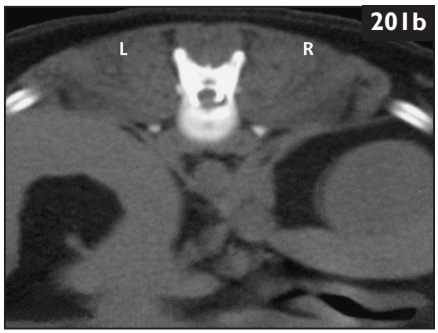
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201 A 7-year-old female neutered Cocker Spaniel presented for difficulty walking, which has now progressed to not being able to use her hindlimbs. She has been given 25 mg carprofen for perceived pain. General physical examination is normal except that she is unable to walk or stand. Neurologic examination findings are as follows:

Cranial nerves/mentation	Normal
Retinal examination	Normal
Spinal palpation	Very painful distal thoracic spine
Panniculus	Not elicited; area too painful
Posture	Sitting with forelimbs supporting weight of thorax; hindlimbs stretched out beneath abdomen not supporting weight; unable to stand on hindlimbs even with assistance
Gait and voluntary motor	Normal forelimbs; minimal to no voluntary movement of both hindlimbs
Proprioception	Normal forelimbs; absent both hindlimbs
Spinal reflexes	Normal forelimbs, increased (hyperreflexia) sciatic, patellar, and cranial tibial reflexes both hindlimbs
Withdrawal	Normal x 4
Muscle mass	Normal x 4
Orthopedic examination	Normal x 4
Anal tone	Normal



i. Localize the lesion from the neurologic findings.
ii. What are the differential diagnoses for this neurologic problem?
iii. What constitutes medical management of acute disc prolapse?
iv. What clinical signs warrant immediate consultation with a surgeon or neurologist to discuss further intervention?
v. A routine myelogram with lumbar puncture (**201a**) followed by a CT scan is performed (**201b**). Evaluate the myelogram/radiograph and the CT post-contrast region of T13/L1.



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Answer: 201

201 i. The lesion is localized between the T3 and L3 spinal cord segments.
ii. Fibrocartilagenous embolus, prolapsing/ruptured intervertebral disc, acute hemorrhage around or within the spinal cord, spinal fracture, neoplasia affecting the spinal cord.
iii. Analgesia with a combination of opioids, non-steroidal or steroidal anti-inflammatory analgesics, muscle relaxants, and strict cage rest are the mainstay. The type and dosage of anti-inflammatory drug are based on veterinarian preference. Rehabilitation therapy, acupuncture, therapeutic laser, passive range of motion, and massage are adjuncts to medical therapy. Bladder expression, fecal evacuation, and regular cleaning may be required.
iv. The acute onset, lack of voluntary movement and extensor tone (ventral and lateral cord compression), and loss of proprioception in the rear (dorsal cord compression) demonstrate compression of the entire circumference of the cord at the affected segment. Early surgical decompression of the cord could result in an improved functional outcome.
v. Myelogram: lateral radiograph shows attenuation of the dorsal contrast column, slight attenuation of the ventral contrast column with dorsal deviation of both dye columns at T13/L1. These changes are consistent with a prolapsed disc and compression of the spinal cord. CT: hyperdense material in the right ventral aspect of the spinal canal at T13/L1 resulting in dorsal and left displacement of the spinal cord with flattening of the right ventral margin.

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202 A 4-year-old female entire Schnauzer-cross presents because of two fluid-filled sacs hanging from her vulva (**202**). The first sac was observed about 45 minutes prior to presentation and the second sac 20 minutes prior to presentation. She was bred approximately 62 days ago to a large male Schnauzer. This is her first litter. T = 37.7°C (99.9°F); HR = 150 bpm; RR = 60 bpm; CRT = 1 sec; MM pale pink, moist. Abdomen is tense and she is having visible abdominal contractions, which were not observed prior to presentation. Fetal HR = 180 bpm. Rectal examination reveals a fetus at the pelvic inlet.

i. What are the fetal and maternal causes of dystocia?

ii. List at least four signs of dystocia.

iii. Stage 1 labor is defined by a progesterone level less than what value?

iv. What is oxytocin, what is its mechanism of action, and what are the pros and cons of its use in a pet with dystocia?

v. List six indications for emergency cesarean section.





203 An 8-year-old male cat presents after being hit by a car. He has been stabilized, but has a luxated mandible (**203a**).

i. What options do you have to support his nutritional needs during the repair and recovery period?

ii. A right lateral thoracic radiograph (**203b**) was taken after completion of the procedure elected for enteral nutrition. Evaluate the radiograph.

iii. What are potential causes of your radiographic diagnosis?

iv. What are the potential complications of this pathology?

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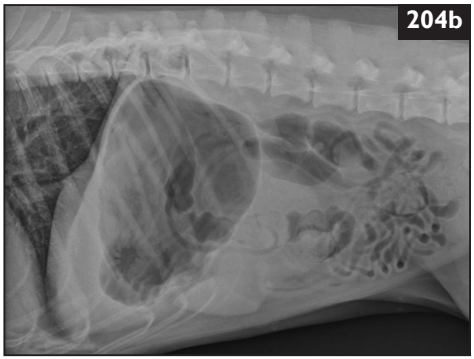
Answers: 202, 203

202 i. Fetal causes include increased fetal size, abnormal presentation, position, posture, or development. Maternal causes include systemic disease, reduced pelvic size, abnormal reproductive tract anatomy, or abnormal expulsion (uterine intertia).
ii. Presence of uteroverdin without immediate fetal delivery; prepartum pregnancy toxemia (ketosis without hyperglycemia); failure to produce a fetus after 30 minutes of strong contractions; weak straining for 2 hours without delivery; >4–6 hours since birth of last pup; retained pup in canal.
iii. <2 ng/ml.
iv. A drug that promotes uterine contraction (ecbolic) by increasing intracellular influx of calcium. It can be used for non-obstructive dystocia, when uterine inertia is not complete. Pros: stimulates uterine contraction, reduces uterine hemorrhage, promotes uterine involution, and decreases incidence of fetal membrane retention. Cons: can also interrupt uteroplacental blood flow and cause ineffective tetanic uterine contractions, which could affect fetal viability. Higher doses of oxytocin are associated with fetal hypoxemia; conservative doses (0.25–2 IU/dog SC) are recommended. Oxytocin is avoided when an immediate cesarean section can be performed to improve fetal viability.
v. (1) Obstruction: fetal–maternal disparity, fetal malposition, non-fetal obstruction of canal, uterine torsion. (2) Fetal distress (HR <160 bpm). (3) Failure to deliver with oxytocin (non-obstructive dystocia). (4) Presence of uteroverdin, meconium, excessive hemorrhage, or pus in vaginal discharge. (5) Maternal illness. (6) >65 days post breeding (or 63 days post ovulation).

203 i. Esophagostomy; nasogastric, nasoesophageal, or percutaneous gastrostomy tube placement.
ii. There is an orotracheal tube in place ending at the level of 2nd/3rd rib. There is an esophagostomy tube placed in the distal third of the esophagus. Subcutaneous air is present in the mid-cervical region. Within the thorax, the trachea and dorsal aspect of the esophagus have an air interface. Radiographic diagnosis: pneumomediastinum.
iii. Causes of pneumomediastinum include: trauma to the trachea; penetrating cervical wound extending into the mediastinum; alveolar tear; esophageal tear (including incorrect placement of the esophagostomy tube into the mediastinum); dental procedures.
iv. Pain due to subcutaneous emphysema, respiratory distress/failure due to pneumothorax, and/or tension pneumomediastinum.

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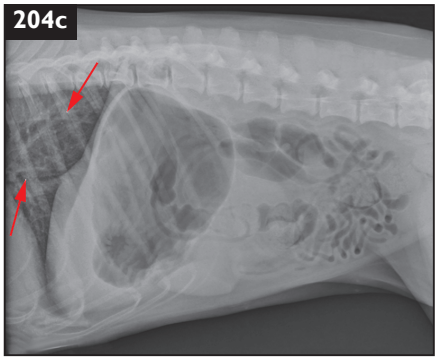


204 An 8-year-old female neutered Labrador presents for vomiting food and mucus after eating. She later vomited white mucoid foam several times. T = 38.7°C (101.7°F); HR = 110 bpm; RR = panting; CRT = 2 sec; MM pink; perfusion adequate; hydration normal. The dog has a very relaxed anal sphincter tone. She is initially treated with subcutaneous fluids and maropitant, and radiographs (**204a, b**) are obtained. The dog returns the next day with the history now more compatible with regurgitation, not vomiting. She is drooling excessively and has epiphora OS, bilateral scleral injection, and a corneal ulcer (positive fluoroscein stain) with decreased tear production OD.
i. Interpret the radiographs and provide a radiographic diagnosis.
ii. What is the differential diagnosis for the most anterior GI problem found on the radiographs?
iii. What is the diagnostic plan for this anterior GI problem?
iv. How is the dog managed?

205 Titers for antibodies to acetylcholine receptors in the dog in case **204** were consistent with a diagnosis of myasthenia gravis (MG).
i. What is an alternative diagnostic method for MG?
ii. How do you specifically treat MG?

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Answers: 204, 205



204 i. There is a gas distended stomach, cecum, and lower esophagus (**204c**, arrows). The small bowel has some gas. The radiographic diagnosis is megaesophagus, aerophagia, and gastric and intestinal ileus.
ii. Causes of megaesophagus: severe hypokalemia, hypomagnesemia, or hypocalcemia; esophagitis (secondary to vomiting, recent obstruction, or toxic ingestions); gastroesophageal reflux; persistent right aortic arch (congenital); esophageal stricture (congenital or acquired); esophageal obstruction; iatrogenic (sedation, anesthesia, or recent endoscopic procedures/orogastric intubation); neuromuscular diseases (polyradiculoneuritis, tick paralysis, myasthenia gravis); endocrine diseases (hypoadrenocorticism, severe hypothyroidism); toxins such as lead.
iii. A thorough history/physical examination with CBC, biochemistry, urinalysis, blood gas and electrolyte panel will rule out many causes. Additional blood tests include thyroid panel, ACTH stimulation test, acetylcholine receptor antibody testing, and lead levels. Endoscopy of the esophagus may be necessary.
iv. Hospitalization and treatment with IV isotonic balanced crystalloids, placement of a nasogastric or PEG tube for decompression and nutritional support, supportive care, and topical eye medications. The megaesophaus may persist (depending on the underlying cause), requiring long-term management. Elevated feeding, use of a Bailey chair, or placement of a gastric feeding tube may be necessary. Feeding a soft diet may assist in food passage from the esophagus. Malnutrition and aspiration pneumonia are common complications.

205 i. The tensilon test. The short-acting anticholinesterase drug edrophonium is injected and the dog observed for an immediate short-term improvement in muscle strength and movement.
ii. An acetylcholinesterase inhibitor such as pyridostigmine is administered. Other treatments, such as steroids (or other immunosuppressive drugs such as azathioprine or mycophenolate mofetil), thymectomy, and plasmapharesis, may provide additional therapeutic benefits.

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206 An 8-week-old mixed-breed puppy presents for abdominal distension, difficulty breathing, and crying (**206a**). T = 37.9°C (100.3°F); HR = 160 bpm; RR = panting; CRT = 2 sec; MM pale pink; estimated 6% dehydrated (skin turgor/MM moisture). Thoracic auscultation normal. Abdominal palpation found pain with very firm loops of small bowel. PCV = 0.29 l/l (29%); TS = 45 g/l (4.5 g/dl); BUN = 3.6 mmol/l (10 mg/dl); glucose = 6.1 mmol/l (110 mg/dl). Fecal examination revealed numerous roundworm eggs.

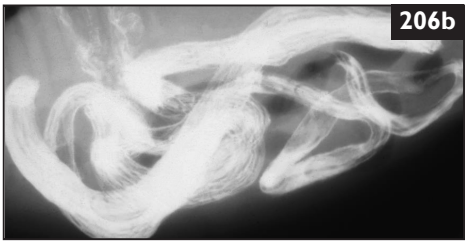


i. List at least three problems prevalent in the pediatric patient.

ii. Intravascular fluid support is needed. Severe hypovolemia is making intravascular access impossible without cut-down in this tiny puppy. What is another route for providing intravascular volume replacement? What fluid(s) would be selected?

iii. What are possible causes of the abdominal pain and distension?

iv. Assess the radiographic spot film of the abdomen of the puppy with contrast (**206b**).



v. What treatment is warranted based on the diagnostic findings? How do any listed medications work?

207 A laboratory database of the dog with dystocia in case **202** shows normal glucose and a normal electrolyte panel. The owner agrees to have an emergency cesarean section performed.

i. What preparations will reduce the time the dog is under anesthesia and reduce risks to the fetus?

ii. Describe an anesthetic/analgesic protocol that will have the least consequences to the dog and fetus.

iii. Describe the surgical procedure for removing the puppies from the uterus during cesarean section.

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206 i. Smaller size anatomically, increased surface area, less vascular compliance, higher metabolic rate, less glycogen storage capacity, lower intravascular fluid volume, lower TS value, lower PCV, drug metabolism may vary, potentially different drug reactions (e.g. tetracycline, fluroquinolone), inability to concentrate urine.
ii. Intraosseous needle or catheter or jugular venous catheter; isotonic balanced crystalloid to replace hydration deficits.
iii. Intestinal FB, linear FB, intussusception, intestinal parasite impaction, parvovirus enteritis.
iv. The distended small bowel is filled with multiple linear objects, compatible with intestinal parasite impaction.
v. Medical treatment should include analgesics and treatment for intestinal parasites (e.g. fenbendazole, pyrantel pamoate). Pyrantel is a parasitic neuromsucular depolarizing agent; fenbendazole inhibits glucose uptake by the worm through tubulin inhibition, so the parasites lose their grip and pass. However, should impaction persist despite deworming medications, surgical intervention may become necessary. This puppy was treated successfully with fenbendazole.

207 i. Perfusion and hydration deficits are rapidly corrected. Clean towels, several bulb aspirators, oxygen, and a warmed incubator are made ready in the surgical prep area. All available personnel are instructed on the method of fetal resuscitation. The patient is anesthetized and surgically prepared in the surgery suite. Assisted or mechanical ventilation is recommended. During the preparation time, the surgeon is scrubbing and unpacking the surgical pack.
ii. Choose a titratable anesthetic agent with a rapid and short duration of effect. Propofol permits immediate orotracheal intubation and can be administered as a CRI. Analgesia through administration of a regional (epidural) and local (skin incision) anesthetic using lidocaine or bupivacaine is desirable. Pure opioid agonists (morphine, oxymorphone) can be added to the epidural injection to prolong postsurgical analgesic effects. Once the pups have been extracted, additional opioids can be administered IV to the dog, propofol discontinued, and inhaled anesthetics used during closure.
iii. A ventral midline incision is made from the umbilicus to the pubis. The uterus is then exteriorized using moistened towels. A hysterotomy incision is made on the ventral midline of the uterine body. The fetus is removed first and placed on a sterile towel. The amniotic sac is broken and the fetal fluids suctioned from the oral cavity. If the placenta readily separates, it is handed to an assistant with the pup in the towel. If the placenta does not readily separate or bleeds excessively, the umbilical cord is clamped and ligated first. The remaining pups are manipulated by massaging the uterine horns and gently pulling them into the uterine body and out through the incision.

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208 A 7-year-old male neutered DLH cat presented for straining to urinate for 48 hours, vomiting yellow foam, and sudden collapse at home. The cat was given IV isotonic balanced crystalloids, regular insulin, and glucose for immediate treatment of hyperkalemia, anesthetized, and the urethra unblocked with a urethral catheter. Only 20 ml of urine was recovered from the urinary bladder once the catheter was passed. The abdomen was painful and distended with a palpable fluid wave. Post-obstruction laboratory database: PCV = 0.49 l/l (49%); TS = 80 g/l (8.0 g/dl); glucose = 3.9 mmol/l (70 mg/dl); BUN >2.8 mmol/l (80 mg/dl); Na+ = 155 mEq/l; K+ = 10.4 mEq/l.

i. Abdominocentesis produced yellow tinged fluid (**208**). How do you diagnose this fluid as urine?
ii. What systemic consequences are anticipated from uroabdomen?
iii. How should this patient be stabilized?
iv. What can be done to evaluate the integrity of the urinary bladder?
v. What definitive treatment is recommended for this cat?
vi. How is the patient managed/monitored after definitive treatment?

209 A 4-year-old male Pitbull presented within 1 hour of being attacked by a Rottweiler dog. The Pitbull had bite wounds on the neck and chest and had been shaken from side to side. T = 36.9°C (98.4°F); RR= 50 bpm with loud inspiratory sounds (heard without a stethoscope); CRT = 3 sec; MM white, dry; femoral pulses absent with cold distal limbs. Abdominal palpation found pain and possibly a fluid wave. Emergency database: PCV = 0.45 l/l (45%); TS = 52 g/l (5.2 g/dl); glucose = 4.6 mmol/l (83 mg/dl); BUN = 14.3 mmol/l (40 mg/dl); Na+ = 148 mEq/l; K+ = 3.1 mEq/l; pH = 7.13; HCO_3 = 12 mEq/l; PCO_2 = 25 mmHg; lactate = 6.7 mmol/l (60 mg/dl); aPTT = 130 sec; platelet estimate = 5 platelets/oil immersion field; Doppler systolic BP = 65 mmHg.

i. Prepare the initial 4-Step Fluid Resuscitation Plan.
ii. Explain what complications should be anticipated with this 'Big Dog Little Dog'-type traumatic injury.



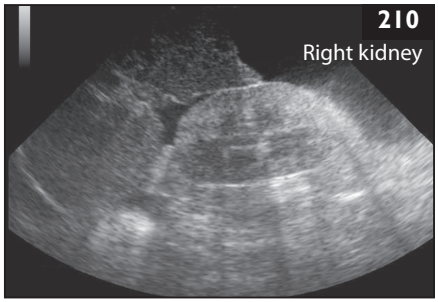
iii. The dog was shaved and multiple bite wounds revealed (**209**). Describe your approach to these wounds.
iv. Why should this dog be considered an SIRS patient?
v. What analgesia would you recommend during the first few days of hospitalization? Justify your selection.

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208 i. A fluid creatinine level twice the blood creatinine level supports uroabdomen. Cytology of abdominal fluid and urine with culture/susceptibility are used to identify a septic abdomen.
ii. Hyperkalemia and azotemia (elevated BUN and creatinine) and subsequent side-effects (nausea, GI ulceration); abdominal pain. Uroperitoneum causes a severe peritonitis, third-body fluid spacing, electrolyte and blood gas abnormalities (metabolic acidosis), shock, uremic encephalopathy, and consequences of SIRS. Should the urine contain bacteria, bacterial peritonitis can ensue.
iii. IV crystalloids (without potassium) for hydration and diuresis and analgesics are given. Hyperkalemia causing cardiac abnormalities (changes on ECG, altered rate, or signs of poor perfusion) is treated with IV calcium gluconate or insulin and glucose. Glucose is added to IV fluids if insulin and glucose are given. A peritoneal catheter is secured to drain abdominal urine. Intermittent peritoneal lavage may dilute the inflammatory mediators and reduce pain. A urinary catheter is placed to divert urine and decompress the bladder to promote healing of any tear.
iv. A positive-contrast cystourethrogram.
v. Some bladder ruptures may heal on their own with medical management, keeping a urinary catheter in place for 5–7 days. Surgery may be necessary for some patients.
vi. Hydration and perfusion parameters are monitored closely while fluid is draining from the peritoneal cavity and out of the urinary catheter. A continuous ECG if serum potassium is high until response to diuresis and urine drainage. Electrolytes, blood gas, and renal values are monitored q12–24h.

209 i. (1) Perfusion and hydration deficits; (2) combination of isotonic balanced crystalloids and HES (tetrastarch or hetastarch); (3) low normal end-points for resuscitation goals owing to trauma and unknown bleeding potential; (4) small volume infusion techniques.
ii. Crushing injuries with bite wounds cause tissue necrosis, with shearing forces potentially tearing internal organs/structures.
iii. Multimodal analgesia is prescribed. Radiography and ultrasonography can demonstrate internal injuries. A generous area is surgically prepared over affected skin regions. Devitalized skin and soft tissues are debrided and dissecting tracts opened to permit cleaning, debridement, and repair. Drains are placed in regions of dead space. Open wound management can be used for heavily contaminated wounds. Abdominal penetrating wounds are cleaned, debrided, and the body wall repaired from the outside. An exploratory celiotomy is warranted to repair, lavage, and suction the abdomen after abdominal wall penetration. Thoracic external wounds are explored, cleaned, and debrided. Full thoracotomy exploration is not recommended unless severe injury to the lung or ribs requires complete exposure.
iv. Circulating mediators (cytokines) are produced in response to the global trauma, tissue damage, and bite wound contamination. This will culminate in a global systemic inflammatory response, vasodilation, and increased capillary permeability.
v. Using a full agonist opioid (e.g. fentanyl, morphine) with lidocaine and low-dose ketamine allows for overall reduction in dose of each and affects multiple pain pathways, thus increasing efficacy.

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210 A 5-year-old male neutered Terrier presents for PU/PD and abdominal enlargement progressive over several weeks. T = 38.6°C (101.4°F); HR = 130 bpm; RR = 24 bpm: CRT = 2 sec; MM dry and bright pink; femoral pulses strong; perfusion adequate; 8% dehydration estimated. Thoracic auscultation normal and abdominal palpation finds a pendulous, fluid-filled abdomen. BCS is 2/9 with significant generalized muscle wasting. Abdominal ultrasound shows the right kidney surrounded by anechoic fluid (**210**). Abdominocentesis finds clear (colorless, transparent) fluid.

i. What organs can be responsible for occurrence of ascites, and what is the primary mechanism(s) of fluid production with dysfunction of that organ?

ii. What diagnostic tests are initially recommended in addition to ultrasound? What specific tests can be performed on the abdominal fluid to help determine the underlying cause?

iii. What initial diagnostic indicators may differentiate ascites due to primary intestinal pathology from primary renal (glomerular) disease?

iv. List some anticipated complications when treating a patient with ascites. Give some recommendations for management.



211 A 5-year-old female neutered Labrador-cross is presented for PU/PD, anorexia, and vomiting yellow foam (**211**). TPR are normal. Perfusion is normal; the dog is 6% dehydrated. Initial blood work: PCV = 0.46 l/l (46%); TS = 61 g/l (6.1 g/dl); creatinine = 141.4 µmol/l (1.6 mg/dl); BUN = 17.8 mmol/l (50 mg/dl). CBC shows a mild stress leukogram. Indirect Doppler SAP = 175 mmHg in the resting dog (repeatable three times). Urinalysis: SG = 1.013, 3+ proteinuria, negative blood, ketones, glucose, 0–3 WBC and occasional granular cast in sediment.

i. What additional diagnostic steps are indicated?

ii. Describe the International Renal Interest Society (IRIS) stages for renal failure in the dog.

iii. If this dog has a urine protein:creatinine of 0.8, what stage is this dog in?

iv. You make a diagnosis of idiopathic glomerulonephritis. Discuss some complications that may occur with this disease and how they may be managed.

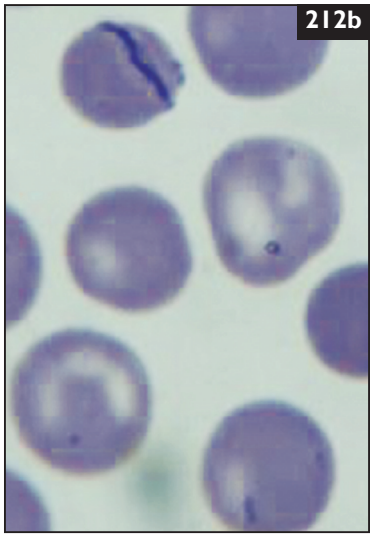
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210 i. Heart: portal and/or systemic hypertension; liver: portal hypertension, insufficient albumin production; kidney: albumin loss through glomerulus; GI tract: inadequate absorption or excessive loss of proteins.
ii. Routine biochemistry, CBC, heartworm test, BP, and urinalysis provide a baseline. Abdominal ultrasound with aspiration and analysis of abdominal fluid, urine protein:creatinine ratio, thoracic radiographs, and echocardiogram help define the effusion and identify its origin. Abdominal fluid analysis can include a refractometer reading to determine SG and/or protein content, a fluid creatinine, glucose, lactate, bilirubin content, as indicated, and fluid sediment cytology.
iii. Primary renal (glomerular) disease: low albumin, proteinuria (high urine protein:creatinine ratio), and poor urine concentrating ability (isosthenuria); BUN, creatinine, phosphorus, and potassium levels are variable depending on the overall renal function; arterial BP is often elevated. Primary GI disease: panhypoproteinemia without elevated urine protein:creatinine ratio, signs of GI disturbance (diarrhea, acholic feces). Weight loss may be present in both.
iv. Include: loss of intravascular COP and fluid extravasation; increase in intra-abdominal pressure; hypertension; thrombosis or embolism due to loss of antithrombin; poor perfusion and dehydration due to fluid shifts; peripheral edema. Treatments that may be of benefit include: administration of synthetic colloid as part of fluid therapy plan; drainage of intra-abdominal fluid to relieve intra-abdominal pressure; monitoring arterial BP and providing vasodilator therapy when indicated; identification of thrombosis/embolism and heparin therapy when necessary; monitoring antithrombin levels and plasma administration to replace when critically low; massage and range of motion exercises to stimulate peripheral fluid uptake.

211 i. UPC ratio (if indicated), urine culture, leptospirosis test, serologic testing for *Borrelia burgdorferi*, *Anaplasma* spp., *Ehrlichia* spp., and *Dirofilaria* spp. (heartworm). Imaging of the dog's renal system/abdomen with radiographs and/or ultrasound.
ii. IRIS stages (dogs): stage 1 – creatinine (CR) <125 µmol/l (1.4 mg/dl); stage 2 – CR 125–179 µmol/l (1.4–2.0 mg/dl); stage 3 – CR 180–438 µmol/l (2.1–5.0 mg/dl); stage 4 – CR >440 µmol/l (5.0 mg/dl). Substage is based on UPC ratio: <0.2 = non-proteinuric; 0.2–0.5 = borderline proteinuric; >0.5 = proteinuric. ABP substage based on BP/degree of risk of end-organ damage. Minimal risk (0); systolic <150 mmHg/diastolic <95 mmHg, low risk (1); 150–159/95–99 mmHg, moderate risk (3).
iii. Stage 2 (CR 125–179 µmol/l [1.4–2.0 mg/dl]), proteinuric (UPC ratio >0.5), moderate risk of end-organ damage (ABP substage 2). (See IRIS staging guidelines.)
iv. Albumin <20 g/l (2.0 g/dl) raises suspicion for decreased antithrombin levels. Antithrombotics (e.g. aspirin or clopidogrel) should be considered. Renal loss of albumin can lower COP with subsequent peripheral edema. ACEIs can reduce renal protein loss. Hypertension can be managed with ACEIs, calcium channel blockers, and arterial dilators. Dietary phosphorus restriction or administration of phosphate blockers such as aluminum hydroxide or calcium carbonate can maintain/control hyperphosphatemia. Alterations in body sodium and water can be managed with dietary sodium restriction and ensuring access to water.

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212 A 7-year-old Golden Retriever presents for lethargy and reduced appetite. One month prior she had a hemoabdomen and splenectomy for a bleeding hematoma, and had received whole blood transfusion. She is not on any medication other than heartworm and flea prevention. T = 39.1°C (102.4°F); HR = 116 bpm; RR = 30 bpm; CRT = 2 sec; MM pale pink, moist; femoral pulses strong; perfusion and hydration appear adequate. No abnormalities found on auscultation or palpation.

i. PCV = 0.2 l/l (20%), TS = 58 g/l (5.8 g/dl). The serum is shown in a hematocrit tube (**212a**). Provide a differential diagnosis list for the anemia based on the color of the serum.

ii. What is the diagnostic plan for this dog?

iii. What therapeutic plan is implemented while awaiting results of the additional tests?

iv. CBC shows Hct of 17%. What is the difference between a PCV and an Hct measurement?

v. A pathologist evaluates the blood smear and identifies small, non-refractile basophilic structures formed in chains across the RBCs (**212b**). What is your tentative diagnosis? What test would definitively diagnose this problem?

213 A 12-year-old male neutered cat presents for howling and acting confused, which started 1 hour ago. He has a history of increased drinking and urination and has lost some weight over the past year. T = 39°C (102.3°F); HR = 240 bpm; RR = 30 bpm; CRT = 1 sec; MM pink and moist; femoral pulses bounding; perfusion appears hyperdynamic with normal hydration. Thyroid is easily palpated. Ophthalmic examination reveals no menace response and a normal cornea and anterior chamber. Resting pupils are dilated OU and only minimally responsive to direct and consensual light. Retinal examination OU finds indistinctly bordered, grayish, parachute-shaped bullae in the vitreous OU without visualization of a normal retina.

i. What is the ocular diagnosis?

ii. List some causes of this diagnosis?

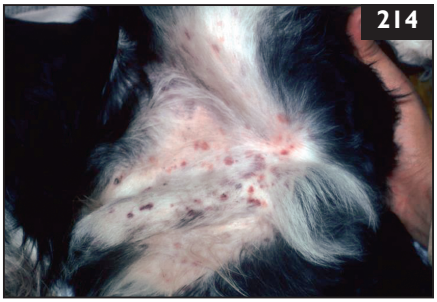
iii. Doppler indirect arterial BP is 220 mmHg systolic. This is repeatable following butorphanol sedation with the cat resting on the owner's lap in the examination room. You make a diagnosis of hypertension. What are the diagnostic and therapeutic plans for this cat? What is the prognosis for vision?

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212 i. Absence of icterus or jaundice reduces the probability of an active hemolytic process. Other causes might include blood loss, hematologic infection, neoplasia, and anemia of chronic disease. Assess whether the anemia is regenerative or not.
ii. Comprehensive CBC with reticulocyte count and pathologist's review, serum biochemistry, urinalysis, testing for tick-borne infection, and thoracic and abdominal imaging to evaluate for neoplasia or internal hemorrhage. Coombs test to look for immune-mediated disease.
iii. Doxycycline to treat possible hematologic infection. There is no discolored serum to support an immune-mediated process, so immunosuppressive medication should not be prescribed at this time.
iv. PCV is determined by centrifuging a sample of whole blood and fractionating the red cells, white cells, and platelets and plasma into layers. PCV is the most dense layer at the bottom of the column and is measured as a percentage of the whole column. Hct is measured with an automated analyzer by multiplying the red cell count by the mean corpuscular volume. Hct is slightly more accurate because there are small fractions of plasma trapped in the red cell fraction of the PCV, which can falsely increase the value.
v. *Mycoplasma haemocanis* infection. *M. haemocanis* PCR.

213 i. Bilateral retinal detachment.
ii. Hypertension, trauma, inflammation, neoplasia.
iii. CBC, comprehensive biochemistry panel with thyroid level, and urinalysis are recommended. Acute treatment with antihypertensive medication (e.g. esmolol or nitroprusside IV as a CRI) and starting a calcium channel blocker (e.g. amlodipine) for oral long-term control. Prognosis is guarded for vision and it will take days to determine visual outcome. The owner must be counseled that this is probably an acute manifestation of a systemic problem that requires diagnosis and treatment. The owner should consider referral to a veterinary ophthalmologist for evaluation for retinopexy procedures.

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214

214 A 5-year-old male mixed-breed dog presents for 'red spots' developing in the skin over 3 days (**214**). Appetite had been declining and the stool was soft and black in color. The dog appeared to be normal except for: thin (BCS = 3/9); non-raised 'red spots' within the dermis and on the MM; black tarry feces. Emergency laboratory database: PCV = 0.25 l/l (25%); TS = 50 g/l (5.0 g/dl); glucose = 5.3 mmol/l (95 mg/dl); BUN = 10.7 mmol/l (30 mg/dl); PT = 15 sec (n = 12–17 sec); aPTT = 60 sec (n = 60–107 sec); platelet estimate = 3 platelets/oil immersion field (platelets appeared large).

i. What general disorder is anticipated when these 'spots' are seen?

ii. Does anything else from the history, physical examination, or database support the presence of this disorder?

iii. Platelet counts with a machine may be unreliable. Discuss how else platelet numbers should be evaluated. What does each 'platelets per oil immersion field' value correspond to with an estimated platelet count?

iv. What is your diagnostic plan for this dog?

v. A diagnosis is not known at this time. Is any treatment recommended based on the information provided?


215a

215 A 6-year-old male neutered Yorkshire Terrier presents after being hit by a car. He has not walked and has been unresponsive since the trauma. T = 35.5°C (96°F); HR = 72 bpm; RR = 20 bpm; CRT = 3 sec; MM pale and dry; femoral pulses weak; middle stage of shock; 8% dehydration estimated. There is hypersalivation, no movement of the tongue, no gag reflex, and his forehead is swollen on the right side. Anisocoria with left pupil larger than right and no menace seen. Generalized weakness but reflexes, tone, conscious proprioception, withdrawal, and pain perception present in all four limbs. There is blood throughout the urine. Mentation is decreased (mild to moderately obtunded), but he is responsive.

i. What are the primary goals when assessing, treating, and monitoring an animal with head trauma?

ii. What are the pros and cons of using CT in head trauma?

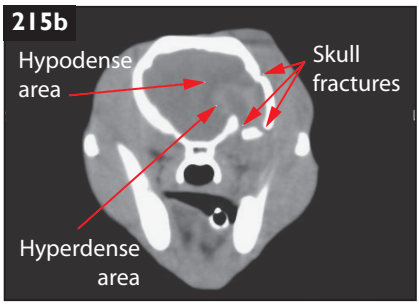
iii. What are the pros and cons of using MRI in head trauma?

iv. The CT scan from this dog is shown (**215a**). Describe the abnormalities.

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214 i. Primary coagulopathy (platelet disorder).
ii. Black tarry stool or melena, although the low BCS warrants further investigation.
iii. Platelet number and morphology should be examined by microscopy. The number of platelets per oil immersion field should be estimated along with platelet clumping at the periphery of the blood smear. As a general rule, one platelet per oil immersion field is equivalent to a count of 15×10^9 platelets/l.
iv. CBC to evaluate all cell lines; pathology review of a blood smear for parasites; agglutination and RBC morphology; reticulocyte count for RBC regeneration; serum biochemical profile; urinalysis (free catch) to evaluate for organ malfunction as a cause of disease or damage from internal hemorrhage; thoracic radiographs and abdominal ultrasound to evaluate for neoplastic lesions; PCR tick-borne panel profile looking for blood parasites (e.g. *Anaplasma*, *Bartonella*, *Babesia*, *Mycoplasma*, *Ehrlichia*, *Rickettsia*, *Neorickettsia*).
v. IV fluid therapy to replace fluid deficits and maintain fluid needs. If the platelet count is 50×10^9/l, a tentative diagnosis of immune-mediated thrombocytopenia (ITP) may be made and treatment initiated with immunosuppressive corticosteroids +/- azathioprine. Doxycyline is prescribed for possible tick-borne infections. Single treatment with human IV immunoglobulin G (IVIg) as well as vincristine has been found to increase platelet count, speed recovery time, and reduce duration of hospitalization in dogs with suspected ITP. Cyclosporine is another option for ITP.

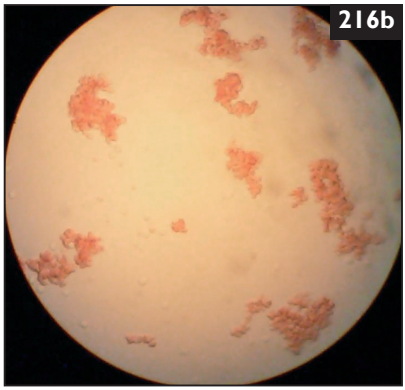
215 i. Oxygen to maintain PaO_2 at >60 mmHg (SpO_2 >90%). IV fluid infusion (isotonic crystalloids + HES boluses using small volume infusion technique) to maintain SABP >90 mmHg. $PaCO_2$ is maintained between 35 and 45 mmHg. Minimize any increase in ICP: elevate head and body on a 20 degree incline, suppress coughing and sneezing. Furosemide (0.75–2 mg/kg IV 30 minutes before mannitol) followed by mannitol (0.1–0.5 g/kg IV) if no intracranial hemorrhage. Monitor with the Rule of 20, keeping blood glucose between 4.4 and 6.6 mmol/l (80 and 120 mg/dl), stabilize other traumatic injuries, provide analgesia, treat seizures and hyperthermia, and ensure adequate nutrition.
ii. Pros: detects acute intracranial hemorrhage, edema, subdural or other hematomas, and/or fractures, directing treatment and potential surgical intervention; CT studies take less time than MRI. Cons: requires anesthesia and exposes animal to ionizing radiation (small risk); also significant cost and expertise.
iii. Pros: provides superior imaging and detail of soft tissue (brain and spinal cord and intranasal disease) than CT. Cons: requires a longer period of anesthesia, carries significant expense, and can be challenging to monitor patients; limited information on bony structures; significant cost and expertise.



iv. Fractures of the left side of the skull, and hyperdense material within the brain surrounded by hypodense area (**215b**) consistent with intraparenchymal hemorrhage and surrounding cerebral edema.

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216 A 5-year-old female neutered Lhasa-cross presents for inactivity and not eating for 2 days (**216a**). T = 37.7°C (99.8°F); HR = 160 bpm; RR = 48 bpm (tachypnea); CRT = 2 sec; MM white; perfusion poor; hydration normal. Thoracic auscultation finds normal lung fields. Initial database reported hemolytic serum and anemia (PCV = 0.12 l/l [12%]).

i. A microscopic view of a drop of blood placed on a slide and mixed with a drop of saline is shown (**216b**). What do you see?

ii. CBC shows spherocytosis and a regenerative response (reticulocytes = 90,000/μl). You initiate immunosuppression with corticosteroids and azathioprine and administer a pRBC transfusion. Describe a cross-match procedure. Can it be done in this case?

iii. Following transfusion, PCV = 0.22l/l (22%) and the patient is eupneic and has a normal HR. Discuss the pharmacologic effects of the following medications used for treating immune-mediated hemolytic anemia: prednisolone; azathioprine; cyclosporine; aspirin; clopidogrel.

iv. 24 hours post transfusion the patient is in significant respiratory distress with tachypnea and a synchronous breathing pattern with an inspiratory effort and expiratory grunt. Thoracic auscultation is normal; PCV = 0.19 l/l (19%). Mild increase in rectal temperature (39.7°C [103.5°F]). What is the most likely cause of the sudden onset of respiratory clinical signs?

v. What could have caused this?

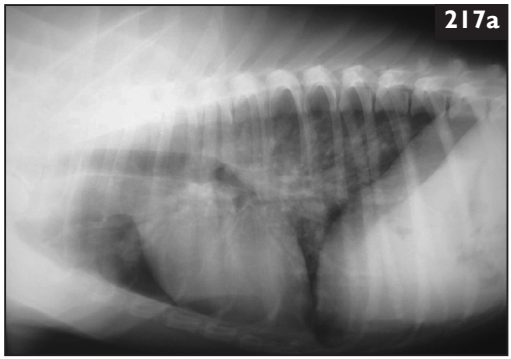
vi. What tests can be performed to look for evidence of this pulmonary complication?

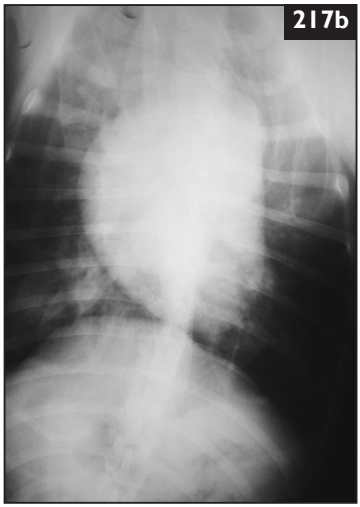
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Answer: 216

216 i. Auto-agglutination.
ii. A major cross-match involves looking for microscopic agglutination when donor RBCs are mixed with recipient plasma; a minor cross-match involves looking for microscopic agglutination when donor plasma is mixed with recipient RBCs. Because this patient is auto-agglutinating, the cross-match procedure may not be accurately interpreted.
iii. Prednisolone: high dose decreases circulating T lymphocytes and inhibits leukocyte migration, phagocytosis, and the complement cascade, resulting in immunosuppression and reduced red cell destruction; full effect may take several days. Azathioprine: thought to inhibit RNA and DNA synthesis and mitosis, reducing cellular immunity and red cell destruction; may take weeks for full effect to be recognized. Cyclosporine: reversible inhibition of T-helper and T-suppressor lymphocytes and reduce cellular and humoral immunity and red cell destruction. Aspirin: irreversible thromboxane inhibitor reducing platelet aggregation; might reduce risk of thromboembolic events. Clopidogrel: reversibly inhibits ADP receptor activity on the platelet and platelet aggregation, which may reduce thromboembolic events.
iv. Pulmonary thromboembolus.
v. Exposure to particulate matter from fragmented red cell membranes initiates the clotting cascade via factor VII activation. This hypercoagulable state predisposes the patient to thrombus formation, which can result in a pulmonary thromboembolism. In addition, particulate matter from the blood transfusion could also have been an initiating factor.
vi. Thoracic radiographs may show blunting and dilation of the pulmonary arteries and angiography might show the clot; an echocardiogram might show right-sided cardiac dilation suggestive of pulmonary artery outflow obstruction; contrast-enhanced pulmonary CT might identify an obstruction to blood flow.

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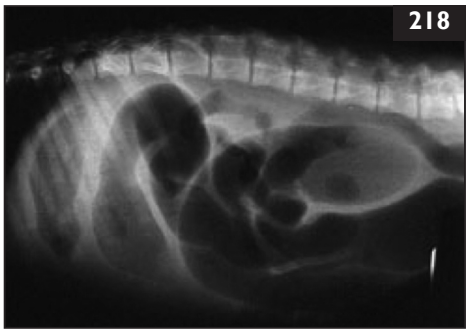
217 A 4-year-old female neutered Hound-cross rescued from Louisiana is presented for coughing and weakness. She has had a cough since the owners adopted her 3 weeks ago and was on antibiotics that did not help. T = 39.6°C (103.2°F); HR = 120 bpm: RR = 36 bpm; CRT = 1–2 sec; MM pink; perfusion adequate; hydration normal. Thoracic auscultation finds loud, harsh lung sounds bilaterally and a right-sided grade III/VI heart murmur. Review the radiographs (**217a, b**) and answer the following questions:

i. What are the radiographic abnormalities, and what is the likely radiographic diagnosis?

ii. Given the radiographic findings, what are your next diagnostic steps?

iii. How do you treat the most likely problem?

iv. What complications do you anticipate during treatment of this problem, and what treatment might be indicated?



218 This lateral abdominal radiograph (**218**) was obtained from a 9-year-old intact male Bull Mastiff presented for anorexia and weakness.

i. Please provide your radiographic impression and a differential diagnosis.

ii. What would be the diagnostic plan?

iii. What are the most life-threatening causes of these GI changes?

iv. What are immediate concerns for stabilization?

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217 i. Mild cardiomegaly (right ventricular), dilated and tortuous pulmonary veins, and a diffuse pulmonary interstitial pattern. Aortic knob on the ventrodorsal view.
ii. Given the dog's history and physical examination and radiographic findings, testing for heartworm disease is recommended.
iii. A complex treatment regimen for dogs is recommended by the American Heartworm Society. Day 1 start restricted activity, monthly heartworm prevention with a macrocytic lactone, and if microfilaria or signs of heartworm disease are present, pretreat with diphenhydramine and initiate prednisone (0.5 mg/kg PO q12h for week 1, q24h for week 2, and q48h for weeks 3 and 4). Doxycyline is also given (10 mg/kg PO for 4 weeks). Melarsomine (2.5 mg/kg deep IM) is effective for treatment of adult and immature heartworms and can be administered on days 60, 90, and 91; prednisone therapy and strict rest (for an additional 8 weeks) are reinstituted during this period of time. Surgical removal of heartworms is a high-risk procedure and usually limited to dogs with caval syndrome.
iv. Given the clinical signs and severe radiographic changes, the dog is likely at high risk for thromboembolic disease; allergic/anaphylactic type reactions can also occur. The dog's activity should be strictly limited to prevent cardiovascular and embolic complications; diphenhydramine and prednisone therapy initiated when indicated (see above). The use of aspirin in these dogs has not been shown to improve outcome. The 'three-dose' melarsomine protocol results in a 98% successful kill of adult worms.

218 i. There is severe generalized gas distension throughout the GI tract reflecting generalized ileus. Causes include: lower ileal obstruction, toxin ingestion, opioid administration, viral enteritis, electrolyte abnormality, and mesenteric torsion.
ii. The diagnostic plan should include: parvovirus test, electrolyte and blood gas panel, thorough history of toxin exposure, blood lead level, repeat radiographs to detect any movement of gas or relief of gas distension, ultrasound or CT evaluation.
iii. Mesenteric volvulus and lower intestinal obstruction can be immediately life-threatening, warranting emergency exploratory surgery after rapid stabilization and ruling out infectious and metabolic problems.
iv. This dog will likely have poor perfusion, hypotension, an active third-body fluid space and SIRS problems, including leaking capillaries, vasodilation, circulating cytokines, hypoalbuminemia, coagulopathy, and pain.

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219 A 5-year-old male neutered Boxer presents for a 'swollen neck' that occurred within the last 30 minutes prior to presentation. The dog does not want to walk and is lethargic. T = 38.3°C (101.0°F); P = 120 bpm; RR = 24 bpm. Abdominal palpation and thoracic auscultation are normal. The dog is reluctant to move his head when walking or when called. He looks around the room with his eyes only and appears reluctant to move his neck. His ears are pulled back (**219**) and he cries during palpation of the cervical region. Gait normal; however, the right forelimb is in flexion approximately half the time. Neurologic examination: mentation and CNs 2–12 appeared to be normal; significant neck pain and a root signature on the right; normal tone, strength, proprioception, and reflexes in all four limbs. Anal and tail movement and tone normal. Orthopedic examination reveals only neck pain.

i. List your differential diagnoses.
ii. What is your diagnostic plan?
iii. List general classes of analgesic drugs/modalities for severe neck pain and any advantages/disadvantages for each.
iv. What is a root signature, and what does it indicate?
v. Is surgery indicated at this time? Why or why not?

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Answer: 219

219 i. Intervertebral disc disease, inflammatory disease (meningitis), infectious meningitis or discospondylitis, Wobbler syndrome, trauma, muscular injury/spasm. Vascular disease (fibrocartilagenous emboli, thrombosis, expanding hematoma), neoplasia, and syringomyelia are considered but less likely since the dog has normal motor function in all four limbs.
ii. Cervical radiography under heavy sedation or anesthesia is often performed first. CBC, serum biochemistry, blood gas and electrolyte panel, coagulation panel, and creatinine kinase level are submitted since inflammatory, infectious, and neoplastic diseases are differentials. CT or MRI, with or without myelography, along with CSF analysis are options. Infectious disease testing (toxoplasmosis, *Neospora caninum*) is warranted if the condition fails to improve.
iii. See *Table*.

Class of drug	Advantage	Disadvantage
NSAID	Well tolerated, potent	Possible GI, renal, liver effects
Glucocorticosteroids	Potent anti-inflammatory	PU/PD, polyphagia, GI bleed, hyperpnea, immunosuppression
Tramadol (narcotic-like)	Well tolerated, inexpensive	Variable pain relief
Muscle relaxants	Skeletal muscle relaxation	Sedation, liver metabolism
Opioids	Potent pain relief, well tolerated in mild to moderate dosages	Sedation, dysphoria, ileus, urine retention, histamine
GABA analog	Good for neuropathic pain	Sedation, liquid has xylitol
Dopaminergic, anti-viral	Good adjunctive analgesic	Not good analgesia alone, CNS side-effects possible
Therapeutic laser/acupuncture	Well tolerated, few side-effects	Cost, potential ocular injury with laser

iv. The nerve roots leaving the spinal cord to the affected limb are inflamed or irritated. The problem is around the cord and meninges on the side and at the level of the cord innervating the affected limb.
v. Not indicated. Diagnostic information is not available and medical management has not yet been optimized. Neurologic findings support a caudal cervical lesion(s) with little or no motor deficit. Surgery is indicated when medical therapy fails to bring improvement or neurologic deficits progress (e.g. inability to walk, lack of deep pain).

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220 A 12-year-old male Cocker Spaniel presents for respiratory difficulty and a moist soft cough of 2 days' duration. The owner noted quick, shallow breaths. T = 37.9°C (100.2°F); HR = 160 bpm; RR = 60 bpm; CRT = 1.5 sec; MM pink; synchronous breathing pattern. Thoracic auscultation finds bilateral moist lung sounds (crackles) and a grade III/VI left-sided systolic murmur. Heart and pulse rates are synchronous. A lateral thoracic radiograph is obtained (**220**).

i. What are your radiographic findings?

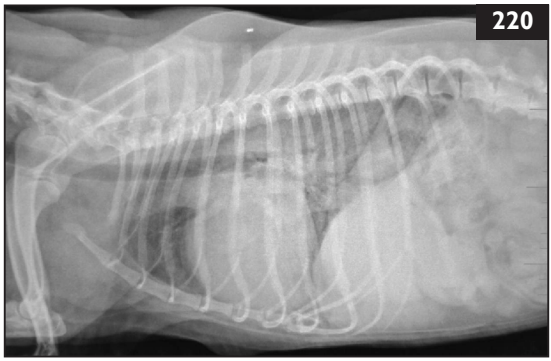
ii. What is your tentative diagnosis given the dog's age, breed, history, and physical examination findings?

iii. The ACVIM has made a consensus regarding the staging of congestive heart disease. What are the criteria for Stages A, B, C, and D? Which stage is most likely for this dog?

iv. What additional diagnostics would you recommend?

v. What is cardiac troponin I (cTnI), and might it be useful to measure blood levels?

vi. What are the ACVIM consensus recommendations for standard maintenance treatment for dogs with Stage C heart failure?



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Answer: 220

220 i. There are marked interstitial and alveolar lung infiltrates in the perihilar and caudodorsal lung fields. The pulmonary veins appear to be larger than the arteries. Cardiomegaly is evident.
ii. The primary differential is CHF secondary to either mitral valve disease or dilated cardiomyopathy. The Cocker Spaniel breed can have either or both as underlying pathology. Other differentials include pneumonia (bacterial, viral, or fungal), non-cardiogenic pulmonary edema (from seizures, asphyxiation, electrocution, or other neurologic diseases), or aspiration pneumonia.
iii. Stage A = high-risk dog without structural abnormality or murmur; B = structural abnormality but no clinical signs of CHF; C = structural abnormalities and previous or current clinical signs of heart failure; D = clinical signs of heart failure refractory to standard treatment. This dog is likely in Stage C.
iv. Include BP, ECG, 3-view thoracic radiographs, echocardiogram, CBC, and urinalysis.
v. Troponin I is a cardiac biomarker that is released when cardiac injury has occurred. Studies have shown that levels are higher in dogs with moderate to severe heart disease and low or undetectable in normal healthy dogs.
vi. Preload is decreased with furosemide and/or spironolactone, contractility is addressed with pimobendan or digoxin, and afterload is reduced with an ACEI or pimobendan. Other therapies may vary.

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221 A 5-year-old male neutered DSH cat presented after ingesting some yarn (**221a**). The owner tried to pull it out, but found it was stuck down the cat's throat. T = 38.3°C (101°F); HR = 180 bpm; RR = 25 bpm; CRT = 1–2 sec; MM pink, moist; pulses strong; perfusion normal; hydration normal. Abdominal palpation found bunched and corrugated (plicated) loops of small intestines.

i. Should the yarn coming from the mouth be cut prior to treatment?

ii. What is happening within the GI tract as a result of ingestion of the linear (yarn) FB (LFB)?

iii. What is the best method of removing the LFB? What complications are anticipated, and how are they managed?

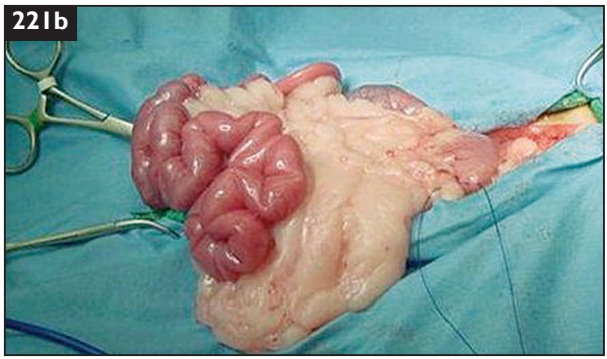
iv. What can be done immediately after definitive treatment to greatly reduce the risk of vomiting and promote the return of GI motility?



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Answer: 221

221 i. Having access to the oral end of the string may be of benefit during surgical retrieval. When the attachment is contributing to the pathology of the LFB, it is cut to move freely down the esophagus.
ii. The bowel gathers along the LFB, causing bunching or plication of intestines (**221b**). The linear object becomes taut, with peristalsis causing a 'sawing' action against the LFB. The intestinal mucosa is damaged and the bowel may be perforated in several locations, commonly along the mesenteric border.
iii. Surgery. Typically, incisions are made into the bowel at a relatively healthy looking section, starting at the oral end and moving aborally to release/remove the foreign object (i.e. stomach, then duodenum, then jejunum). If there is an anchored anterior end, this is released as soon as possible to allow easier removal. Multiple enterotomies may be required to avoid damage as the LFB is withdrawn from the plicated bowel. All segments of the bowel are carefully evaluated for perforation or ischemia. Management of complications ranges from debridement of perforation sites with closure to intestinal resection and anastomosis. Dehiscence can occur after GI surgery. Thorough abdominal lavage is performed prior to closure; closed abdominal drainage may be beneficial if peritonitis is anticipated.
iv. Placement of a nasogastric tube can allow continuous gastric decompression and early enteral feeding.



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