Veterinary Technician's Large Animal Daily Reference Guide

Amy D'Andrea
and
Jessica Sjogren

WILEY Blackwell

Table of Contents

Veterinary Technician's Large Animal Daily Reference Guide

Amy D'Andrea, BS, MEd, CVT, VTS (EVN)
New England Institute of Technology
Veterinary Technology Program
Warwick, RI

Jessica Sjogren, BS in Veterinary Technology, CEST
Emergency Technologist
VCA South Shore Animal Hospital
South Weymouth, MA

WILEY Blackwell

Editorial offices: 1606 Golden Aspen Drive, Suites 103 and 104, Ames, Iowa 50010, USA

The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

9600 Garsington Road, Oxford, OX4 2DQ, UK

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell.

instructions for each medicine, equipment, or device for, among other things, any changes in the instructions or indication of usage and for added warnings and precautions. Readers should consult with a specialist where appropriate. The fact that an organization or Website is referred to in this work as a citation and/or a potential source of further information does not mean that the author or the publisher endorses the information the organization or Website may provide or recommendations it may make. Further, readers should be aware that Internet Websites listed in this work may have changed or disappeared between when this work was written and when it is read. No warranty may be created or extended by any promotional statements for this work. Neither the publisher nor the author shall be liable for any damages arising herefrom.

Library of Congress Cataloging-in-Publication Data

Veterinary technician's large animal daily reference guide / [edited by] Amy D′Andrea, Jessica Sjogren.

p. ; cm.

Includes bibliographical references and index.

ISBN 978-0-8138-1621-0 (softback : alk. paper) – ISBN 978-1-118-69478-7 – ISBN 978-1-118-69484-8 – ISBN 978-1-118-69488-6 – ISBN 978-1-118-69499-2 (Pub) – ISBN 978-1-118-69502-9 (Mobi)

I. D′Andrea, Amy. II. Sjogren, Jessica.

[DNLM: 1. Veterinary Medicine–methods–Handbooks. 2. Animal Technicians–Handbooks. SF 748]

SF981

636.089–dc23

2013010434

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover images: © istock image; Left: Brzi; Center: LazingBee; and Right: R.J. Seymour.

Cover design by Nicole Teut

Contributors

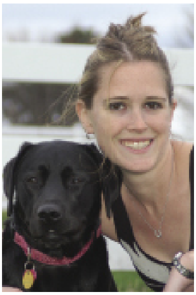
EDITORS

Amy D'Andrea, BS, MEd, CVT, VTS (EVN)

New England Institute of Technology

Veterinary Technology Program

Warwick, RI



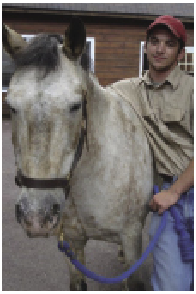
Jessica Sjogren, BS in Veterinary Technology, CEST

Emergency Technologist

VCA South Shore Animal Hospital

South Weymouth, MA

ILLUSTRATOR



Nathan Davis, BS, CVT

Zookeeper

Franklin Park Zoo

Boston, MA

CONTRIBUTING AUTHORS

Katie Brown, BS, CVT, ESMT

Equine Massage Therapist

Glennville, GA

Jamie Defazio, CVT, VTS-EVN

Evening and Midnight Nursing Supervisor

New Bolton Center's Widener Hospital: The Large Animal Hospital of University of Pennsylvania

Kennett Square, PA

Barbara Dugan, CVT

Adjunct Instructor, Technician

New Bolton Center's Widener Hospital: The Large Animal Hospital of University of Pennsylvania

Kennett Square, PA

Manor College Program of Veterinary Technology

Jenkintown, PA

Maria Ferrer, DVM, MS, DACT

Clinical Assistant Professor Theriogenology

Kansas State University College of Veterinary Medicine

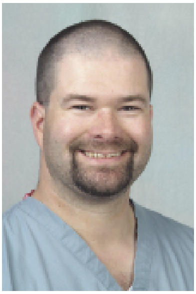
Manhattan, KS

Ryan Healy, BS

Manager

Scarlet Hill Farm

Groton, MA



Patrick Hennigan, BS, CVT, LVT

Anesthesia Technologist

Tufts University Cummings School of Veterinary Medicine

Grafton, MA

Sheri Miller, LVT, VTS-EVN

Radiology Technician

Rood and Riddle Equine Hospital

Lexington, KY

Ashley Moulton, BS in Veterinary Technology, CEST

Neurology Technologist

VCA South Shore Animal Hospital

South Weymouth, MA

Sarah Ouellette, BS, CVT

Surgery Technician

Bulger Veterinary Hospital

North Andover, MA

Preface

The *Veterinary Technician's Large Animal Daily Reference Guide* is a comprehensive resource designed for use in educational settings, as well as large animal veterinary facilities. This text provides veterinary technicians with detailed information about a wide variety of large animal species. As the veterinary technician profession becomes increasingly diversified, there is a greater need for a text that covers all aspects of veterinary medicine as it relates to large animal species. Practicing veterinary technicians, as well as veterinary technician students, will find this book useful. It is designed not only as a quick reference guide, but also as a detailed collection of information ranging from anatomy and preventative health care to pharmacology and internal medicine and everything in between.

This book was created from the desire to create a textbook that could provide a wide array of information about large animals in one place. Practicing veterinary technicians and students will find it useful, as it will serve as a quick reference guide in practice and also as an all-encompassing resource in the classroom.

The chart and table format of this book supplies the information in an easy-to-utilize manner. All of the information is organized in a way that is designed to enable the reader to look up topics effortlessly and quickly.

Several of the chapters reference many helpful illustrations, pictures, and diagrams that enrich the information in the text. Black-and-white, as well as color, artwork provide meaningful enhancement to the material.

We are proud to have collaborated with some of the industry's top professionals in authoring the material in each of the chapters. Each individual brings a wealth of knowledge and experience to this project, with the end result being this one-of-a-kind collection of large animal veterinary information.

Amy D'Andrea

Jessica Sjogren

Acknowledgments

This book has become a labor of love for both Jessica and me, and we want to thank each and every person who has dedicated their time to making it a reality. Teaching large animal nursing has been a passion of mine for over 15 years, and it is my hope that this text will become a trusted resource for many practicing veterinary technicians and veterinary technician students.

First and foremost, I am thankful for the support and perseverance of my friend and colleague, Jessica Sjogren, without whom this book would never have been possible. Next, we would like to offer our appreciation to the many individuals who authored chapters in this text. Their expertise and knowledge has truly made this project a superior collection of information.

The illustrations were created by Nathan Davis, who not only did an outstanding job, but also has given his time freely to make sure we portrayed the information in the diagrams as accurately as possible.

To all of my students who have given me the satisfaction of molding generations of veterinary technicians—I thank you. You have become the symbol of our profession. I learned just as much from you. This project is dedicated to you. May you always be the proud, caring animal advocates I knew you could be.

Finally, to my two amazing children, Austin and Morgan Butzier; my stepdaughter, Madison Borrelli; and the love of my life, my husband Greg D'Andrea—I thank you for your support and love. Family is what makes life worth living, and I live every day to the fullest because of each of you.

Amy D'Andrea

I want to thank my family, especially my parents, for believing in and encouraging me. I would like to thank Kevin for his love and support and my friends, especially Ashley, who has helped me through this process. I would not have been able to do this without them. Lastly, I want to thank all the authors for their knowledge, hard work, and devotion and thank Nate for his amazing drawings and enthusiasm. Amy, I would not be

where I am today without you. All of you made this possible, so thank you.

Jessica Sjogren

Chapter 1

Anatomy

Amy D'Andrea and Jessica Sjogren with illustrations by Nathan Davis

Introduction

In relation to large animal species, anatomy plays an integral role in how the body works. As technicians, we should be familiar with how the body is put together and the vital functions of each structure. There are nine basic animal systems that we study: the integumentary system, the musculoskeletal system, the cardiovascular system, the lymphatic system, the respiratory system, the digestive system, the nervous system, and the genitourinary system.

This chapter will give a basic overview of each system and the specific anatomical structures that are important to recognize in various large animal species (Table 1.1). In addition, this chapter includes a detailed description of equine conformation and its relation to structural abnormalities.

Table 1.1 / Systems Overviews

System Name	Anatomical Structures	Functions
Integumentary	• Epidermis • Dermis • Hypodermis or subcutaneous layer • Hair • Glands of the skin	• One of the largest and most extensive organ systems in the body • Composed of 4 tissue types • Covers and protects underlying structures within the body • A critical barrier to the harsh outer world

	• Claws/ dewclaws • Hooves • Horns	
Musculoskeletal	• Bone • Axial skeleton • Appendicular skeleton • Joints • Skeletal muscle • Cardiac muscle • Smooth muscle • Tendons	• The framework of the body that supports and protects soft tissues within the body • Provides movement and some body functions
Cardiovascular	• Heart • Blood • Arteries • Veins • Capillaries	• Regulates body functions and delivers oxygen, antibodies, inflammatory cells, and nutrients throughout the body • Removes waste from tissues • The heart pumps blood throughout the vessels to maintain body function.
Lymphatic	• Plasma • Red blood cells • Platelets • White blood cells • Lymphatic fluid • Immune components	• Transport system • Cellular metabolism • Assists in immune response • Aids in homeostasis
Respiratory	• Upper respiratory tract	• Responsible for the complex process of respiration and gas exchange within the body

	• Lower respiratory tract • Lungs • Thorax	• Brings oxygen into the body and carries carbon dioxide out
Digestive	• Oral cavity • Esophagus • Stomach (monogastric/ ruminant) • Small intestine • Cecum (horses) • Large intestine • Rectum and anus	• Breaks down complex foods, such as hay and concentrates, into nutrient molecules and absorbs the nutrients into the bloodstream for the body's use
Nervous	• Neurons • Central nervous system • Peripheral nervous system • Brain • Spinal cord	• A complex communication system that monitors the body's internal and external environments and directs the activities of the body
Genitourinary	• Kidneys • Ureters • Bladder • Urethra • Testes • Penis • Ovaries • Uterus • Cervix • Vagina • Vulva	• There are multiple, combined functions of this system that include filtering of waste products from the body and eliminating them in various ways, as well as reproduction.

Figure 1.1 Conformation of a normal side view.

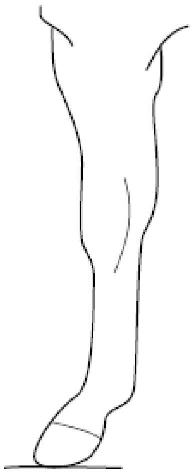


Figure 1.2 Conformation of a normal hind and front view.

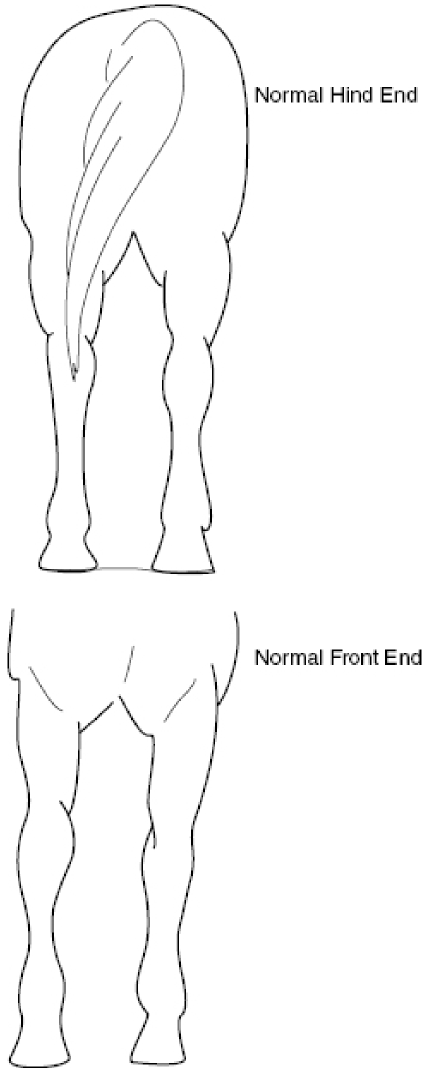


Figure 1.3 Conformation faults in the forelimb of the horse.

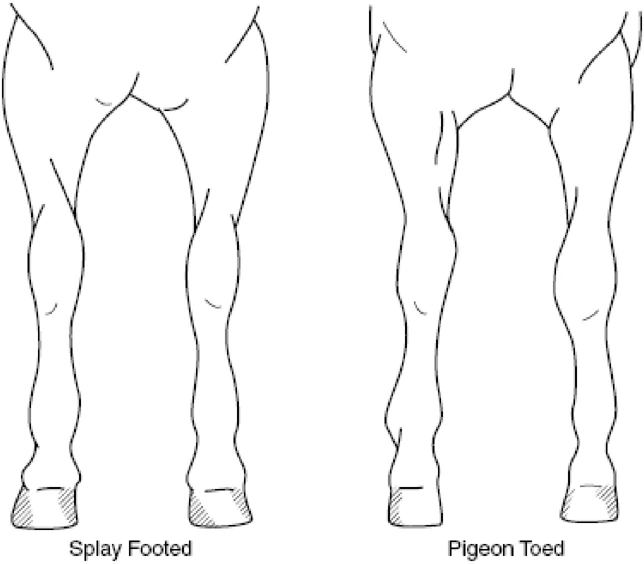


Figure 1.4 Conformation faults in the forelimb of the horse.

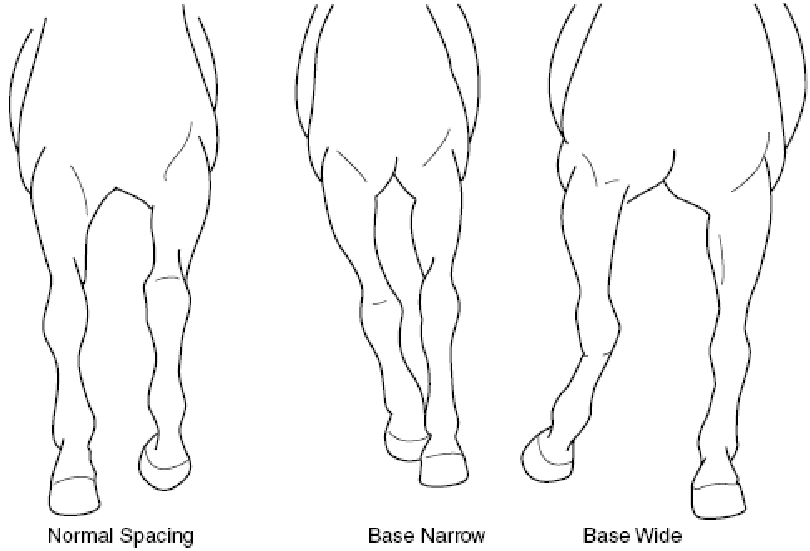


Figure 1.5 Conformation faults in the forelimb of a horse (frontal view).

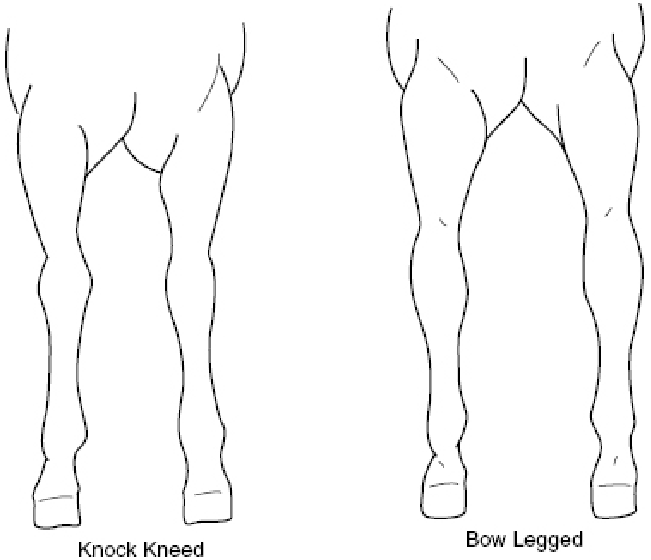


Figure 1.6 Conformation faults in the hind limb of the horse (side view).

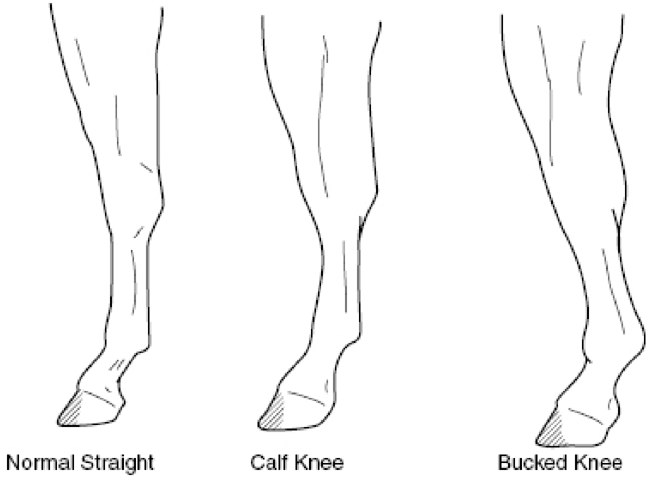


Figure 1.7 Conformation faults in the croup/hip of the horse (side view).

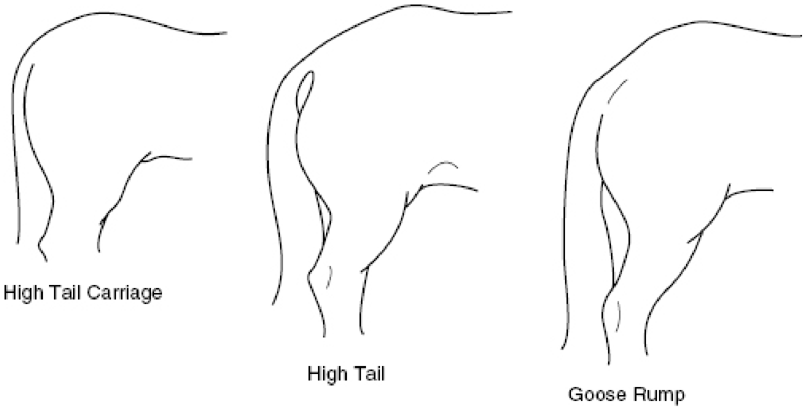


Figure 1.8 Conformation faults in the hind legs of a horse (back view).

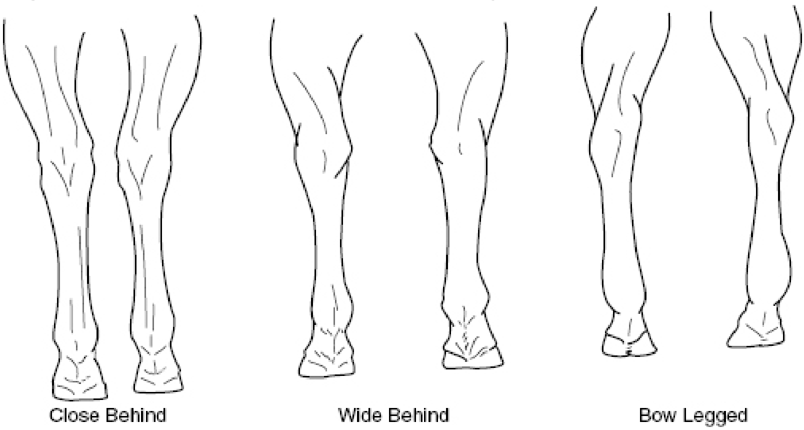


Figure 1.9 Conformation faults in the hind limbs of a horse (side view).

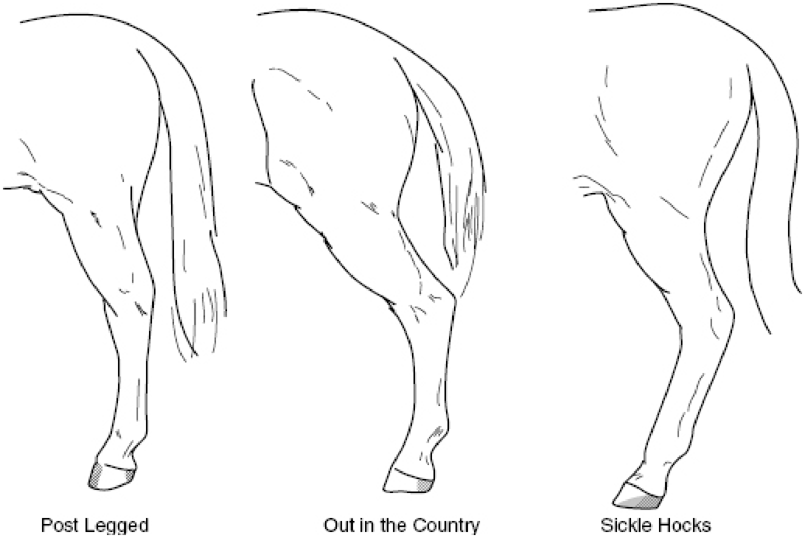
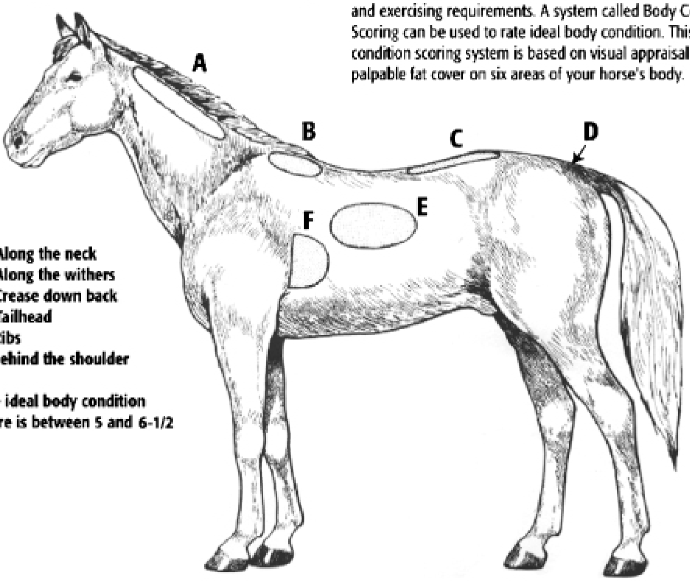


Figure 1.10 Body condition scoring of the horse. (Reprinted with permission from *AAEVT's Equine Manual for Veterinary Technicians*, published by Wiley Blackwell).

Body Condition Scoring

Many physiological functions in horses are influenced by body condition including horse's maintenance, reproductive and exercising requirements. A system called Body Condition Scoring can be used to rate ideal body condition. This condition scoring system is based on visual appraisal and palpable fat cover on six areas of your horse's body.



A. Along the neck
B. Along the withers
C. Crease down back
D. Tailhead
E. Ribs
F. Behind the shoulder

The ideal body condition score is between 5 and 6-1/2

Description of Individual Condition Scores (Score 1-9)

1. Poor: Animal extremely emaciated; spinous processes, ribs, tailhead, tuber coxae (hip joints), and ischia (lower pelvic bones) projecting prominently; bone structure of withers, shoulders and neck easily noticeable; no fatty tissue can be felt.

2. Very Thin: Animal emaciated; slight fat covering over base of spinous processes; transverse processes of lumbar vertebrae feel rounded; spinous processes, ribs, tailhead, tuber coxae (hip joints) and ischia (lower pelvic bones) prominent; withers, shoulders and neck structure faintly discernible.

3. Thin: Fat buildup about halfway on spinous processes; transverse processes cannot be felt; slight fat cover over ribs; spinous processes and ribs easily discernible; tailhead prominent, but individual vertebrae cannot be identified visually; tuber coxae (hip joints) appear rounded but easily discernible; tuber ischia (lower pelvic bones) not distinguishable; withers, shoulders and neck accentuated.

4. Moderately Thin: Slight ridge along back; faint outline of ribs discernible; tailhead prominence depends on conformation, fat can be felt around it; tuber coxae (hips joints) not discernible; withers, shoulders, and neck not obviously thin.

5. Moderate: Back is flat (no crease or ridge); ribs not visually distinguishable but easily felt; fat around tailhead beginning to feel spongy; withers appear rounded over spinous processes; shoulders and neck blend smoothly into body.

6. Moderately Fleshy: May have slight crease down back; fat over ribs spongy; fat around tailhead soft; fat beginning to be deposited along the side of withers, behind shoulders, and along sides of neck.

7. Fleshy: May have crease down back; individual ribs can be felt, but noticeable filling between ribs with fat; fat around tailhead soft; fat deposited along withers, behind shoulders, and along neck.

8. Fat: Crease down back; difficult to feel ribs; fat around tailhead very soft; area along withers filled with fat; area behind shoulder filled with fat; noticeable thickening of neck; fat deposited along inner thighs.

9. Extremely Fat: Obvious crease down back; patchy fat appearing over ribs; bulging fat around tailhead, along withers, behind shoulders, and along neck; fat along inner thighs may rub together; flank filled with fat.

Figure 1.11 Body condition scoring chart of cattle.

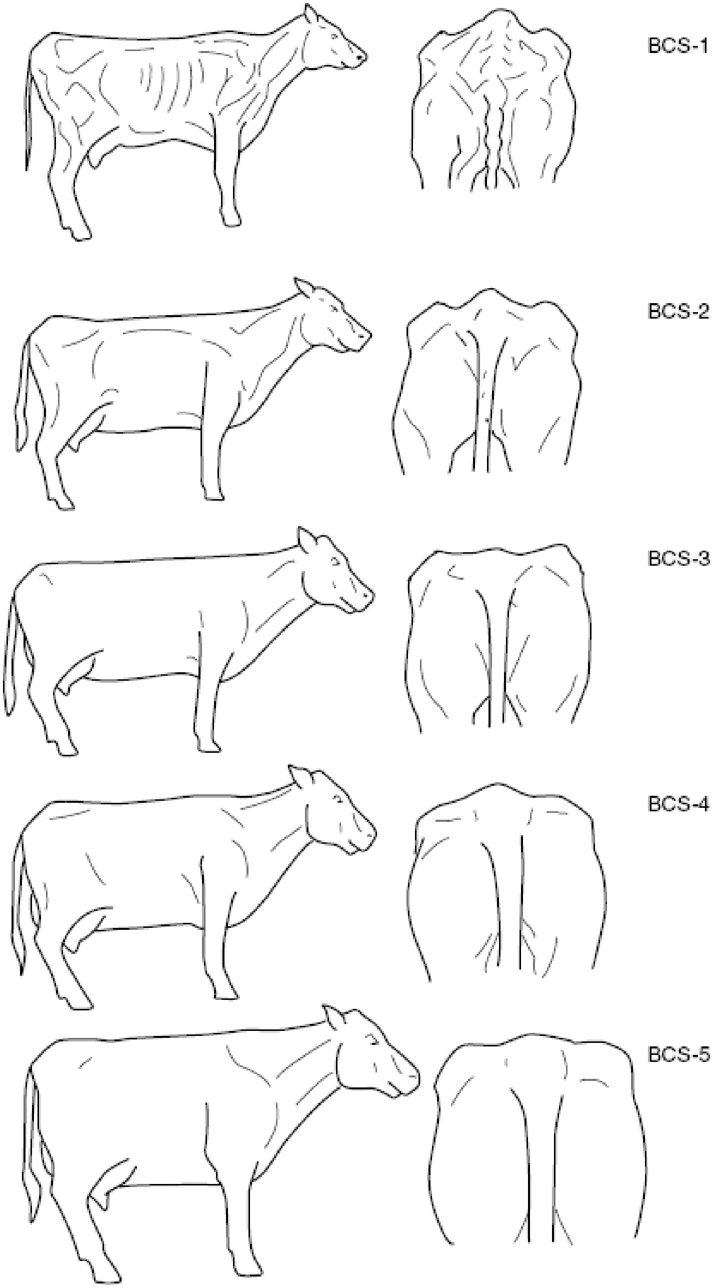

BCS-1
BCS-2
BCS-3
BCS-4
BCS-5

Figure 1.12 Lower limb bones of the horse.

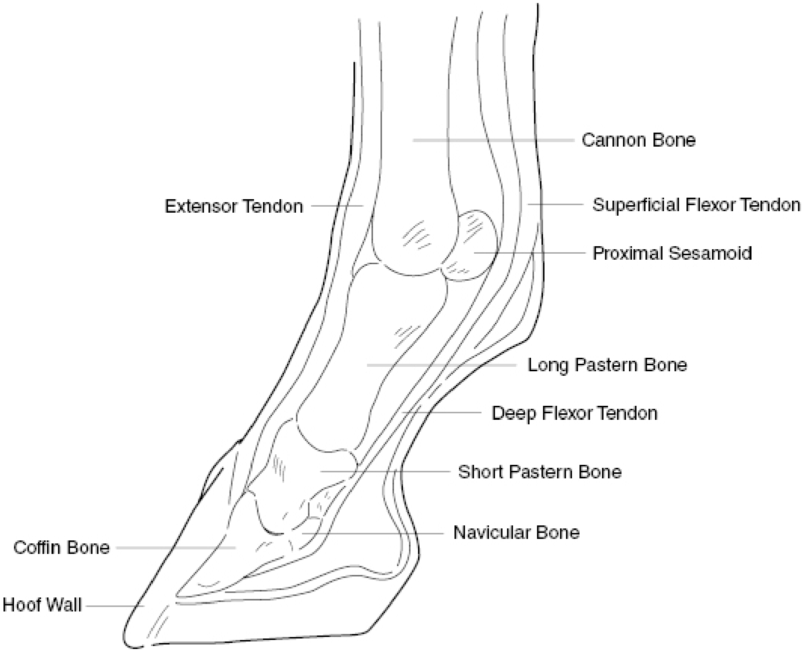


Figure 1.13 Diagram of the superficial muscles of the pig.

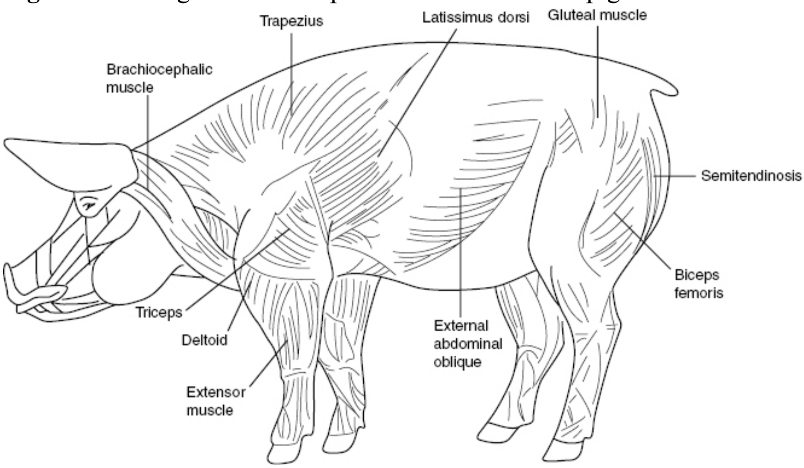


Figure 1.14 Equine skull.

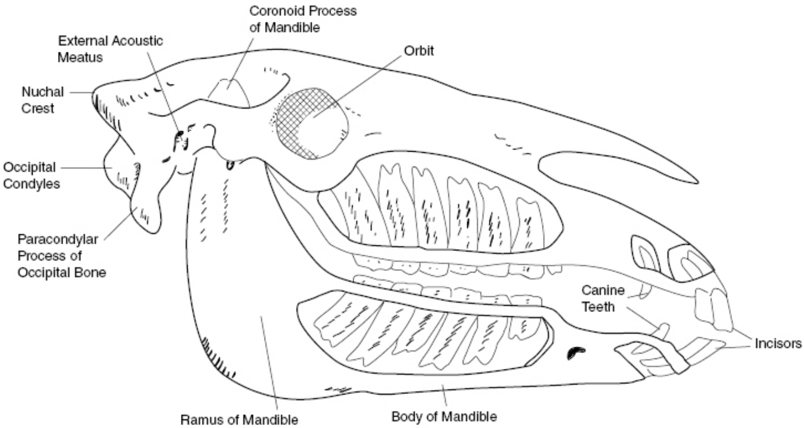


Figure 1.15 Equine spinal column.

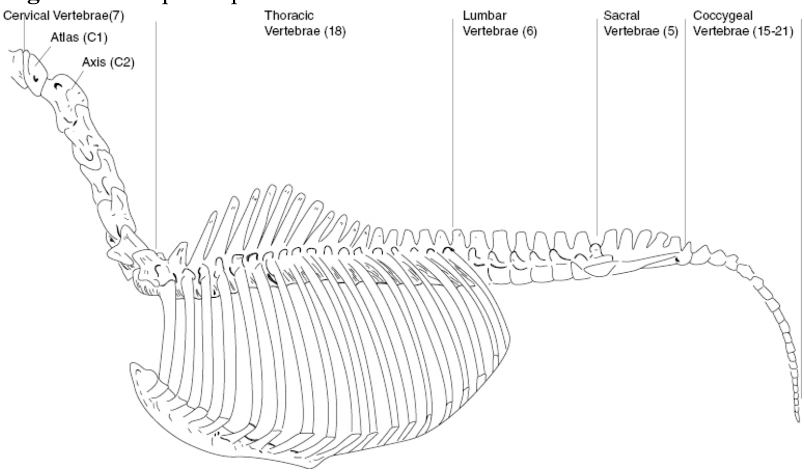


Figure 1.16 Diagram of the anatomy of the cow.

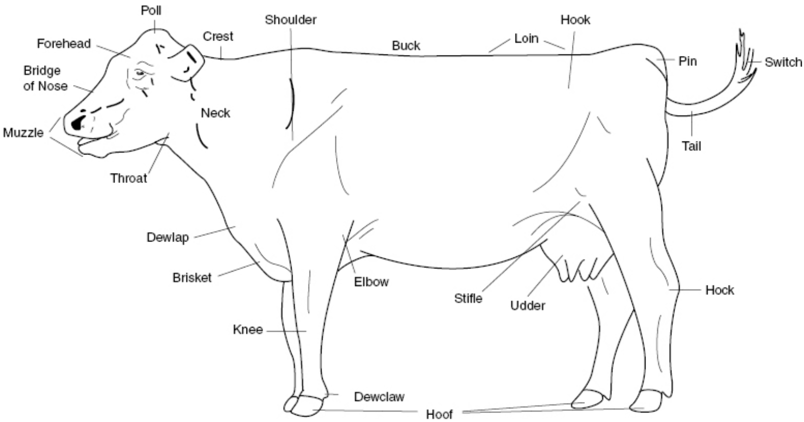


Figure 1.17 Diagram of the anatomy of the goat.

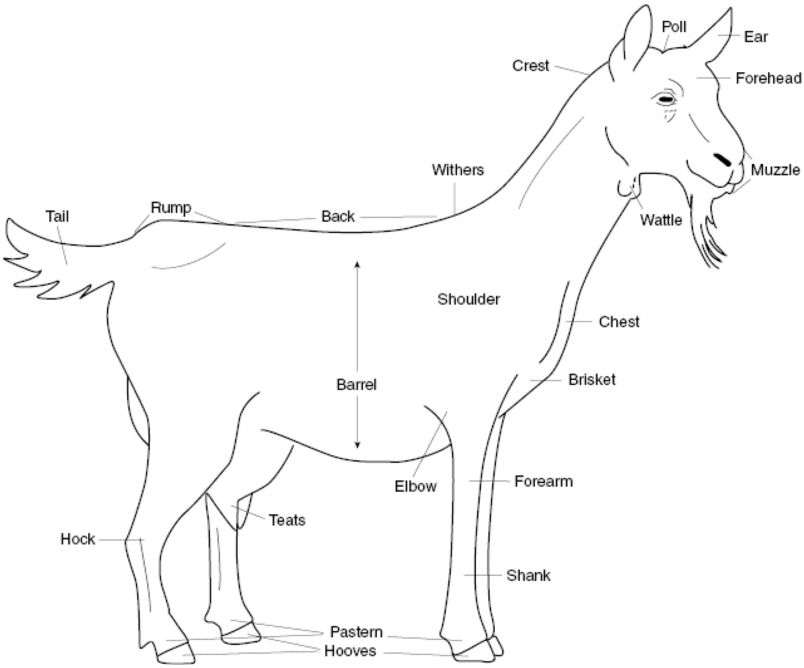


Figure 1.18 Diagram of the anatomy of the horse.

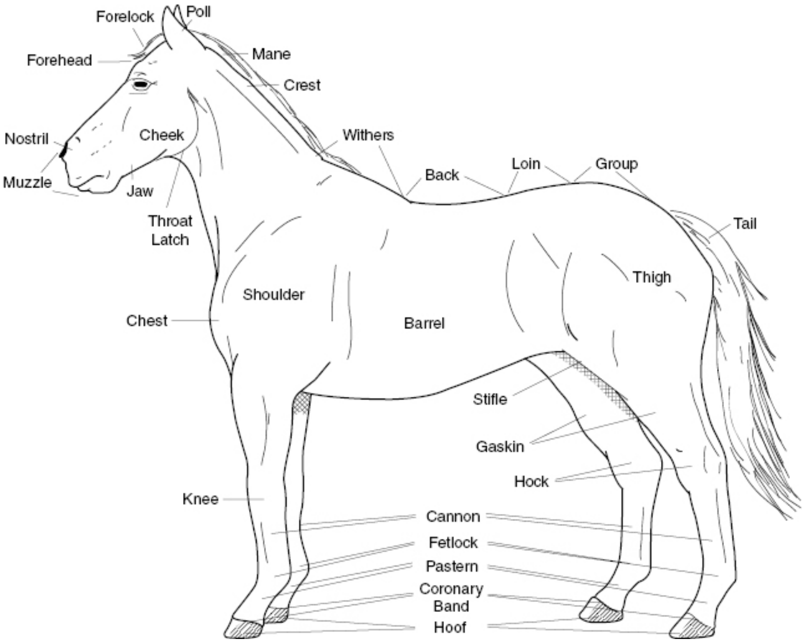


Figure 1.19 Diagram of the anatomy of the pig.

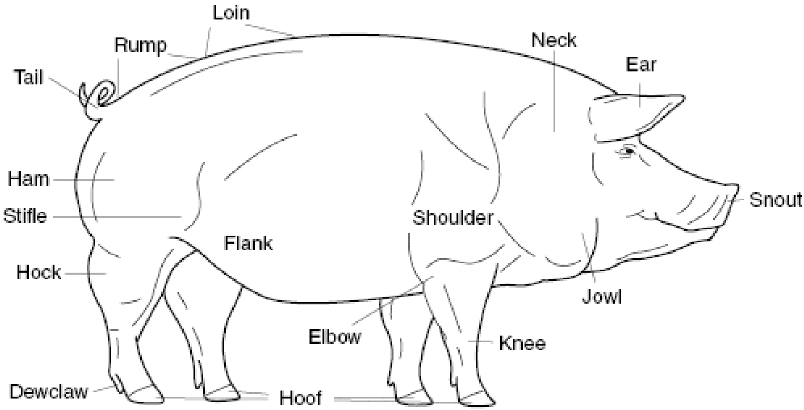


Figure 1.20 Lateral view of the respiratory tract of the horse.

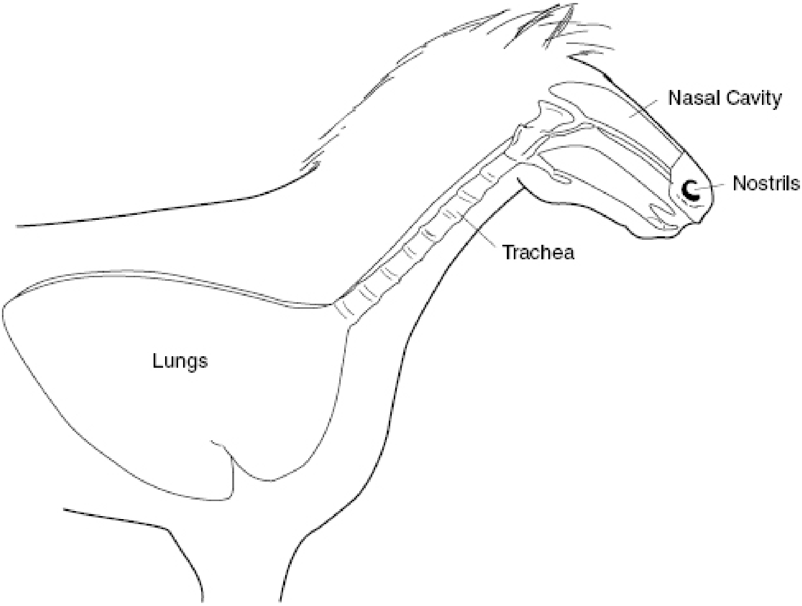


Figure 1.21 Equine muscles.

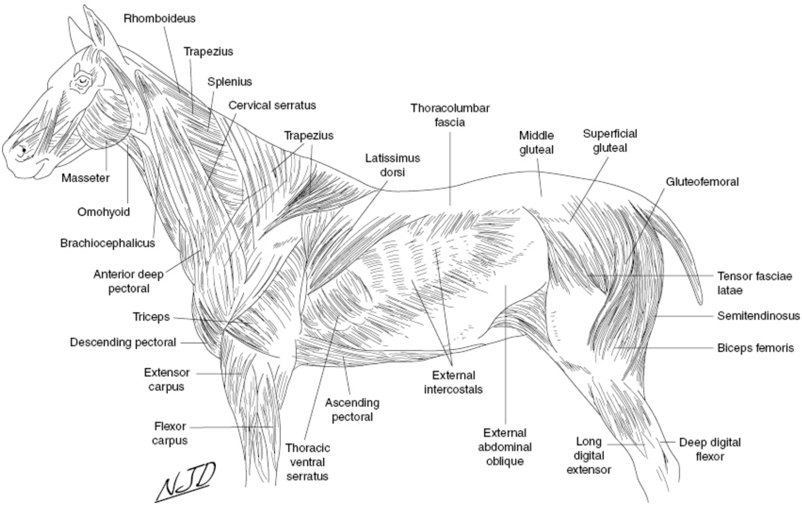
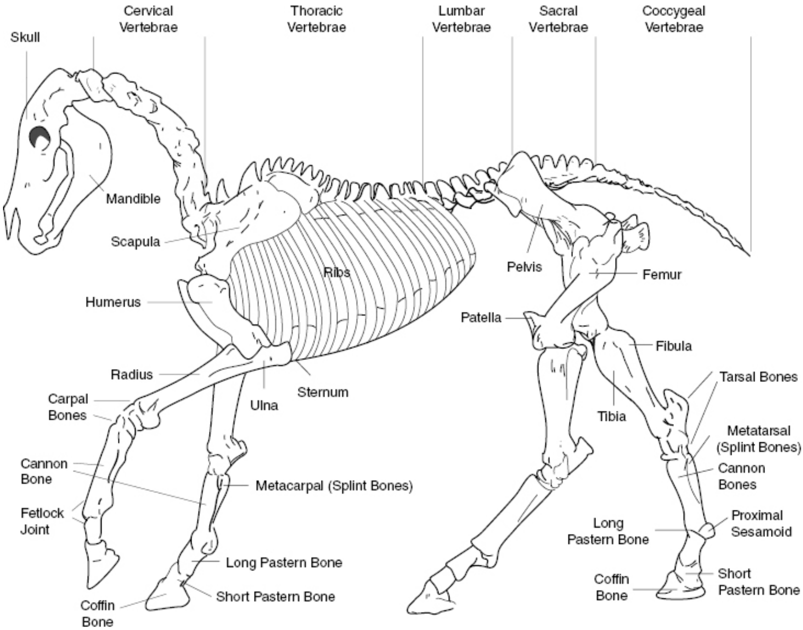


Figure 1.22 Equine skeleton.



Skull
Cervical Vertebrae
Thoracic Vertebrae
Lumbar Vertebrae
Sacral Vertebrae
Coccygeal Vertebrae
Mandible
Scapula
Ribs
Pelvis
Femur
Humerus
Patella
Fibula
Radius
Sternum
Ulna
Carpal Bones
Tarsal Bones
Tibia
Metatarsal (Splint Bones)
Cannon Bone
Cannon Bones
Metacarpal (Splint Bones)
Fetlock Joint
Long Pastern Bone
Proximal Sesamoid
Long Pastern Bone
Coffin Bone
Short Pastern Bone
Short Pastern Bone
Coffin Bone

Chapter 2

Preventative Health Care

Amy D'Andrea and Jessica Sjogren

Key Terms and Phrases	Abbreviations		
Acute	AD: Right ear	EEE: Eastern equine encephalitis	OU: Both eyes
Ailment	ADR: Are not doing right	EIA: Equine infectious anemia	PHF: Potomac horse fever
Alopecia	AS: Left ear	EKG: Electrocardiogram	R/O: Rule out
Ataxia	AU: Both ears	EPM: Equine protozoal meningitis	RV: Rabies vaccine
Auscultation	BAL: Bronchial alveolar lavage	EVA: Equine viral arteritis	SOAP: Subjective, objective, assessment, plan
Axillary	BAR: Bright, alert, and responsive	HR: Heart rate	Stat: Immediately
Chronic	BCS: Body condition score	Hx: History	T: Tetanus
Esophageal	BHV: Bovine herpesvirus	IBR: Infectious bovine rhinotracheitis	TPN: Total parenteral nutrition
Immunization	BRDC: Bovine respiratory disease complex	IM: Intramuscular	TPR: Temperature, pulse, and respiration
Infectious	BRT: *Brucella* milk ring test	IOP: Intraocular pressure	TV: Tidal volume
Mentation	BVD: Bovine viral diarrhea	IPV: Infectious pustular vulvovaginitis	Tx: Treatment
Palpation	CBC: Complete blood count	LA: Large animal	VEE: Venezuelan equine encephalitis
Parenteral	CEM: Contagious equine metritis	LOC: Level of consciousness	WEE: Western equine encephalitis
Percussion	CRT: Capillary refill time	MLV: Modified live vaccines	WNL: Within normal limits
Pulmonary	DA: Displaced abomasum	MM: Mucous membrane	WNV: West Nile virus
Signalment	DD or ddx: Differential diagnosis	N/A: Not applicable	Wt: Weight
	DDN: Dull, depressed, and nonresponsive	OD: Right eye	
	Dx: Diagnosis	OS: Left eye	

Introduction

Preventative health care consists of services that are designed to help prevent diseases and/or ailments in animals. It includes routine physical examinations, vaccinations, deworming programs, nutrition, and hoof/foot and dental care (in large animals). Each species has a recommended preventative health care program that is designed for its optimum health benefits and encourages an overall healthier life. This approach to veterinary care is proactive, and it is important to establish a preventative program at every stage of life.

Physical Examinations

The physical examination is by far the most cost effect diagnostic tool available in veterinary medicine. Much can be learned about the animal through a thorough examination. Technicians can play vital roles by assisting the veterinarian in this process. It is also important that technicians have the ability to assess an animal's overall health so that they can better help their clients with compliance in animal care. Large animal species should have a physical examination at least once per year. A proper exam should be done prior to purchasing an animal, prior to immunization, prior to any procedure involving anesthetics, and when the veterinarian is visiting the farm to see an animal with a problem. The following tables will cover methods and specific areas of the physical examination in both pediatric and adult patients.

Table 2.1 / Large Animal History

Type of Information	Information That Should Be Obtained
Person Providing Information	• Owner • Trainer • Farm employee
Insurance Information	• Company name • Policy information • Type of insurance

Patient Signalment	• Age • Sex • Breed • Color • Markings
Diet	• Feed schedule • Forage/hay • Grain • Supplements • Dietary changes
Water	• Sources and availability
Housing/ Type	• Environment • Turnout schedule • Geographic location • Shelter
Reproductive Status	• Castrated versus intact, maiden, pregnant (breeding date), parity, breeding male, breeding history, collection history, EVA (equine viral arteritis), contagious equine metritis (CEM), Trichomoniasis, brucellosis status.
Vaccination History	• What was administered and when?
Deworming History	• What was administered and when?
Previous Illness	• When illness occurred, its duration, its severity
Chief Complaint	• Onset (acute or chronic) • Severity • Previous occurrence
Herd Information	• Number of animals in herd • Identified animals that are affected • Any deaths due to occurrence

Table 2.2 / Preliminary Examination

	Definition/Normal/Abnormal	Equipment and Technique

Chief Complaint	• The current issue for which the owner is seeking veterinary care for their animal	• Thorough patient history • Appetite, water intake, urination, defecation, behavior, changes in temperament, any current medications
Past History	• Any previous health conditions, behavior changes, and/or physical changes that may worsen the current complaint	• Documentation • Immunization dates • Deworming dates and pharmaceuticals used • Hoof care • Floating dates • *Reproductive hx:* Number of offspring
Signalment	• Age • Breed • Sex • Reproductive status	• N/A
General Appearance	• Body condition score • Overall health status • Attitude • Obvious lameness • Wounds • Lesions	• Visual evaluation of the animal's condition, including the coat, integument, temperament • Evaluation of fat deposits in relation to skeletal features
Heart Rate	• This reflects cardiac function. Normal • *Equine:* 28–49 beats/min • *Bovine:* 48–84 beats/min • *Small ruminant:* 70–80 beats/min • *Swine:* 70–120 beats/min	• Direct palpation of pulse • Auscultation of the thoracic cavity • Electrocardiograph

Respiration	• This reflects proper oxygenation of the body's tissues and the ability to eliminate carbon dioxide from the blood. Normal resting rates • *Equine:* 10–14 breaths/min • *Bovine:* 26–50 breaths/min • *Small ruminant:* 16–34 breaths/min • *Swine:* 32–58 breaths/min	• Auscultation of the thoracic cavity • Pulmonary examination • Examination of the nares, nose • Auscultation of the trachea
Pulses	Normal (see Heart Rate above.) • Match rate and rhythm of the heart rate. • Digital artery, facial artery, coccygeal artery	• Direct palpation • Use index and middle finger over designated arteries to evaluate pulse quality, strength, rate, and symmetry.
Mucous Membranes	Normal • Pink	• Visual observation • Gingival, conjunctiva of the lower eyelid, membrane lining of the sheath or vulva
Capillary Refill Time	Normal • 1–2 seconds	• Direct palpation • Pressure applied to the mucous membranes until blanched and then timed for blood (pink color) to return

Temperature	Normal
	• *Equine:*
	  • *Mares:* 100°F
	  • *Stallions:* 99.7°F
	• Bovine:
	  • *Dairy:* 101°F
		• Rectal thermometer
		• Temperature probe (rectal or esophageal)

	• *Beef:* 101.5°F • *Small ruminant:* 102.3°F • *Swine:* 102.5°F	
Weight	• See body condition scoring system	• Recorded in kilograms and pounds • Weight tape based on species • Note the body condition score (BCS) and dietary history

Table 2.3 / Types of Physical Examinations

Type of Examination	Reason	Skills Utilized
Diagnostic Physical Exam	• Evaluation of medical and/or surgical problems	• TPR • Multisystem examination and/or system-specific evaluation
Insurance Examination	• Required by an insurance company (predominantly in horses) before an animal can be insured • Types of insurance and animal value determine extent of the examination.	• TPR • Ranges from basic to thorough multisystem exam
Prepurchase Examination	• At the request of a potential buyer • Performed in order to determine physical status of an animal for anticipated use and estimated value	• Depth of exam is determined by intended use by the buyer and estimated value of the animal. • Diagnostic physical exam and radiographs • *Blood samples:* This can be done with a needle and syringe or a Vacutainer®

		(Figures 2.1, Figure 2.2, Figure 2.3) • Electrocardiogram (EKG) • Endoscopy • Diagnostic imaging • Ultrasound • Reproductive soundness (mare or stallion)

Figure 2.1 Intravenous venipuncture (Vacutainer® system).

Figure 2.2 Intravenous venipuncture (Vacutainer®; waiting for blood tube to fill before removing).

Figure 2.3 Intravenous venipuncture (needle and syringe).

Table 2.4 / Physical Examination

System	Examination Findings	Equipment/Technique
Integument	• This includes skin/hair coat, hooves, and horns. • Alopecia, parasites, swellings, lesions, rashes, pigment changes, abscesses, infections, cracked hooves, thrush	• Visual inspection • Use strong lighting, Wood's lamp • Skin scraping, tape test, biopsy, culture

Cardiovascular	• This includes heart sounds and pulse integrity. • Rate and sound quality, murmurs, arrhythmias, pulse deficit	• Auscultation/ palpation • Stethoscope • Electrocardiogram • Ultrasound
Musculoskeletal	• Heat, swelling, lameness, range of motion	• Observation/ palpation • Nerve blocks, bone scan • Flexion test • Radiographs • MRI • Ultrasound
Respiratory	• Respiratory rate • Respiratory effort • Nasal discharge, lung sounds, tracheal airflow	• Visual inspection, rebreathing bag exam • Auscultation/ palpation • Stethoscope • Endoscopy • Bronchial alveolar lavage (BAL) or tidal volume (TV)
Ears	• Redness, skin issues, alopecia, parasites, cartilage. (Large animal species are able to move their ears to listen to their surroundings.)	• Visual inspection • Palpation • Ear swab
Eyes	• Redness, swelling, discharge, symmetry, lesions, wounds, reflexes, cloudiness, corneal abrasions, masses, pupil constriction	• Visual inspection • Palpation • Pupillary light response • Ophthalmoscope • Tear test • Fluorescein stain • Rose bengal stain • Tonopen

Lymphatics	Enlargement, firmness, heat, painful • *5 sets of lymph nodes:* Mandibular, prescapular, axillary, inguinal, and popliteal	• Visual inspection • Palpation
Gastrointestinal	• Gastrointestinal motility, abdominal sounds, colic, impaction, gastrointestinal disease	• Auscultation • Percussion • *Feces*: Quantity and consistency
Oral Cavity	• Soft palate integrity, abscessed teeth, retained deciduous teeth, wear patterns, quidding, appetite changes	• Visual inspection. (Sedation may be required for a good exam.) • Head lamp • Palpation
Urogenital	• Pain, discharge, swelling of genitals, lesions, masses, wounds, sheath cavity inspection, penile retraction, inspection of the testicles or vulva, estrous cycles, urination history	• Visual inspection and observation of urination • Ultrasound for a female or male • Palpation • Urinalysis
Neurologic	• Mentation, gait, behavior changes, ataxia, reflexes, postural reactions, sensation, coordination, head posture, weakness, muscle atrophy	• Visual inspection • Palpation • Percussion • Nerve blocks

Table 2.5 / Other Assessments

Assessment	Location	Evaluation
Mucous Membranes	• Gums (gingival), conjunctivae of the eyes, lining of nostrils, inner	• Color, capillary refill time, moisture

	portion of vulva (females)	
Hydration Status	• Skin, mucous membranes, feces	• Skin turgor • MM tackiness • CRT • Laboratory tests
Height	• Level ground at base of front hoof to the top of shoulder or withers	• Measurement with specifically designed height tape for specific large animal species
Weight	• Trunk or barrel behind elbow, in heart girth	• Measurement of circumference of the barrel or trunk of the animal in the heart girth. (Tapes are specific for each species.)

Vaccinations

Colostrum is the first secretion of a dam's mammary gland. It contains essential immunoglobulins for the neonate. Newborn large animals are born immunologically naive and must ingest and absorb the large macromolecules of IgG, IgM, and IgA within the first 18–24 hours to provide passive immunity. Failure of ingestion or absorption results in failure of passive transfer or an immunocompromised neonate. The neonate begins to make its own antibodies within the first few weeks. Vaccination is used to boost the immune system and assist in the prevention of or protection from contagious diseases.

The animal needs vaccinations to continue to improve its protection against contagious diseases. Vaccines are stored in the refrigerator and rolled before drawing up into a syringe. They should be given using an aseptic technique.

Guiding Principles for Vaccinating an Animal

- Physical examination is required before giving vaccines.
- Do not vaccinate pregnant animals with modified live vaccines. (Some modified live vaccines may be used if the initial vaccine was given prior to breeding.)
- Animals that are febrile or are in debilitated health should not be vaccinated.
- Allow the vaccine to come to room temperature before injecting.
- After drawing the vaccine up from the vial, change the needle.
- Distract the patient during injection.

Adverse Reactions from Vaccinations

Reactions that can occur after injecting a vaccine are sensitivity at the injection site, a small knot or bump, hives, fever, lethargy, abscess at the injection site, and anaphylactic shock.

Vaccine Categories

1. Live vaccines
- **a.** Changed version of the infecting agent that stimulates the immune system and does not require as many doses
  - **i.** Examples:
    - **(a)** Modified live vaccines (MLV)
    - **(b)** Recombinant vector vaccines

2. Killed vaccines
- **a.** Not able to replicate and need multiple doses to aid in protection. Adjuvants are usually included to stimulate immunity.

Table 2.6 / Equine Injection Sites

Areas for Injection	Intramuscular (IM) (Figure 2.4) or Intranasal • Lateral neck • Pectoral

	• Semimembranous • Semitendinous (**Note**: Gluteal muscles are often avoided because it is hard to drain a post-injection abscess.)
Frequency	*Broodmares:* 4–6 weeks before foaling (**Note**: This makes the concentration of antibodies the highest possible for the colostrum.) *Foal:* • Series of 3 vaccines • If the mare was not vaccinated, the series should begin at 3–4 months of age. • If the mare was vaccinated properly, the series should be started at 5–6 months of age.

Note: Sedation and medication can be administered intravenously for the fastest results (Figure 2.1, Figure 2.2, Figure 2.3, and Figure 2.5). (Do not give any medications or sedation unless directed by your veterinarian.)

Figure 2.4 Intramuscular medication administration.

Figure 2.5 Basic clinical technique (SQ medication administration).

Table 2.7 / Vaccines for Preventing Fatal Diseases in Horses

Disease	Tetanus (Lockjaw)	Encephalomyelitis	West Nile Virus (WNV)
Definition	Powerful neurotoxin that comes from an anaerobic, spore-forming bacterium (*Clostridium tetani*). Tetanus is found in the soil and caused by a contamination of a puncture wound/laceration in the foot.	• Viral disease which affects the central nervous system • Transmitted by mosquitoes and the reservoir is birds. • Most pathogenic viruses for horses are alphaviruses of the family *Togaviridea*. These species include Eastern, Western, and Venezuelan viruses. • Eastern *Encephalomyelitis (EEE):* Occurs east of the Mississippi River • Western *Encephalomyelitis (WEE):* Occurs west of the Mississippi River • Venezuelan Equine *Encephalomyelitis (VEE):* Occurs in South and Central America	Not as lethal as EEE, but the horse may require several days in intensive care
Presentation	Presenting Clinical Signs • Incubation period is 10–14 days • Walking, turning, and backing are difficult. • Erect ears • Tail is stiff and extended. • Front nares dilated • Third eyelid prolapsed • Localized stiffness in the masseter muscles and muscles in the neck and hind limbs ("sawhorse" stance) • Area of the wound may also be stiff. • Extension of the head and neck is caused by spasms of the neck and back muscles. • Sweating	Presenting Clinical Signs • Also known as "Sleeping Sickness" because the initial signs are lethargy, depression, inappetence, and fever • Altered mentation • Impaired vision • Aimless wandering • Head pressing • Circling • Unable to swallow • Irregular ataxic gait • Paresis • Paralysis • Convulsions	Presenting Clinical Signs • Neurologic abnormalities • Colic • Lameness • Anorexia • Fever • Feed refusal • Depression
	Examination Findings • Reflexes are increased, and the animal is excited easily making the spasm more violent. • Increased heart rate, rapid breathing, congestion of mucous membranes • Temperature slightly above normal—can rise to 108–110°F at the end of the disease	Examination Findings • Virus travels by way of the lymphatics to lymph nodes and replicates in macrophages and neutrophils causing lymphopenia, leukopenia, or viremia. • Lesions may be seen in cortical and thalamic areas, as well as brain-stem deficits • Neurologic signs	Examination Findings • Low-grade fever • Neurologic signs • Cataplexy or narcolepsy • Fine and coarse tremors of the face and neck muscles • Peripheral lymphopenia • Hyponatremia • Azotemic

Disease	Tetanus (Lockjaw)	Encephalomyelitis	West Nile Virus (WNV)
Diagnosis	Laboratory • Occurrence of tetanus toxin in serum • If a wound is evident, bacterium in gram-stained smear • Anaerobic culture Imaging • N/A Procedures • N/A	Laboratory • Virus isolation and identification or detecting a specific increase in antibody titer • Hemagglutination inhibition, complement fixation, virus neutralization and ELISA or IgM • Corpse's brain should be examined for the presence of nonsuppurative meningoencephalitis. • Differential diagnoses include rabies, hepatoencephalopathy, leukoencephalomalacia, protozoal encephalomyelitis, equine herpesvirus 1, veriminous, meningoencephalomyelitis, cranial trauma, botulism, meningitis Imaging • N/A Procedures • N/A	Laboratory • IgM rises sharply and falls during the first 6–8 wk after exposure. • Neutralizing antibody titers (primarily IgG) develop slowly during this time and stay elevated for several months. Imaging • N/A Procedures • N/A
Treatment	Medication • Curariform agents • Tranquilizers or barbiturate sedative in combination with 300,000 UI tetanus antitoxin twice a day • Using chlorpromazine and phenobarbital may lower hyperesthetic reactions and convulsions. Nursing Care/Patient Care • Very important during the acute period of spasms • Place in a quiet, darkened stall • Feed and water should be high enough so animal does not have to lower the head. • Sling may be useful if having difficulty standing or rising.	Medication • Antiinflammatories • Anticonvulsants, if needed Nursing Care/Patient Care • Fluids • Keep comfortable	Medication • Flunixin meglumine—NSAID • Use of dexamethasone and mannitol for horses that are recumbent • Detomidine—prolonged tranquilization • Low dosages of acepromazine—relief from anxiety in both recumbent and standing horses • Phenobarbital • Antioxidants, such as vitamin E • Broad-spectrum antibiotics should be given for treatment of wounds, cellulitis, and pneumonia. Nursing Care/Patient Care • Fluids • Nutritional support • Slings are used to strength and decrease pulmonary and traumatic sequelae.

Disease	Tetanus (Lockjaw)	Encephalomyelitis	West Nile Virus (WNV)
Follow-Up	Prevention/Avoidance • *Vaccination: Mares:* 4–6 weeks before foaling • *Foals:* If the mare was vaccinated: Series of 3 starting at 4–6 months of age in 4–6 week interval between the first and second doses. Third dose is given at 10–12 months of age. If mare was unvaccinated: Start at 1–4 months of age with 4-week intervals between doses. • Booster yearly • Surgical procedures should be as sterile as possible • After surgery, turned out on clean ground, grass pastures • Iodine or chlorine reliably kill the spores. Complications • N/A Prognosis • Good but death can occur	Prevention/Avoidance • Must be done before springtime; in areas that are warm year-round, some veterinarians choose to do twice a year • *Adult horses, previously unvaccinated against EEE/WEE or of unknown vaccination history:* Give a primary series of 2 doses within a 4–6 week interval between doses. Revaccinate before the onset of the next vector season and yearly thereafter. • *Pregnant mares vaccinated beforehand:* Vaccinate 4–6 weeks before foaling. • *Pregnant mares, unvaccinated or having unknown vaccination history:* Immediately begin a 2-dose primary series with a 4-week interval between doses. Booster at 4–6 weeks before foaling or before the onset of the next vector season—whichever occurs first. • *Foals of mares vaccinated against EEE/WEE in the pre-partum period:* A primary 3-dose series beginning at 4–6 months of age. A second vaccine is given 4–6 weeks after the first. The third dose should be administered at 10–12 months of age, prior to the onset of the next mosquito season. • *Foals of unvaccinated mares or having unknown vaccination history:* Give a primary 3-dose series beginning at 3–4 months of age. A 4-week interval between the first and second doses is recommended. The third dose should be administered at 10–12 months of age, before the onset of the next mosquito season. • Because of earlier seasonal disease risk in the southeastern US, vaccination may be started at 2–3 months of age. When starting vaccinations in younger foals, a series of 4 primary doses should be administered.	Prevention/Avoidance *Three licensed vaccines are currently available:* 1 *Inactivated whole virus vaccine with an adjuvant:* Label says initial series of 2 intramuscular injections administered 3–6 weeks apart, then given 12 months later. 2 *Recombinant vector vaccine with protective antigens expressed in a Canary Pox vector that does not replicate in the horse:* Contains an adjuvant. Label says first series of 2 intramuscular injections administered 3–6 weeks apart, then given again 12 months later. The product is labeled as an aid in protection against WNV viremia. 3 *Modified live chimera vaccine having the protective proteins of WNV expressed in a flavivirus vector*: This vaccine does not contain an adjuvant. Label instructions are for a single injection followed by a yearly booster. • *Adult horses previously vaccinated:* Annually in the spring, before the onset of the mosquito season • *Adult horses previously unvaccinated or having unknown vaccinal history:* Administered in the same way as initial vaccination of foals • *Inactivated whole virus vaccine:* A first series of 2 doses is administered to naive horses, with a 4–6 week interval between doses. The label recommends an annual booster. • *Recombinant Canary Pox vector vaccine:* A first series of 2 doses is administered to naive horses with a 4–6 week interval between doses. The label recommends an annual booster. • *Modified live flavivirus chimera vaccine:* Primary immunization is by a single dose administered to horses that are 5 months of age and older. The label recommends an annual booster. • *Pregnant mare previously vaccinated:* 4–6 weeks before foaling • *Pregnant mares previously unvaccinated*: Start a primary vaccination series immediately. (See Adult horses previously unvaccinated.)

Disease	Tetanus (Lockjaw)	Encephalomyelitis	West Nile Virus (WNV)
		• *Horses having been naturally infected and recovered:* These likely develop lifelong immunity. (Consider revaccination only if the immune status of the animal changes the risk for susceptibility to infection. Examples of these conditions would include the long-term use of corticosteroids and pituitary adenoma.) • Applying an insect repellent that contains pyrethrin on the horse daily during mosquito season, particularly at times when mosquitoes may be most active • Fans that blow over stalls can lower mosquito feeding. • Environmental management is crucial and includes keeping the barn area, paddocks, and pastures cleared of weeds and organic material, such as feces, that might harbor adult mosquitoes. • Clean water tanks and buckets at least weekly to reduce mosquito breeding areas. • Remove anything that may hold stagnant water. Complications • N/A Prognosis • Asymptomatic infections may occur. • Mortality of horses showing clinical signs from WEE is 20–50%, EEE 50–90%, VEE 50–75%.	• *Foals of vaccinated mares:* • *Inactivated vaccine:* Give a primary 3-dose series starting at 4–6 months of age. A 4–6 week interval after the first vaccine is recommended. • *Recombinant Canary Pox vector vaccine:* No data are available for the vaccination of foals. • *Modified live flavivirus chimera vaccine:* Administered in the same way as initial vaccination of foals • *Foals of unvaccinated mares:* The first series of vaccinations should be started at 3–4 months of age and, if possible, completed before the start of the high-risk mosquito season. • *Inactivated vaccine:* Give a primary series of 3 doses with a 30-day interval after the first dose and 60 days between the second and third doses. If the primary series is initiated during the mosquito season, a break of 3–4 weeks between the second and third doses is preferable to the above described interval of 8 weeks. *Recombinant Canary Pox vaccine:* First dose is started at 5–6 months. A second dose is given at a 3–4 week interval after the first dose. • *Modified live flavivirus chimera vaccine:* Not to be given to foals younger than 5 months of age • *Horses having been naturally infected and recovered:* Likely develop life-long immunity. Consider revaccination only if the immune status of the animal changes the risk for susceptibility to infection. Examples would include the long-term use of corticosteroids and pituitary adenoma. • Apply an insect repellent that contains pyrethrin on the horse daily during mosquito season, particularly at times when mosquitoes may be most active. • Fans that blow over stalls can lower mosquito feeding. • Environmental management is crucial and includes keeping the barn area, paddocks, and pastures cleared of weeds and organic material (such as feces) that might harbor adult mosquitoes. • Clean water tanks and buckets at least weekly to reduce mosquito breeding areas. • Remove anything that may hold stagnant water. Complications • N/A Prognosis • 32–35% mortality rate

Disease	Tetanus (Lockjaw)	Encephalomyelitis	West Nile Virus (WNV)
Notes	• Rare but fatal risk of Thieler's disease following the use of tetanus antitoxin needs to be considered.	• Humans can contract EEE from infected mosquitoes but can not contract it from horses. • Clinical signs in people vary from mild flu-like symptoms to death. Children, elderly, and immunosuppressed are most susceptible. • Horses that are infected with sylvatic subtypes of VEE are also dead-end hosts, but horses that are infected with epizootic strains of VEE have a constant and significant viremia that results in virus shedding in body fluids. Infection may be passed from horse to horse by aerosolization. Horses may become systemically ill and may die with or without neurologic signs	• Humans can contract WNV by mosquito, and elderly are most likely to contract the disease. Asymptomatic infection is the most common. • Clinical signs in people are fever, headache, and malaise.

Table 2.8 / Vaccines to Minimize Illnesses in Horses

Disease	Influenza	Herpesvirus (Rhinopneumonitis)	Strangles (*Streptococcus equi equi*)
Definition	Highly contagious illness that spreads quickly among susceptible horses by aerosolization of virus during coughing	DNA virus that occurs in horses worldwide. There are two common strains of herpes: • EHV-1 causes abortion, respiratory disease, and neurologic disease. • EHV-4 causes respiratory disease only but can occasionally cause abortion.	Infectious, contagious disease of Equidae characterized by abscessation of the lymphoid tissue of the upper respiratory tract
Presentation	Presenting Clinical Signs • Incubation is 1–3 days • Submandibular lymphadenopathy • Nasal discharge • *Coughing:* Dry, harsh, and nonproductive • Anorexia • Depression	Presenting Clinical Signs • *Respiratory disease:* Fever, coughing, nasal discharge • *Neonatal foals:* Infected in utero are usually abnormal from birth. Weakness, respiratory distress, CNS signs, and death usually occur within 3 days. • *Older foals:* Nasal discharge is the most common sign of illness.	Presenting Clinical Signs • Mucoid to mucopurulent nasal discharge • Depression • Difficulty swallowing • Inspiratory respiratory noise • Extended head and neck

	Examination Findings
	• Fever (103–106°F)
	• Submandibular lymphadenopathy
		Examination Findings
		• *Fever:* Commonly seen with other clinical signs, but may be the only clinical sign and may go undetected
		• Jaundice in foals exposed in utero
		• Stridor in foals exposed in utero
		• *Abortion:* No warning signs of approaching abortion, usually occurs late pregnancy (8+ months), but occasionally as early as 4 months
		• *Neurologic disease:*
		  • Incoordination of the hind limbs
		  • Urine retention/dribbling
		  • Bladder atony
		  • Recumbency
		• Neurologic signs may be followed by fever and respiratory signs
			Examination Findings
			• The incubation time of strangles is 3–14 days, and the first sign of infection is fever of 103–106°F.
			• Submandibular lymphadenopathy
			• Older animals with residual immunity may develop an atypical or catarrhal form of the disease with mucoid nasal discharge, cough, and mild fever.
			• Metastatic strangles ("bastard strangles") is characterized by abscessation in other lymph nodes of the body, mainly the lymph nodes in the abdomen and, infrequently, the thorax.

Diagnosis	Laboratory • Influenza A antigen detection • Paired serology (hemagglutination inhibition) • Nasopharyngeal swabs are used for virus isolation and antigen detection. • Must get these tests as soon as possible Imaging • N/A Procedures • N/A	Laboratory • Virus isolation • PCR • Serology Imaging • N/A Procedures • Cannot be diagnosed by clinical findings	Laboratory • Bacterial culture of exudate from abscesses or nasal swab • Complete blood count (CBC) will show neutrophilic leukocytosis and hyperfibrinogenemia • Serum biochemical analysis is usually unremarkable. Imaging • Ultrasound of the retropharyngeal area • Radiographic examination of the skull to see the location and extent of retropharyngeal abscesses Procedures • Complicated cases may need endoscopic examination of the upper respiratory tract (including the guttural pouches).
Treatment	Medication • NSAIDs are recommended for fever of >104°F. • Antibiotics are used when the fever goes beyond 3–4 days or when purulent nasal discharge or pneumonia is present. Nursing Care/Patient Care • Rest • Fluids • Supportive care	Medication • Antibiotics are used when secondary bacterial infection is suspected, as evidenced by purulent nasal discharge or pulmonary disease. Nursing Care/Patient Care • Rest • Supportive care	Medication • NSAIDs for pain and fever • Antimicrobial therapy is controversial. • Antibiotic therapy is used when there are dyspnea, dysphagia, prolonged high fever, and severe lethargy/anorexia. • Giving penicillin during the early stage of infection (≤ 24 hr of onset of fever) will usually stop the abscess formation. Nursing Care/Patient Care • Environment should be warm, dry, and dust free. • Warm compresses are applied to sites of lymphadenopathy. • Drainage of mature abscesses will quicken recovery. • Ruptured abscesses should be flushed with dilute (3–5%) povidone-iodine solution for several days until discharge stops.
Follow-Up	Prevention/Avoidance • 3 types of vaccines • *Inactivated vaccines:* The First series is 2 doses. A 3-dose priming regimen is recommended. A 3-dose schedule is essential for at least one of the most effective inactivated vaccines. These are used for pre-foaling boosters to increase colostral antibody levels against influenza virus. • *Modified-live cold-adapted equine influenza/A2 vaccine:* Administered intranasally. The vaccine has been proven to be very safe, and a single dose is protective for 12 months. The product is licensed for vaccination of nonpregnant animals over 11 months-of-age, followed by boosters at 6-month intervals.	Prevention/Avoidance • An inactivated vaccine is the only vaccine currently recommended by the manufacturer as an aid in prevention of EHV-1 abortion. Vaccine should be given during months 3, 5, 7, and 9 of pregnancy. Killed or live vaccines can be used. Vaccination should begin when foals are 3–4 months old and, depending on the vaccine used, a second dose given 4–8 weeks later. Booster every 3–6 months through maturity. Vaccination against EHV-1 should include all horses on the premises. • Isolation of new horses for 3–4 weeks	Prevention/Avoidance • *Killed vaccines:* Killed vaccines are helpful for prevention of strangles. Vaccination with these vaccines should not be expected to prevent disease, but appropriate pre-exposure vaccination with these vaccines have been shown to ease the severity of clinical signs in affected horses if the disease occurs and has been shown to reduce the incidence of disease by as much as 50% during outbreaks of purpura. Hemorrhagica can be a side effect of the killed vaccine or of the disease in general. • *Modified live vaccine, intranasal:* The vaccine organisms must be able to reach the site with adequate numbers to allow protection. Accurate vaccine delivery is important.

Disease	Influenza	Herpesvirus (Rhinopneumonitis)	Strangles (*Streptococcus equi equi*)

	• *Canary Pox vector vaccine:* Given intramuscularly, provides protection for at least 6 months. The beginning of immunity has been known at 14 days after administration of the first dose of vaccine. Safe to use in foals as young as 4 months of age. Also used for pre-foaling boosters.
	• *Adult horse, previously vaccinated:* Show or pleasure horses continuously at risk of exposure should be revaccinated every 6 months. Other adult horses can be vaccinated once a year.
	• *Adult horses, unvaccinated or having an unknown vaccination history:* One dose of the MLV intranasal vaccine or a primary series of 3 doses of the inactivated-virus vaccine is suggested, with 3–4 weeks between the first and second vaccinations, and 3–6 months between the second and third vaccinations. Boosters should be every 6–12 months, depending on the age of the horse, as well as the amount of risk and the duration of the infection. When using a Canary Pox vector vaccine, a 2-dose series is given with the second dose given 4–6 weeks after the first dose. Give a booster every 6 months.
	• *Pregnant broodmares previously vaccinated:* Vaccinate 4–6 weeks before foaling, using the inactivated-virus vaccine or the Canary Pox vectored vaccine.
	• *Pregnant broodmares, unvaccinated or having an unknown vaccination history:* Use a 3-dose series of the inactivated-virus vaccines, wait 4–6 weeks to give the second vaccine, and the third dose should be administered 4–6 weeks prepartum. When using a Canary Pox vector vaccine, a 2-dose series is used, giving the second dose 4–6 weeks after the first dose but no later than 4 weeks pre-partum.
		• Keep pregnant mares away from nonpregnant mares.
		• Any recovered horse must be in insolation for 3 weeks after last clinical sign
		Complications
		• N/A
		Prognosis
		• Fair
			• *Adult horses previously vaccinated:* Based on assessment risk and manufacturer's recommendations, the vaccine can be given every 6–12 months.
			• *Unvaccinated or having unknown vaccine history of an adult horse:*
			  • *Killed vaccine:* Intervals of 2–4 weeks with a series of 2–3 doses followed by annual revaccination. Revaccinate at 6-month intervals, regardless of the injectable product used.
			  • *Modified live vaccine:* Give 2 doses 3 weeks apart. These can be given either every 6 months or annually.
			• *Broodmares previously vaccinated:*
			  • *Killed vaccine:* Broodmares can be vaccinated 4–6 weeks prior to delivery. They can be vaccinated with approved products that contain inactivated M-protein.
			• *Unvaccinated broodmares or unknown history:* Killed vaccine containing M-protein with final dose to be administered 4–6 weeks predelivery. (See killed vaccine schedule.)
			• *Foals:*
			  • *Killed vaccine:* Foals at high risk for exposure can be given 3 doses of M-protein product with 4–6 weeks between each vaccine, starting at 4–6 months of age.
			  • *Modified live vaccine:* This can be given at 6–9 months of age with 2 doses, 3 weeks between each dose.
			  The vaccine can be given to foals that are at high risk of exposure as young as 6 weeks of age, but this has not been studied adequately. A third dose should be administered 2–4 weeks prior to weaning.
			Note: Adverse reactions are increased when the product is given to young foals.

	• *Foals of vaccinated mares:* Give a single dose of the MLV intranasal vaccine or a primary series of 3 doses of inactivated-virus vaccine starting at 6 months of age. Wait 4–6 weeks between the first and second vaccinations. The third dose should be given between 10 and 12 months of age. • *Foals of nonvaccinated mares:* Give a single dose of the MLV intranasal vaccine or a primary series of 3 doses of inactivated virus vaccine starting at 6 months of age, unless there is a serious threat that requires earlier vaccination. • *Outbreak:* If an outbreak occurs, boost immunity. If detected early enough in horses that have previously been vaccinated, any vaccine can be used. In unvaccinated horses or horses with an unknown vaccination history, the early onset of immunity after administration of the intranasal product (protection within 7 days) may recommend its use. • Isolate new horses for 2 weeks. Complications: N/A Prognosis: Fair		• Isolation • Temperature of exposed horses should be taken twice a day. • Horses that develop fever should be isolated. • Equipment used should be cleaned with detergent and disinfected with chlorhexidine or glutaraldehyde. • Control flies; they can transmit the infection. • Anyone in contact with an infected animal needs to wear protective clothing or change clothes. • With 2 negative nasal swabs, quarantine new animals for 14–21 days. • The horse continues to shed *Streptococcus Equi* for 1 month; 2 negative nasal swabs with 4–7 days between each swab.
Notes	• Can be self-limiting • Horses 1–5 years old are most susceptible, but immunity can be overwhelmed in horses that show. • Immunized horses can be subclinical and shed the virus.	• *Infection of any route:* The incubation period can be as short as 24 hours, but typically it is 4–6 days. • EHV abortion can occur anywhere from 2 to several months after the virus. • Aerosol transmission is the most common way of transmission, but it can be transmitted indirectly. It can be viable for several weeks in the environment, fomites, aborted fetuses, or fluids. Infected foals are highly contagious.	

Disease	Botulism (*Clostridium botulinum*)	Potomac Fever (Equine Monocytic Ehrlichiosis, Equine Ehrlichial Colitis)	Equine Viral Arteritis (EVA)
Definition	Caused by toxins produced by *Clostridium botulinum*, an anaerobic, spore-forming bacteria present in all soil. Toxin proliferates under vegetative conditions.	• Acute enterocolitis syndrome causing mild colic, fever, and diarrhea in horses of all ages, as well as abortion in pregnant mares. The agent that caused Potomac fever was formerly known as *Ehrlichia risticii*, which has recently been renamed *Neorickettsia risticii*. • The life cycle for *Neorickettsia risticii* is complicated. The bacteria have been identified in flatworms (flukes). They develop in aquatic snails and are released into water. Damselflies, dragonflies, and mayflies (aquatic insects) pick up the immature flukes. A grazing horse may then ingest these insects that are carrying *Neorickettsia risticii*.	Infectious disease, caused by equine viral arteritis (EVA), an RNA virus.
Presentation	Presenting Clinical Signs • Difficulty chewing and swallowing • Muscle paralysis • Poor tail, tongue, and eyelid tone • Series of muscular weakness and recumbency	Presenting Clinical Signs • Diarrhea • Depression • Anorexia • Lethargy • Laminitis • Mild colic	Presenting Clinical Signs • *Respiratory infection:* Serous nasal discharge, cough, conjunctivitis, lacrimation • Anorexia
Disease	Botulism (*Clostridium botulinum*)	Potomac Fever (Equine Monocytic Ehrlichiosis, Equine Ehrlichial Colitis)	Equine Viral Arteritis (EVA)
	Examination Findings • Flaccid paralysis with normal mentation • Hypoventilation, respiratory arrest • Paresis/Inability to stand for extended periods • Limb paralysis • Trouble seeing • *Shaker foal syndrome:* Foals are usually less than 4 weeks old. Commonly there are premonitory signs. Usually, they show signs of progressive symmetric motor paralysis, stilted gait, muscular tremors, and the inability to stand for more than 4–5 min. Other clinical signs include dysphagia, constipation, mydriasis, and frequent urination. As the disease worsens, dyspnea with extension of the head and neck, tachycardia, and respiratory arrest occur. Death usually occurs 24–72 hours after the start of clinical signs. The most reliable necropsy findings are pulmonary edema and congestion and excessive pericardial fluid, which contains free-floating strands of fibrin.	Examination Findings • Fever may go up to 107°F. • Quiet gut sounds • Edema in the legs, ventral part of the body, or prepuce of males • Abortion (by transplacental transmission) • Toxemia • Dehydration • Leukopenia • Leukocytosis	Examination Findings • Fever • Abortion • Palpebral and periorbital edema
Diagnosis	Laboratory • Identification of toxin in plasma, liver, or gastrointestinal tract • Probable diagnosis is based on identification of *Clostridium botulinum* spores in gastrointestinal contents or wounds. Imaging • N/A Procedures • N/A	Laboratory • PCR • IFA titers Imaging • N/A Procedures • N/A	Laboratory • Clinical findings Imaging • N/A Procedures • N/A
Treatment	Medication • N/A Nursing Care/Patient Care • Hyperimmune plasma	Medication • Oxytetracycline • NSAIDs Nursing Care/Patient Care • Fluids	Medication • NSAIDs Nursing Care/Patient Care • Supportive care

Disease	Botulism (*Clostridium botulinum*)	Potomac Fever (Equine Monocytic Ehrlichiosis, Equine Ehrlichial Colitis)	Equine Viral Arteritis (EVA)

Follow-Up	Prevention/Avoidance
	• *A killed vaccine (toxoid):* Its main use is to prevent Shaker foal syndrome by colostral transfer of antibodies produced by vaccination of the pregnant mare. Foals vaccinated with the toxoid at 2 weeks, 4 weeks, and 8 weeks of age developed sufficient serologic response, even when passive maternal antibodies are there.
	• There are no licensed vaccines available for preventing botulism due to type C or other subtypes of toxins. Cross-protection between the B and C subtypes does not occur; thus routine vaccination against *C. botulinum* type C is not currently practiced.
	• Carcasses should be disposed of.
	• *Previously vaccinated pregnant mares:* Vaccinate annually with a single dose 4–6 weeks before foaling.
	• *Previously unvaccinated pregnant mares:* Vaccinate during gestation with a starting series of 3 doses given in 4-week intervals with the last dose administered 4–6 weeks before foaling.
	• *Foals of vaccinated mares (in endemic areas):* Administer a starting series of 3 doses, with 4 weeks between doses, starting at 2–3 months of age. Because maternal antibodies do not interfere with vaccine response, foals at high risk may have the vaccination series started as early as 2 weeks of age.
	• *Foals of unvaccinated mares (born in—or moving to—endemic areas):* Give a primary series of 3 doses in 4-week intervals, with the first dose at 1–3 months of age. Foals at high risk may have the vaccination series started as early as 2 weeks of age. Foals of unvaccinated mares may benefit from transfusion of plasma from a vaccinated horse or from administration of *C. botulinum* type B antitoxin.
		Prevention/Avoidance
		• Vaccination should be given before peak challenge during the summer or fall.
		• *Adult horses, previously vaccinated:* Booster at 6–12 month intervals but, a period of 3–4 months for horses in an endemic area.
		• *Adult horses, previously unvaccinated or with unknown vaccination history:* Give a main series of 2 doses, at a 3–4 week interval. The best protection occurs 3–4 weeks after the second dose.
		• *Pregnant mares previously vaccinated against PHF (Potomac horse fever):* Vaccinate from every 6 months to annually, the first dose to be administered 4–6 weeks before foaling.
		• *Pregnant mares unvaccinated or with unknown vaccinal history:* Give a starting series of 2 doses, at a 3–4 week interval, with the second dose administered 4–6 weeks before foaling.
		• *Foals:* After 5 months of age, begin a 2-dose series given at a 3–4 week interval.
		• *Horses having been naturally infected and recovered:* Give a main series (as described above) or booster vaccine (if previously vaccinated) 12 months after recovery from natural infection.
		Complications
		• N/A
		Prognosis
		• Good
			Prevention/Avoidance
			• *Indications for vaccination against EVA:*
			  • To protect stallions from infection and following development of the carrier state
			  • To vaccinate seronegative mares before being bred
			  • To limit outbreaks in nonbreeding areas
			• *Breeding stallions, previously vaccinated:* A yearly booster, no earlier than 4 weeks before breeding
			• *Breeding stallions, first-time vaccinates:* Before vaccinating, all stallions must go through serologic testing and must have negative results. After vaccination stallions must be isolated for 4 weeks prior to breeding
			• *Teasers:* Yearly booster
			• *Mares to be bred to carrier stallions or to be bred with virus-infective semen:* Should first be tested
			• *Mares free of antibodies:* After vaccination is given the mare should be isolated for 3 weeks.
			• *First-time vaccinated mares:* After the mare is inseminated, isolate for another 3 weeks.
			• *Mares with the antibody:* Able to be bred to a carrier stallion or infective semen without vaccination. After breeding, they should be separated from unvaccinated animals for 24 hours.
			• *Pregnant mares:* Do not vaccinate.
			• *Nurse mares:* Vaccinate yearly.
			• *Foals:* Do not vaccinate foals less than 6 weeks of age at high risk of natural exposure to infection.
			• *Colt*: At 6 and 12 months of age. Do not test for antibodies prior to 6 months of age.

	• *All other horses (where indicated):* Start a primary series of 3 doses of vaccine given at 4-week intervals and an annual booster. • *Horses having been naturally infected and recovered:* Duration of immunity following natural infection is highly unpredictable. As the serum antibody does not interfere with response to vaccination, a recovered horse (foal or adult) may receive a 3-dose series after it is fully recovered from the disease. • Bleach is used as a disinfectant after the body has removed toxins and/or vegetative cells. • Clostridial spores are resistant to nearly all environmental conditions and disinfectants. • Dietary deficiencies should be fixed and decaying grass should be taken away from the diet. Complications • Paralysis Prognosis • Can be lethal		• Isolation of new horses • Isolation of sick horses Complications • N/A Prognosis • Good
Notes	Transmission • Ingestion of toxin in contaminated feed • *Toxicoinfectious:* Shaker foal syndrome • Large quantity of bacteria overgrows in gut then exudes toxin. • *Direct contact:* Wound contamination or passing through umbilicus in foals • A rare—but fatal—risk of Thieler's disease following the use of antitoxins needs to be considered.	Transmission • *Incubation:* Approximately 1–3 weeks • Transplacental • Oral ingestion of trematodes. (Usually seen with horses on pastures around creeks and rivers. PHF can also occur in animals housed in racetrack stalls.) • Whole blood transfusion from an infected donor • Affected horses are not considered to be contagious by natural contact with other horses.	Transmission • Contact with respiratory secretions • Infected stallions • *Artificial insemination:* Fresh or frozen

Table 2.9 / Areas of Injection and Blood Draws in Cattle

Areas of Injection	• *Subcutaneous vaccination:* In front of the shoulder blade	• *Intramuscular:* Can be given in the rump, thigh, or neck
Area of Blood Draws	• *Intravenous venipuncture:* Coccygeal vein (Figure 2.6)	• N/A

Figure 2.6 Intravenous venipuncture (coccygeal vein). Courtesy of Tiffany Matthews.

Table 2.10 / Dairy and Beef Cattle Vaccines

Disease	Blackleg, Malignant Edema, False Blackleg, Gas Gangrene, and Gangrene	Leptospirosis in Cattle (Redwater of Calves)	Brucellosis in Cattle (Contagious Abortion, Bang's Disease)
Definition	Caused by *Clostridium chauvoei (feseri), Clostridium septicum, Clostridium chauvoei, Clostridium sordelli,* occasionally *Clostridium novji type B, Clostridium perfringens type A,* or *Clostridium carnis* and is found worldwide. Found in the soil and can live for many years.	Worldwide, zoonotic, several pathogenic serovars. Slow growing corkscrew-like motility type bacteria that are aerobic with gram-negative spirochetes. Approximately 220 different serovars pathogenic Leptospira have been identified.	A disease in cattle caused by Brucella abortus that affects the reproductive tract
Presentation	Presenting Clinical Signs • Lameness • Depression • Swelling throughout all major joints	Presenting Clinical Signs • *Calves:* Anorexia, trouble breathing • *Older cattle:* Abnormal milk production. Thick, yellowish tinged blood. Clots are thick. Udders are flabby and soft. • Animals that are pregnant can spontaneously abort or have a still birth, weak neonates, or a healthy birth but infect the baby.	Presenting Clinical Signs • Abortion • Still born • Calves are weak. • Reduced milk production
	Examination Findings • Fever may be present.	Examination Findings • *Calves:* Fever, jaundice, hemolytic anemia, hemoglobinuria	Examination Findings • Placenta is retained. • Testicles, ampullae, seminal, and epididymides can become infected in bulls, causing infective semen.
Diagnosis	Laboratory • N/A Imaging • N/A Procedures • Necropsy	Laboratory • Serology with matching serum samples Imaging • N/A Procedures • N/A	Laboratory • *Brucella* milk ring test (BRT) • Market cattle testing • Culture fetus Imaging • N/A Procedures • N/A
Disease	Blackleg, Malignant Edema, False Blackleg, Gas Gangrene, and Gangrene	Leptospirosis in Cattle (Redwater of Calves)	Brucellosis in Cattle (Contagious Abortion, Bang's Disease)
Treatment	Medication • N/A Nursing Care/Patient Care • N/A	Medication • Tetracycline and oxytetracycline in acute case caught early • Oxytetracycline, amoxicillin, and enrofloxacin in chronic cases Nursing Care/Patient Care • Blood transfusions may be necessary. • Supportive care	Medication • N/A Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • Two doses of the vaccine administered between 2 and 6 months of age with each vaccination being given 2–6 weeks apart. Then booster yearly. Complications • N/A Prognosis • Poor	Prevention/Avoidance • Vaccinate heifers 2–3 times in monthly intervals prior to breeding, then again at midgestation of their first pregnancy. • Vaccinate yearly or every 6 months in a high-risk area. • If pregnant herds are diagnosed, vaccinate to reduce abortion. • Rat, opossum, raccoon, and skunk control • Keep away from streams and ponds. • Keep cattle away from pigs and wildlife. Complications • N/A Prognosis • Poor	Prevention/Avoidance • Vaccinate heifer calves at 4–12 months (use regulatory, federally accredited DVM only). • All cattle are tested prior to slaughter. • Testing of herds is regular. Herds are tested until 2–3 tests are negative. • The most danger to herds is from replacements. The replacement should be calves or nonpregnant heifers that have been vaccinated. • If a heifer is pregnant, it should come from a non- brucellosis herd. • The replacement should be rested and isolated for 30 days.
Notes	• Cattle are usually found dead.	• N/A	• Infections that are left untreated for a long time may cause arthritic joints.

Disease	Shipping Fever—Bovine Respiratory Disease Complex (BRDC)	Bovine Viral Diarrhea (BVD)	Parainfluenza 3
Definition	• Disease that affects the respiratory system is caused by stress, such as traveling, dehydration, starvation, chilling, overheating, and exposure to vehicle exhaust fumes. Can also be caused by secondary bacterial infection in the lower respiratory tract. • There is usually a viral component, as well as the animal's environment, that contributes to this disease, followed by a secondary bacterial component.	RNA virus, classified as a *Pestivirus* in the Flaviviridae family	RNA virus classified in the *paramyxovirus* family
Presentation	Presenting Clinical Signs • See pneumonia.	Presenting Clinical Signs • Clinical signs appear 6–12 days after infection and last 1–3 days. • Common in cattle 6–24 months old • Inappetence • Diarrhea • Decreased milk production	Presenting Clinical Signs • Cough • Serous nasal and lacrimal discharge • Increased breath sounds
	Examination Findings • See pneumonia.	Examination Findings • Fever • Mucosal lesions • Increased respiratory rate • Nasal secretions • Transient leukopenia may also be seen.	Examination Findings • Fever • Increased respiratory rate
Treatment	Medication • Antibiotics Nursing Care/Patient Care • Isolate • Supportive care	Medication • Antibiotics Nursing Care/Patient Care • Supportive care • Fluids	Medication • Antimicrobials Nursing Care/Patient Care • Supportive care • Oxygen, if needed
Diagnosis	Laboratory • See pneumonia. Imaging • See pneumonia. Procedures • See pneumonia.	Laboratory • Assays and virus isolation of serum, viral RNA, or viral antigen in specimens or tissues • ELISA Imaging • N/A Procedures • N/A	Laboratory • Enzyme immunoassay • Fluorescent antibody and immunoperoxidase staining Imaging • N/A Procedures • N/A

Disease	Shipping Fever—Bovine Respiratory Disease Complex (BRDC)	Bovine Viral Diarrhea (BVD)	Parainfluenza 3
Follow-Up	Prevention/Avoidance • *Modified vaccines:* Viral respiratory vaccines are controversial with entry to feedlots. • Reported to increase mortality • Booster before stressful situation (2–3 weeks prior). Then can booster during stressful situation. Avoidance • Give long-acting antibiotics "on arrival" for high risk. • Minimize transportation times with rest periods and access to food and water. • Wean calves 2–3 weeks before shipping. • Perform surgical procedures before transporting. Complications • N/A Prognosis • Fair	Prevention/Avoidance • Vaccinate between 4–6 months and 12–16 months • Booster yearly Complications • N/A Prognosis • Guarded	Prevention/Avoidance • Vaccinate at 4–6 and 12–16 months Complications • N/A Prognosis • Fair
Notes	N/A	N/A	N/A

Disease	Bovine Respiratory Syncytial Virus	Bovine herpesvirus 1 (BHV-1) is associated with infectious bovine rhinotracheitis (IBR), infectious pustular vulvovaginitis (IPV), balanoposthitis, conjunctivitis, abortion, encephalomyelitis, and mastitis.
Definition	RNA virus, classified as a *pneumovirus* in the paramyxovirus family	• N/A
Presentation	Presenting Clinical Signs • Depression • Anorexia • Cough • Nasal and eye discharge • Open-mouth breathing	Presenting Clinical Signs • *Respiratory form:* Coughing, nasal discharge, conjunctivitis • *Genital infections:* Elevation of the tailhead, mild vaginal discharge, frequent urination, swollen vulva, small papules, or ulcers
	Examination Findings • Fever • Increased respiratory rate • Dyspnea	Examination Findings • Fever • Inflamed nares • Dyspnea
Diagnosis	Laboratory • Enzyme immunoassay • Fluorescent antibody • Immunoperoxidase staining Imaging • N/A Procedures • N/A	Laboratory • Rise in serum antibody titer • Viral isolation Imaging • N/A Procedures • N/A
Treatment	Medications • Antimicrobial therapy Nursing Care/Patient Care • Supportive care • Oxygen, if needed	Medications • Antimicrobial therapy Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • Vaccinate between 4 and 6 months and 12 and 16 months, then yearly Complications • N/A Prognosis • Guarded	Prevention/Avoidance • *Modified live or inactivated:* Intramuscular and intranasal IM may cause abortion. • First vaccine is given at 6–8 months of age, before being bred, then yearly. • Feeder calves should be vaccinated 2–3 weeks before entry into the feedlot.
Notes	• N/A	• N/A

Table 2.11 / Small Ruminant Vaccines

Disease	Tetanus (Lockjaw)	Enterotoxemia Type C, (Also Called Hemorrhagic Enteritis or "Bloody Scours"), Type B, Type D (Also Called "Pulpy Kidney Disease")	Sore Mouth (Contagious Ecthyma, Orf)
Definition	Powerful neurotoxin that comes from an anaerobic, spore-forming bacterium (*Clostridium tetani*). Tetanus is found in the soil and is caused by a puncture wound or laceration in the foot.	*Enterotoxemia type C:* Affects mostly kids within the first couple weeks of life. Causes bloody infection of the small intestine. *Enterotoxemia type D:* Can affect any age kid	Infectious dermatitis that affects the lips of young animals
Presentation	Presenting Clinical Signs • Incubation period is 10–14 days. • Walking, turning, and backing are difficult. • Erect ears • Tail is stiff and extended. • Front nares are dilated. • Third eyelid is prolapsed. • Localized stiffness in the masseter muscles and muscles in the neck and hind limbs ("sawhorse" stance) • Area of the wound may also be stiff. • Extension of the head and neck is caused by spasms of the neck and back muscles. • Sweating	Presenting Clinical Signs • Most die before signs are seen. • Stop nursing • Listless • Recumbent • Blood-tinged diarrhea	Presenting Clinical Signs • Lesions of lips and often also found on the mucosa of the mouth • Ewes that are nursing can develop lesions on their udders.
	Examination Findings • Reflexes are increased, and the animal is excited easily, making the spasm more violent. • Increased heart rate, rapid breathing, congestion of mucous membranes • Temperature slightly above normal can rise to 108–110°F at the end of the disease.	Examination Findings • Based on clinical findings	Examination Findings • Clinical findings
Diagnosis	Laboratory • Occurrence of tetanus toxin in serum • If a wound is evident, bacterium in gram-stained smear • Anaerobic culture Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • Clinical findings	Laboratory • N/A Imaging • N/A Procedures • Clinical findings
Treatment	Medications • Curariform agents • Tranquilizers or barbiturate sedative in combination with 300,000 UI tetanus antitoxin twice a day • Using chlorpromazine and phenobarbital may lower hyperesthetic reactions and convulsions. Nursing Care/Patient Care • Very important during the acute period of spasms • Place in a quiet darkened stall. • Feed and water should be high enough so animal does not have to lower the head. • Sling may be useful if having difficulty standing or rising.	Medications • N/A Nursing Care/Patient Care • Supportive care	Medications • Antibacterial to treat secondary infections • Topical and parenteral antibiotics can help with secondary infection of skin lesions. Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • *Does and ewes:* Expecting should be vaccinated 2–4 weeks before birth, and females that are giving birth for the first time should be vaccinated late in their pregnancy, twice before giving birth. • *Rams and bucks:* Should be boostered annually with CD-T • *Kids and lambs:* Vaccinate at 6–8 weeks of age, then again at 2–4 weeks. • *Kids and lambs from nonvaccinated dams:* Vaccinate at 1–3 weeks then booster at 3–4 weeks. • Booster when docking, castrating, and disbudding or elastrator bands. • Booster yearly. • Surgical procedures should be as sterile as possible. • After surgery, turn out on clean ground and grass pastures. • Iodine or chlorine reliably kills the spores. • Booster yearly. • Surgical procedures should be as sterile as possible. • After surgery, turn out on clean ground and grass pastures. • Iodine or chlorine reliably kills the spores. Complications • N/A Prognosis • Poor	Prevention/Avoidance • *Does and ewes:* Expecting should be vaccinated 2–4 weeks before birth, and females that are giving birth for the first time should be vaccinated late in their pregnancy, twice before giving birth. • *Rams and bucks:* Should be boostered annually with CD-T • *Kids and lambs:* Vaccinate at 6–8 weeks of age, then again at 2–4 weeks. • *Kids and lambs from nonvaccinated dams:* Vaccinate at 1–3 weeks, then booster at 3–4 weeks. • Booster when docking, castrating, and disbudding or elastrator bands. • Booster yearly Complications • N/A Prognosis • Almost fatal	Prevention/Avoidance • Live vaccines are to be used cautiously to avoid contamination of areas that have not been affected. • Small amount of the live vaccine is normally brushed over an area of the skin or the inside of the thigh, behind the elbow. • Lambs should be vaccinated at 1 month of age with a booster 2–3 months later. • *Unvaccinated lambs:* Should be vaccinated 1–2 months prior to entering feedlots. • Repellents and larvicides can be applied to lesions to prevent myiasis. • Vaccinated animals should be separated from unprotected animals until the scabs have fallen off. Complications • N/A Prognosis • Good
Notes	• All mammals can get tetanus.	• N/A	• More severe in goats but can be seen in sheep. • Humans can contract it, and the lesions are usually found on hands and face and are self-limiting.

Table 2.12 / Areas of Injection in Swine

Areas of Injection	**Subcutaneous (SQ) under the Skin**	**Intramuscular (IM) into the Muscle**	**Intranasal (IN) in the Nasal Passages**
	• Inject only into clean, dry areas. • Skin that is loose in the flank and elbow of small pigs is used. • Use the loose skin behind the ears of sows.	• On the neck behind and below the ears • Avoid the hamstring muscle as it can result in condemnation.	• Tilt the head up and squirt into each nostril.

Table 2.13 / Swine Vaccines

Disease	Erysipelas	Mycoplasmal Pneumonia	Leptospirosis	Swine Influenza
Definition	• Caused by *Erysipelothrix* rhusiopathiae • Can be acute, subacute, or a chronic infectious disease	Clinically mild, chronic, infectious pneumonia of pigs	Serovars Pomana and Bratislava are the most common causes of leptospirosis in swine.	Highly contagious respiratory disease that is caused by type A influenza virus
Presentation	Presenting Clinical Signs • *Acute form:* Usually die without showing signs • Stiffly walking on their toes • Lying on their sternums • Loaner • Shift weight from one foot to the other • Anorexia • Discoloration of the skin	Presenting Clinical Signs • Slow growth rate • Sporadic flare-ups • Lung lesions in slaughtered pigs • Persistent dry cough	Presenting Clinical Signs • Abortion 2–4 weeks before giving birth • Piglets that make it to term are either stillborn or weak at birth and may die shortly after birth.	Presenting Clinical Signs • A typical acute occurrence is characterized by rapid onset and spreads quickly through the entire herd, usually within 1–3 days. • Coughing • Weakness • Discharge of mucous from the nose and eyes • Depression • Anorexia
	Examination Findings • Fever (104–108°F) • Based on clinical findings	Examination Findings • Based on clinical findings	Examination Findings • Abortion	Examination Findings • Fever that can go up to 108°F • Dyspnea
Diagnosis	Laboratory • N/A Imaging: • N/A Procedures: • Based on clinical findings	Laboratory • Serologic tests • ELISA • PCR test from nasal swabs Imaging • N/A Procedures • N/A	Laboratory • Serology with matching serum samples Imaging • N/A Procedures • N/A	Laboratory • Isolate the virus from nasal secretions during the fever Imaging • N/A Procedures • N/A
Treatment	Medication • Penicillin Nursing Care/Patient Care • Supportive care	Medication • Antibiotics (e.g., tylosin, lincomycin, tiamulin, or a tetracycline) Nursing Care/Patient Care • Supportive care	Medication • Tetracycline and oxytetracycline in acute case caught early • Oxytetracycline, amoxicillin, and enrofloxacin in chronic cases Nursing Care/Patient Care • Blood transfusions may be necessary. • Supportive care	Medication • No treatment that is effective • Antibiotics can be used to treat secondary infection. • Expectorants can help relieve symptoms, Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • *Gilts before breeding:* Twice • *Sows before breeding:* Before being bred • *Boars:* Twice a year • *Grower pig:* Purchased as feeder pigs • Good sanitation	Prevention/Avoidance • Vaccine of prefarrowing sows with *Mycoplasmal hyopneumoniae* vaccines • Isolate Complications • N/A Prognosis • Fair	Prevention/Avoidance • 4, 6, 12, and 16 months of age, then yearly • If pregnant herds are diagnosed, vaccinate to reduce abortion. • Rat control • Keep away from streams and ponds. • Keep away from wildlife. Complications • N/A Prognosis • poor	Prevention/Avoidance • Kill vaccines that contain both H1N2 and H3N2 • 4, 6, 12,16 months of age, then yearly • Isolation Complications • N/A Prognosis • Poor
Notes	• N/A	• N/A	• N/A	• Can be transmitted to humans

Disease	Parvovirus	Porcine Reproductive and Respiratory Syndrome	Atrophic Rhinitis	Enteric Colibacillosis
Definition	Females are almost always naturally infected before their second pregnancy and are immune for life.	An enveloped virus with the following two clinical phases: postweaning respiratory disease and reproductive failure	This disease involves two organisms: • *Bordetella bronchiseptica* • *Pasteurella multocida* It has 2 forms: • *Nonprogressive:* Mild and does not seriously affect the swine's growth and performance • *Progressive*: Permanent, severe, and causes poor growth	• Seen in nursing pigs and weanlings • Caused by colonization of the small intestine by enterotoxigenic strains of *Escherichia coli*
Presentation	Presenting Clinical Signs • Prior to 70 days of gestation, can result in death of the fetus • Stillbirths • Mummified fetuses	Presenting Clinical Signs • Reproductive disease • Stillborn piglets • Fetuses that have been mummified • Farrows that are weak or premature • *Lactating sows:* Anorexia and agalactia (lack of lactation postfarrowing)	Presenting Clinical Signs • Seen at 3–8 weeks of age and acute signs • Sneezing • Coughing • Severe cases of nasal hemorrhage can be seen.	Presenting Clinical Signs • Large amounts of watery diarrhea • Dehydration
	Examination Findings • N/A	Examination Findings • Piglets that are suckling can develop respiratory noises that have a thumping pattern. They can also transmit the virus for up to 112 days after they are infected.	Examination Findings • Lacrimal ducts become blocked. Tear stains then appear below the medial canthi of the eyes. • Shorting of the upper jaw can be seen.	Examination Findings • Clinical findings • Acidosis • Before showing signs, pigs may collapse and die.
Diagnosis	Laboratory • Fluorescent antibody tests • Using lungs from a mummified fetus, a virus isolation can be done. Imaging • N/A Procedures • N/A	Laboratory • ELISA or indirect fluorescence Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • Clinical findings	Laboratory • Immunofluorescence or other immunologic procedures and isolation from the small intestine Imaging • N/A Procedure • N/A
Treatment	Treatment • No effective treatment	Treatment • No effective treatment Nursing Care • NSAIDs • Appetite stimulates • Antibiotics	Treatment • Antibiotics to all sows. Prefarrowing sows are most important. Nursing Care/Patient Care • Rest	Treatment • Antibiotics Nursing Care/Patient Care • Fluid and electrolyte balance restoration

Disease	Parvovirus	Porcine Reproductive and Respiratory Syndrome	Atrophic Rhinitis	Enteric Colibacillosis
Follow-Up	Prevention/Avoidance • Inactivated vaccine is available.	Prevention/Avoidance • Swine need to be isolated for 45–60 days. • Disinfect if the virus is on the farm.	Prevention/Avoidance • Bacterins against *Bordetella bronchiseptica* and *Pasteurella multocida* have been developed. Both bacterin-toxoid and toxoid vaccine combinations are available against *Pasteurella multocida*. • Vaccinate sows 4 and 2 weeks prior to farrowing. • Piglets are vaccinated at 1 and 4 weeks of age; however, manufacturer guidelines should be followed. • Chemoprophylaxis • Do not introduce new pigs until the other pigs are healthy. • Adjust ventilation. • Monitor hygiene. • Provide non-dusty feed.	Prevention/Avoidance • *Gilts before farrowing*: Twice • *Sows before breeding:* Before they are bred • *Boars:* Twice a year • Reduce exposure to cold temperatures and damp environments. • Make sure sanitation is good by replacing solid or slatted concrete flooring with wire-mesh flooring.
Notes		• N/A	• N/A	• N/A

Rabies

This disease is an acute viral encephalomyelitis that principally affects carnivores and bats, although it can affect any mammal. There are 3 clinical phases: prodromal, excitative, and paralytic/end-stage. However, this separation is not practical because of the different signs and irregular lengths of the phases.

- **Prodromal period:** Lasts ~1–3 days. The animals show vague central nervous system signs, which intensify rapidly. Then, after the start of paralysis, the disease progresses rapidly, and death is nearly certain. Some animals die quickly without clinical signs.
- **Excitative phase ("furious" rabies):** Aggression is distinct in these animals.
- **"Dumb or paralytic" rabies:** Behavioral changes are minimal, and the disease is obvious mainly by paralysis.
- **Paralytic form:** Paralysis of the throat and masseter muscles, profuse salivation, and inability to swallow. Paralysis progresses rapidly to the whole body. Coma and death come within a few hours.

Table 2.14 / Rabies

Disease	Rabies

<table>
<tr><td>Presentation</td><td>Presenting Clinical Signs
Acute behavioral changes: Anorexia, apprehension, nervousness, irritability, and hyperexcitability
Seek solitude
Change in temperament is apparent.
Aggressiveness
Note: Horses and mules frequently show evidence of distress and extreme agitation. These signs are usually accompanied by rolling, biting, or striking. Due to their size and strength, they become unmanageable in a few hours. They often suffer self-inflicted wounds.</td></tr>
<tr><td></td><td>Examination Findings
Ataxia
Altered phonation
Unexplained progressive paralysis</td></tr>
<tr><td>Diagnosis</td><td>Laboratory
Should be euthanized and the head removed if suspected for rabies
Testing should be done by qualified laboratory personal, who have been chosen by the local or state health department in agreement with established national standardized protocols.
The test of choice is immunofluorescence microscopy on fresh brain tissue, which allows visual examination of a specific antigen-antibody reaction.
Imaging
N/A
Procedures
N/A</td></tr>
<tr><td>Treatment</td><td>Medication
N/A
Nursing Care/Patient Care
Strict inpatient quarantine</td></tr>
<tr><td>Follow-Up</td><td>Prevention/Avoidance
Strict quarantines
Euthanize all animals known to have rabies.
Horses</td></tr>
</table>

- *Adult horses previously vaccinated against rabies:* Vaccinate yearly.
- *Adult horses previously unvaccinated or having unknown vaccination history:* Administer a single dose; booster yearly.
- *Pregnant mares, previously vaccinated against rabies:* Vaccinate 4–6 weeks before foaling. Alternatively, veterinarians may recommend that mares be vaccinated with rabies vaccine before being bred.
- *Pregnant mares, previously unvaccinated or of unknown vaccination history:* Vaccinate 4–6 weeks before foaling.
- *Foals of mares vaccinated against rabies:* Give a primary series. The first dose should not be administered before 6 months of age. The second dose should be given 4–6 weeks later. Booster yearly.
- *Foals of mares not vaccinated against rabies:* Administer according to label directions. The first dose of vaccine should be administered at 3–4 months of age. Booster yearly.
- *Foals of mares with unknown vaccination history:* Follow one of these two rational options:

  1. Assume the mare to be antibody-positive and follow the above recommendations for foals from mares known to be vaccinated against rabies, that is, the first dose starting at 6 months of age followed by second dose 4–6 weeks later. Revaccinate annually thereafter.

  2. Document the rabies antibody status of the foal by testing serum collected from the foal at 24 hours of age or older or from the dam during the peri-parturient period.
  Note: If the foal or mare is rabies antibody-negative, follow the above recommendations for foals of mares known not to be vaccinated against rabies. If the foal or mare is rabies antibody-positive, follow recommendations for foals of mares known to be vaccinated against rabies.

- *Cattle:* Administer a single dose; then booster yearly.
- *Goats and Sheep:* Can be vaccinated yearly.

	Complications • N/A Prognosis • Almost 100% fatal
Notes	• Transmitted in saliva • Inactivated by disinfectants • Animal's head should be chilled on wet ice and sent to the lab for evaluation.

Table 2.15 / Anthrax

Disease	Anthrax
Definition	A disease that is zoonotic and caused by the spore-forming bacterium *Bacillus anthracis*.
Presentation	Clinical findings • Anorexia • Depression • Weakness • Bloody diarrhea
	Examination Findings • Colic • Inflammation in the neck, sternum, lower abdomen, and external genitalia • Fever
Diagnosis	Laboratory • Cotton swab with blood • Bacterial culture • PCR tests • Fluorescent antibody stains • Western blot and ELISA tests • Fixed blood smears that are stained with Loeffler's or MacFadean Imaging • N/A Procedures • N/A

Treatment	Medication • Oxytetracycline • Amoxicillin, chloramphenicol, ciprofloxacin, doxycycline, erythromycin, gentamicin, streptomycin, or sulfonamides Nursing Care/Patient Care • Supportive care

Follow-Up	Prevention/Avoidance
	• Notify appropriate regulatory officials.
	• Quarantine (after vaccination, for 2 wk before movement off the farm, for 6 wk if going to slaughter)
	• Properly dispose of dead animals, manure, bedding, or other contaminated material with preferred cremation or deep burial.
	• Isolate animals that are sick and keep well animals away from contaminated areas.
	• Clean and disinfect stables.
	• Use insect repellents.
	• Remove scavengers that feed on animals that have died from the disease.
	• People who handle the diseased animals should observe sanitary procedures.
	• *Horses*
	    • *Adult horses:* Vaccinate against anthrax. Booster yearly.
	    • *Adult horses previously unvaccinated or of unknown vaccination history:* Give 2 doses with 2–3 weeks between. Booster yearly.
	    • *Pregnant mares:* Do not vaccinate.
	    • *Foals:* No information available.
	• *Adult cattle:* Vaccinate 2–4 weeks before the season of outbreaks. Do not vaccinate 1 week after antibiotics have been given.

Table 2.16 / Hoof Care

Species	Horse	Cattle	Sheep	Goat	Pig
Cleaning	• Daily with hoof pick and brush	• N/A	• N/A	• N/A	• N/A
Trimming	• Feet should be trimmed every 6–9 weeks. • If shod, shoes should be reset every 6 weeks.	• *Dairy cattle:* Once per year • *Beef cattle:* Not routinely trimmed, as they walk more and wear down the hooves	• Cloven hooves should be trimmed once to several times per year.	• Cloven hooves should be trimmed once to several times per year.	• Not routinely trimmed
Equipment Used	• Hoof testers • Nail pullers • Hoof knife • Shoe pullers • Rasp • Nippers	• Hoof knife • Rasp • Nippers • Hoof-trimming chute • Tilt table • Power trimming disks/sanding disks	• Sharp hoof shears	• Sharp hoof shears	• N/A

Table 2.17 / Common Diseases and Disorders of the Hoof

Disease/ Disorder	Affected Animal	Definition	Causes	Symptoms	Treatment
Hoof abscess	• Horses, cattle, small ruminants	• A localized bacterial infection in the sensitive structures of the hoof	• Bacteria invade the inner structure of the hoof through a crack or puncture. • Excessive moisture • Defects in the white line	• Sudden and severe lameness • Increased digital pulse • Swollen leg and/or low grade fever	• Osmotic soak • Poultice • Drawing salve • Horses will need a hoof wrap or bandage to prevent further contamination.
Club foot	• Horses	• An upright hoof where the toe grows at an angle 60° to the ground • Horn of the toe forms a right angle to the ground.	• Hereditary • Poor conformation	• Appearance of the shape of the hoof • Heels and toe are almost equal length.	• Trimming • Occasionally no treatment is warranted.
Sole Bruises	• Horses, cattle	• Direct injury to the sole of the foot by stones • Irregular ground or poor shoeing in horses	• Stepping on stones or irregular ground, causing injury to the sole of the hoof	• Lameness • Visible bruises on the sole of the hoof • Pain	• Hoof bandage • Padding • *Horses:* Shoes with padding • *Cattle:* Shoe/block on opposite claw
Quarter Cracks (Sand Cracks)	• Horses	• Cracks in the hoof wall that start in the coronet and run parallel down the horn tubules	• Excess drying of the hoof • Trauma • Conformation	• Visual crack in hoof wall • If infection is present, purulent discharge may be evident.	• Surgery • Corrective shoeing
Canker	• Horses, primarily heavy draft horses	• Hypertrophy of the horn producing tissues of the hoof	• Unknown • Suspected bacterial infections	• Frog of the hoof is ragged and oily in appearance. • Foul smell • Swollen frogs	• Loose horn and affected tissue should be removed • Antiseptic or antibiotic dressing applied daily • Hoof dressings
Interdigital Hyperplasia	• Cattle	• Tumor or mass in the interdigital space	• Stretching of the distal interphalangeal ligament	• Lameness • Visible tumor or lesion between the toes	• Sometimes no treatment is warranted. • Surgical removal
Foot Rot	• Cattle, small ruminants	• Fusobacterium necrophorum or bacteroides melaninogenicus infection of the hooves	• Poor hygiene • Moist anaerobic environment	• Area between the claws of the hoof swells. • Redness • Tenderness • Pain	• Clean hooves thoroughly. • Antiseptic • Systemic antibiotics • Trim claw to open to the air. • Foot bath

Table 2.18 / Lameness Grading Scale

Grade	Assessment
0	Normal
1	Trouble to see below any conditions, obscure
2	Hard to see, except under certain conditions
3	Constantly seen when trotting
4	Visibly lame with all gaits
5	Puts no weight on affected limb

Chapter 3

Nutrition

Ashley Moulton

Key Terms and Phrases		Abbreviations
Acidosis	Hypoglycemia	BCS: Body condition score
Analgesia	Hypomagnesemia	DNA: Deoxyribonucleic acid
Anemia	Ischemic	N/A: Not applicable
Anorexic	Lamina	NEFA: Non-esterified fatty acid concentrations
Ataxia	Lethargic	NMD: Nutritional myodegeneration
Blind staggers	Metritis	PEM: Polioencephalomalacia
Dyspnea	Necropsy	PO: By mouth
Emaciated	Obtunded	RN: Ribonucleic acid
Epistaxis	Opisthotonos	SQ: Subcutaneous
Gastroenteritis	Parakeratosis	TDN: Total digestible nutrients
Goiter	Paralysis	WMD: White muscle disease
Hematomas	Parturition	
Hyperammonemia	Periparturient	
Hyperglycemia	Polyuria	
glucosuria	Rumen	
Hyperparathyroidism	Steatitis	
Hypersalivation	Vasodilators	
Hypocalcemia		

The Importance of Nutrition

Nutrition is a very important aspect of all animals' well-being; but, when it comes to large animals, it is vital. Large animals are not only companions, but they are also a business and livelihood for many. Nutrition is just as important as a proper vaccine schedule or a physical examination. It is imperative that these animals are given the proper nutrition in order to grow and stay healthy. If owners do not have a good understanding of nutrition, their animals may become ill and die. This may mean the loss of a pet or the loss of income. Many serious animal diseases stem from a nutritional issue; if not addressed promptly, death may occur. Making sure that an animal has the proper amount of vitamins, minerals, water, and protein is a very important part of their care.

Every species of animal has its different nutritional needs; and, within the species, each individual animal has specific needs. For example, a horse that is a pasture pet does not need as much fat or protein content as a horse that is endurance racing. A cow that is nursing a calf needs more nutritional support than a non-nursing heifer. It is our job as veterinary technicians to give the owners of these animals the information that they need. This enables the owners to take proper care of their animals and make sure that all their nutritional needs are met. Veterinary technicians need to be able to educate the owners about the nutrition that is right for their animal and its specific circumstances. Veterinary technicians should be able to educate owners on the diseases and the issues that can arise due to poor nutrition.

Table 3.1 / Vitamins

Vitamin	Vitamin C	Niacin	Riboflavin (Vitamin B2)	Biotin	Thiamine (Vitamin B1)
Use	• Teeth/Bone strength • Metabolism of folic acid • Absorption of iron • Antioxidant	• Helps with growth • Releases energy from fats, carbohydrates and, proteins • Decreases cholesterol levels	• Maintenance of normal blood levels • Metabolism of fats, proteins, and carbohydrates • Hemoglobin production	• Enzyme activities • Metabolism of carbohydrates, fats, and proteins	• Helps with appetite • Coenzyme of energy metabolism • Peripheral nerve function
Signs of Toxicity	• Rare especially in food animals	• Nontoxic	• Nontoxic	• Nontoxic	• Rare • Slow pulse • Sedation
Signs of Deficiency	• Hemorrhage • Ulcerated gums • Enlarged joints • Decreased wound healing	• Decreased growth and appetite • Diarrhea	• Decreased growth • Anemia • Diarrhea	• Lameness • Poor growth • Decreased reproduction • Poor hair quality • Skin ulcerations • Exudates around eyes • Inflammation of mucous membranes	• Decreased body temperature • Heart irregularities • Ataxia • Blindness • Depression • Head pressing • Convulsions • Brain swelling • Death
Sources	• Hay • Green pastures	• Yeast supplements • Wheat barley	• Alfalfa • Supplements • Green pastures • Sweet/White clovers	• Safflower meal • Soybean meal supplements • Young grasses	• Oats • Supplements • Wheat
Affected Animals	• Equine • Bovine	• Swine	• Bovine • Ovine	• Swine • Equine	• Equine • Bovine • Ovine • Caprine

Vitamin	Folic Acid	Cobalamin (Vitamin B12)	Pantonthenic Acid	Pyridoxine (Vitamin B6)
Use	• Choline synthesis • Construction of hemoglobin • Manipulation of protein	• RBC formation • DNA synthesis • Maintenance of nerve tissue	• Maintains normal blood levels • Metabolizes fats, proteins, and carbohydrates • Hemoglobin production	• Fat and carbohydrate metabolism • Nitrogen metabolism
Signs of Toxicity	• Nontoxic	• Nontoxic	• Nontoxic	• Nontoxic
Signs of Deficiency	• Poor growth • Anemia • Diarrhea	• Decreased reproduction rates • Decreased coordination	• Poor hair quality • Enteritis • Goose stepping in swine • Neurologic disorders	• Anemia • Decreased growth • Anorexia • Eye discharge
Sources	• Alfalfa • Wheat • Supplement	• Whey • Brewer's yeast supplements	• Wheat bran • Safflower meal • Supplements • Alfalfa	• Green pastures • Corn gluten meal • Alfalfa • Safflower meal
Affected Animals	• Equine • Bovine	• Swine	• Bovine • Ovine	• Swine • Equine

Table 3.2 / Minerals

Mineral	Iron	Iodine	Cobalt	Zinc
Use	• Muscle oxygenation • Enzyme activation • Hemoglobin production	• Milk production • Influences growth • Hormone production • Muscle tissue development	• Formation of vitamin B12	• Skin • Hair • Development of reproduction organs • Bone maintenance
Signs of Toxicity	• Reproduction disorders • Irregular RBC production	• Hyperparathyroidism • Goiter	• Rare	• Poor growth • Increase in appetite • Stiff gait • Changes in the bone • Anemia
Signs of Deficiency	• Anemia • Pica • Poor hair coat • Decreased iron in milk • Diarrhea	• Reproduction issues • Abortion • Poor hair quality • Decreased growth	• Poor skin and hair coat • Decreased milk and appetite • Abortion	• Irregularities in the bone • Poor appetite • Poor growth • Wool/Hair loss • Poor wound healing • Parakeratosis
Sources	• Alfalfa • Corn gluten meal • Supplements	• Oats • Wheat • Molasses • Iodized salt	• Corn • Wheat • Molasses	• Corn gluten • Germ meal • Wheat by-product supplements
Affected Animals	• Swine • Equine	• Swine • Equine	• Bovine • Equine	• Bovine • Equine • Swine • Ovine

Mineral	Manganese	Chromium	Fluorine	Selenium	Copper
Use	• Clotting cascade • Metabolism of nutrients • Bone/Cartilage growth	• Increased insulin use • Stabilizes DNA and RNA • Synthesis of certain fatty acids	• Teeth • Bone	• Fatty acid oxidation • Sparing tissue damage	• Pigment of hair and wool • Skeletal structure • Reproduction • Absorption of iron • Hemoglobin construction
Signs of Toxicity	• Nontoxic	• Rare	• Deformed teeth and bone • Decreased feed use • Decreased hair and wool quality	• Paralysis • Blind staggers • Anemia • Weight loss • Lameness	• Thirst • Gastroenteritis • Hypersalivation
Signs of Deficiency	• Lameness • Poor growth • Reproduction disorders	• Decrease in fat metabolism • Hyperglycemia glucosuria	• Rare	• Weight • Muscle disease • Liver necrosis	• Diarrhea • Lameness • Anemia • Swayback
Sources	• Wheat • Corn • Grass/Alfalfa hay	• Wheat • Corn • Supplements • Vegetable oil	• Present in most foods	• Wheat by-products • Oil seed meals	• Safflower oil • Molasses • Grass hay • Cottonseed • Mineral mix
Affected Animals	• Ovine • Bovine • Equine	• Bovine • Ovine • Caprine	• Swine • Ovine • Bovine	• Bovine • Ovine • Equine • Caprine • Swine	• Ovine • Bovine

Mineral	Silicon	Molybdenum
Use	• Skeletal development	• Helps metabolize fats, carbohydrates, and proteins • Enamel production • Growth promotion
Signs of Toxicity	• Calculi formation	• Weight loss • Poor hair coat • Deceased reproduction rate • Diarrhea
Signs of Deficiency	• Skeletal abnormalities	• Rare
Sources	• Grains	• Grass • Alfalfa • Hay • Corn • Oats • Wheat
Affected Animals	• Bovine • Equine	• Bovine • Ovine • Caprine

Table 3.3 / Nutritional Deficiencies

Disease	Chronic Manganese Deficiency	Selenium Toxicity	Bloat	Fatty Liver Disease (Fat Cow Syndrome)/Ketosis (Hepatic Lipidosis)
Definition	Manganese is a very important element of nutrition. If there is not an adequate amount in the body, health issues arise.	Selenium is toxic if in the body in large amounts; however, small amounts of selenium are needed for cellular function.	Bloat is the overdistension of the rumenoreticulum from the gases of the fermentation.	This occurs when non-esterified fatty acid concentrations (NEFA) are elevated.
Presentation	Presenting Clinical Signs • Ataxia	Presenting Clinical Signs • Emaciated • Lethargic	Presenting Clinical Signs • Rumen becomes distended quickly.	Presenting Clinical Signs • Hypoglycemia • Hyperammonemia • Altered endocrine profiles
	Examination Findings *Calves*: • Weak pasterns and legs • Swollen joints • Stiffness • Deformed legs • Decreased bone strength	Examination Findings • Rough coats • Abnormal growth of horns and hooves • Lameness • Anemia • Liver cirrhosis and ascites • Heart atrophy • Blind staggers	Examination Findings • Entire abdomen is enlarged. • Skin over left flank area is taut. • Mouth breathing, dyspnea, and grunting. • Frequent urination • Tongue hanging out • Stretching neck out • Regurgitation	Examination Findings *Occurs along with other diseases, such as:* • Mastitis • Displaced abomasums • Metritis • Hypocalcemia • Acidosis
Diagnosis	Laboratory • Heavy metal testing Imaging • N/A Procedures • N/A	Laboratory • Blood test Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • N/A	Laboratory • Liver biopsy • Blood enzyme Imaging • N/A Procedures • N/A
Treatment	• There is no treatment for affected calves, but keep the dietary manganese concentrations at 15–25 mg/kg.	• Eliminate the source of selenium. • Supportive care	• Emergency rumenotomy • Stomach tube to release gas • Placement of a rumen fistula *Antifoaming agents:* • Vegetable oils • Mineral oils • Docusate • Poloxalene	• IV infusion of glucagon *Avoid:* • Fast diet changes • Overconditioning • Environmental stress
Follow-Up	• Supportive care	• Check feed for selenium levels.	• Supportive care • Keep animals off of grazing areas that have bloat-causing agents.	• Supportive care
Affected Animals	• Bovine • Swine	• Cattle • Ovine • Equine	• Bovine • Ovine	• Bovine

Disease	Hypomagnesemic Tetany	Laminitis, Lactic Acid Acidosis, Founder	Milk Fever, Parturient Paresis, Hypocalcaemia
Definition	A metabolic disturbance of hypomagnesemia and a decrease of Mg in the animal's CSF	Ischemic necrosis and aseptic inflammation of the sensitive lamina (corium) in the feet	Occurs a few days after parturition. During this time, the amount of calcium in the body drops and is lost through the milk.
Presentation	Presenting Clinical Signs • Gait is stiff. • Sensitive to sounds and touch • Polyuria • Convulsions *More severe cases:* • Vocalize • Fall over • Convulsive and paddle • Death	Presenting Clinical Signs • Stiffness • Reluctance to walk • Difficulty rising • Spends majority of time lying down • Shifts weight from front to back or vice versa	Presenting Clinical Signs • Ataxic • Tremors at the flank and triceps • Restlessness • Unable to stand • No defecation • Loss of consciousness
	Examination Findings • Plasma Mg is less then 1.2 mg/dL in cattle and less than 0.5 mg/dL in sheep. • Mg found in the urine of affected animal.	Examination Findings • A digital pulse can be found, and there is heat found in the hoof. • Animal reluctant to move or have feet picked up.	Examination Findings • Hypersensitivity • Easily excitable • Obtunded • Anorexic • Tachycardia and difficult time auscultating heart sounds • Weak pulses • Loss of consciousness
Diagnosis	Laboratory • Blood/Urine test Imaging • N/A Procedures • Necropsy	Laboratory • N/A Imaging • Radiographs of hoof Procedures • N/A	Laboratory • Blood work Imaging • N/A Procedures • N/A
Treatment	• Solution of calcium and Mg given slowly IV. • Mg sulfate given subcutaneous (SQ). • During recovery, feed hay that has been treated with Mg oxide. • Animals should be kept in a quiet area away from stimuli while they recover.	• Reduce the inflammation and give analgesia with antiinflammatory drugs. • Vasodilators are used to increase the digital blood flow. • Support for the foot is also important.	• Normal calcium levels need to be restored in the animal's body as soon as possible. However, this needs to be done slowly, and the heart needs to be auscultated throughout the treatment. Calcium can be given by mouth (PO) or IV.

Disease	Hypomagnesemic Tetany	Laminitis, Lactic Acid Acidosis, Founder	Milk Fever, Parturient Paresis, Hypocalcaemia
Follow-Up	• Supportive care	• Supportive care • Avoid grain overload	• Supportive care
Affected Animals	• Bovine • Ovine	• Bovine • Equine	• Bovine

Disease	Polioencephalomalacia (PEM)	Rickets	White Muscle Disease (WMD), Nutritional Myodegeneration (NMD)	Enterotoxemia (Overeating Disease)
Definition	This disease can affect separate animals or it can affect the entire herd. Animals are fed high concentrations of added sulfate to help limit the amount of food intake or food with by-products of corn or sugar cane. It is also associated with altered Thiamine.	This disease is found in young animals. It is commonly caused by a deficiency in phosphorus or vitamin D. Calcium deficiency can also cause this.	It occurs in young animals whose dams were not given enough selenium during the gestation period.	This disease is caused by *Clostridium perfringens* and seems to occur most often in young animals that have a high grain ration.
Presentation	Presenting Clinical Signs • Separate from the group • Will not eat • Ears and face start to twitch. • Animal staggers.	Presenting Clinical Signs • Stiff gait • Difficulty getting up • Bowed limbs • Ataxia	Presenting Clinical Signs • Muscle weakness • Stiffness	Presenting Clinical Signs • Diarrhea • Ataxia • Loss of appetite
	Examination Findings • Seizures • Recumbence • Blindness • Hypermetric gait • Head pressing • Teeth grinding • Opisthotonos	Examination Findings • Bone pain • Pathological fractures	Examination Findings • Degeneration of cardiac muscle and/or skeletal muscle • Death	Examination Findings • Upset digestive tract • Coma • Death
Diagnosis	Laboratory • Blood test Imaging • MRI Procedures • N/A	Laboratory • N/A Imaging • X-rays Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • N/A
Disease	Polioencephalomalacia (PEM)	Rickets	White Muscle Disease (WMD), Nutritional Myodegeneration (NMD)	Enterotoxemia (Overeating Disease)
Treatment	• Treatment is only effective if started early in the disease process. Thiamine is given IV or SQ. Dexamethasone can also be given to help reduce the cerebral edema.	• Adjusting the diet is the first and most important thing that needs to be done. Exposure to natural sunlight will also help to increase the level of vitamin D3.	• Injections of vitamin E and selenium. Correct amounts of vitamin E and selenium in the diet of the dams and the young.	• Antibiotics are used to help clear the infection. • Administration of vitamins C and D Antitoxins are also given.
Follow-Up	• Supportive care and supplements of thiamine	• Supportive care • Balanced diet	• Supportive care • Correct amounts of vitamin E and selenium in the diet of the dams and the young	• Feed animals small, frequent meals, keeping the amount of carbohydrates to a safe level. • There is a vaccine available that can be given to animals older than 2 months of age.
Affected Animals	• Bovine • Ovine • Caprine • Camelids	• Bovine • Swine • Ovine • Caprine	• Baby ovine • Baby bovine • Baby caprine • Baby swine	• Caprine • Ovine • Swine

Disease	Urinary Calculi	Pregnancy Toxemia/Ketosis	Vitamin A (Retinol) Deficiency	Vitamin E Deficiency
Definition	This disease occurs when minerals start to accumulate in the animal's urinary tract. It is common when the animals fed are high in cereal grains and/or silica content. Males have an increased risk.	This disease occurs during the later stages of pregnancy. It is most common in animals that are carrying more then 1 fetus. As the fetuses grow, they demand a high amount of glucose. The female's body then starts to produce a high amount of adipose tissue (fat) to meet this new demand. This causes the liver to be compromised, which causes ketone bodies to be released into the bloodstream.	This disease occurs when the animal does not get enough vitamin A in its diet. This vitamin helps with good vision, muscle/bone growth, skin, and reproduction. Vitamin A comes from yellow vegetables and green forages. Usually animals are only affected by this if they are deprived of good quality pasture for a long time span (more than 6 months).	This disease is usually seen along with selenium deficiency. (See White Muscle Disease.)

Disease	Urinary Calculi	Pregnancy Toxemia/Ketosis	Vitamin A (Retinol) Deficiency	Vitamin E Deficiency
Presentation	Presenting Clinical Signs • Straining to urinate • Painful to urinate • Decreased or slow urination flow • Kicking at prepuce area • Shifting or stomping of feet	Presenting Clinical Signs • Ataxia • Loss of appetite • Lethargic	Presenting Clinical Signs • Poor appetite and weight loss • Poor hair coat • Overproduction of tears • Stallions may show decreased libido.	Presenting Clinical Signs • Swelling • Stiff gait
	Examination Findings • Urine that is alkaline and with high phosphorus levels • Rupture of the bladder • Blood in urine	Examination Findings • Opisthotonos • Death	Examination Findings • Anemia • Night blindness • Seizures • Abortion	Examination Findings • Swollen tongue • Steatitis • Slow growth rate of young
Diagnosis	Laboratory • Urinalysis Imaging • Ultrasound Procedures • N/A	Laboratory • Blood work Imaging • N/A Procedures • N/A	Laboratory • Blood work Imaging • N/A Procedures • N/A	Laboratory • Blood work Imaging • N/A Procedures • N/A
Treatment	• Giving dietary tetracycline, vitamin A (in correct amounts), ammonium chloride, and NaCl can help with this condition.	• Glycerol can be given to help keep the energy source up without producing more adipose tissue. Glucose is given to treat this condition. Propyleneglycol and calcium induce parturition or C-section.	• Vitamin A supplement can be given, but care needs to be taken that there is not too much in animal's diet. Animal can also be put on good quality pasture and be fed yellow vegetables.	• Vitamin E supplement can be added to the animal's feed.
Follow-Up	• Supportive care	• Keep BCS appropriate. • Supportive care	• Keep the animal on a diet with adequate amounts of vitamin A.	• Keep the animal on a diet with adequate amounts of vitamin E.
Affected Animals	• Ovine • Caprine • Equine	• Ovine • Caprine	• Equine • Bovine • Ovine	• Equine

Disease	Vitamin K Deficiency	Iron Deficiency	Zinc Deficiency (Ruminal Parakeratosis)
Definition	Vitamin K is found in the forage that the animals eat. Long-term issues can affect the coagulation of the blood.	This disease causes anemia in the animals that it affects.	This disease causes ruminal parakeratosis, which is the enlargement and hardening of the rumen. This occurs in animals that are not fed the correct amount of zinc in their diet.
Presentation	• Epistaxis • Hematomas • Depressed	• Rough hair coat • Decreased growth	• None seen
Examination Findings	• Pale mucous membranes • Irregular, rapid heart rate • Weak	• Anemia • Listlessness	• Only found if the animal's digestive system is examined
Diagnosis	Laboratory • Blood work Imaging • N/A Procedures • N/A	Laboratory • Blood work Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • N/A
Treatment	• Injections of vitamin K can be given to the animal. Vitamin K supplements can also be added to feed.	• Iron supplements can be given to piglets at birth. Iron supplementation can also be given to other species to bring the iron level in the blood back to a normal level.	• Keep animals on feed that contains the correct amount of zinc. Most commercial feed has adequate amounts.
Follow-Up	• Supportive care	• Supportive care	• Supportive care
Affected Animals	• Equine • Ovine • Bovine	• Swine • Equine • Bovine	• Swine • Equine • Bovine

Table 3.4 / Nutritional Requirements for the Horse

Age	Crude Protein (%)	Calcium (%)	Phosphorus (%)	Digestible Energy (DE) (Mcal/kg)	Estimated Total Feed Consumed as Percentage of Body Weight per Day
Nursing Foal (2–4 Months)	16.0	0.9	0.6	3.3–3.8	0.50–0.75
Weanling (4–6 Months)	14.5	0.7–0.8	0.4–0.5	2.9	2.5–3.5
Yearling (12–18 Months)	12.0–12.5	0.4–0.5	0.25–0.30	2.65–2.80	2.0–3.0
2 Years Old	11.0	0.35	0.2	2.5	2.0–2.5
Mature (Ranges Depend on Exercise Level)	8.0–11.5	0.25–0.35	0.20–0.25	2.00–2.85	1.5–3.5
Stallion During Breeding Season	10.0	0.3	0.25	2.4	1.5–2.5
Pregnant Mare	8–11	0.25–0.50	0.20–0.35	2.00–2.45	1.5–2.0
Nursing Mare	11–13	0.35–0.50	0.25–0.35	2.45–2.60	2.0–3.0

Table 3.5 / Nutritional Requirements for the Dairy Cow

Age	Crude Protein (%)	Calcium (%)	Phosphorus (%)	Digestible Energy (Mcal)
Growing Female (200–1,399 lb)	6.5–17.1	0.19–0.98	0.12–0.32	0.45–1.04
Lactating Female (800–1,800 lb)	0.70–0.99	0.029–0.062	0.024–0.044	7.16–10.89
Bull (1,000–2,900 lb)	20.3–28.6	0.98–1.50	0.14–0.59	14.3–32.1

Table 3.6 / Nutritional Requirements for Beef Cattle

Age	Crude Protein (%)	Calcium (%)	Phosphorus (%)	Digestible Energy (Mcal)
Growing (300–1300 lb)	0.34–2.40	10–42	6–24	3.0–8.4
Yearling (700–1,400 lb)	6.8–14.8	19–28	14–24	8–12
Lactating Cow/Heifer (800–1,400 lb)	1.9–2.9	23–42	19–26	10.0–17.0
Breeding Bull (1,300–2,100 lb)	2.0–2.3	23–33	22–33	9.3–13.3

Table 3.7 / Nutritional Requirements for Sheep

Age	Crude Protein (%)	Calcium (%)	Phosphorus (%)	Digestible Energy (Mcal)
Weaned/Growing	0.35–0.53	4.9–9.4	2.2–4.8	1.3–4.2
Female (110–190 lb)	0.21–0.33	2.0–3.9	1.8–3.4	2.4–3.1
Female During Gestation/Lactation	0.43–0.51	5.6–9.6	4.8–7.8	4.0–7.5

Table 3.8 / Nutritional Requirements for Swine

Age	Crude Protein (%)
Weanling (12–20 lb)	16–20
Breeding Sow	12
Gilt	13–16
Lactating Sow	17
Boar	14–16

Chapter 4

Internal Medicine

Jessica Sjogren and Amy D'Andrea

- Cardiovascular
- Dermatology
- Endocrinology
- Gastroenterology
- Musculoskeletal
- Neurology
- Ophthalmology
- Respiratory
- Urology

Key Terms and Phrases	Abbreviations
Arthrogryposis	ALT: Alanine aminotransferase
Ataxia	AST: Aspartate transaminase
Cachexia	BCG: Bacille Calmette–Guérin
Coalescence	BID: Twice a day
Coalescent	BSE: Bovine spongiform encephalopathy
Congenital	CBC: Complete blood count
Cystic	CNS: Central nervous system
Endometritis	COPD: Chronic obstructive pulmonary disease
Everted	DMSO: Dimethyl sulfoxide
Exudative	ELISA: Enzyme linked immunosorbent assay
Hyperfibrinogenemia	EPM: Equine protozoal myeloencephalitis
Hyperflexion	GGT: Gamma-glutamyl transpeptidase
Hypoplastic	IHC: Immunohistochemistry
Laminae	LDA: Left displaced abomasum
Lead feeding	LDH: Lactate dehydrogenase
Listless	N/A: Not applicable
Lymphangitis	NSAID: Nonsteroidal antiinflammatory drug
Melanocyte	Pd: Polydipsia
Mucopurulent	PrP: Prion protein
Nodular	Pu: Polyuria
Obstipation	RAO: Recurrent airway obstruction
Opisthotonus	RDA: Right displaced abomasum
Paracentesis	SID: Once a day

Pedunculated Pheochromocytoma Purulent Rumen fistula Visceral Volatile fatty acids	TID: 3 times a day vCJD: Variant Creutzfeldt-Jakob disease

Table 4.1 / Cardiovascular

Disease	Anaplasmosis	Anemia	Babesia
Definition	Previously known as gall sickness, which is caused by obligate intraerythrocytic bacteria of the order Rickettsiales, family Anaplasmataceae, genus *Anaplasma*. Transmitted by ticks.	Decrease in the red cell accumulation measured by red blood cell count, hemoglobin concentration, and packed cell volume. Anemia can occur from loss, destruction, or lack of production of red blood cells. *Classified in two categories:* 1. *Regenerative anemia:* Bone marrow responds properly to the decreased red blood cells and increasing red blood cell production and releasing reticulocytes, caused by hemorrhage or hemolysis. 2. *Nonregenerative anemia:* Bone marrow responds inefficiently to the need for increased red blood cells caused by decreased erythropoietin or abnormality in the bone marrow.	Transmitted by ticks and caused by intraerythrocytic protozoan parasites of the genus *Babesia*
Presentation	Presenting Clinical Signs • Anorexia • Loss of coordination • Milk production drops	Presenting Clinical Signs • The signs of anemia depend on the degree of anemia, the duration (acute or chronic), and the underlying cause. • *Acute anemia:* Shock and death if a third or more of the blood is lost quickly and not replaced • The cause of the blood loss may be clear (e.g., hit by car). No evidence may be seen, and internal bleeding may be deemed to be the reason (e.g., a ruptured splenic tumor, coagulopathy, GI ulceration, or parasites). The patient may be icteric if hemolysis is present. • *Chronic anemia:* Anorexia, weakness, and lethargy	Presenting Clinical Signs • Anorexia • Muscle tremors • Weight loss • Constipation or diarrhea
	Examination Findings • Breathlessness when exerted • Rapid bounding pulse • Urine may be brown. • Fever • Mucous membranes pale and then yellow • Abortion	Examination Findings • *Acute anemia:* Hypotension, bounding or weak pulse, pale mucous membranes, and tachycardia • *Chronic anemia:* Splenomegaly, heart murmur, pale mucous membranes, tachycardia	Examination Findings • Fever greater than 105.8°F • Anemia • Jaundice • Increased respiratory rate • Abortion • Bulls may have temporary infertility. • Final-stage hemoglobinemia • Final-stage hemoglobinuria • Lesions, swollen liver, enlarged gallbladder • Urine may be red. • Brain and heart may show congestion or petechia.
Disease	**Anaplasmosis**	**Anemia**	**Babesia**
Diagnosis	Laboratory • Microscopic examination with Giemsa-stain Imaging • N/A Procedures • Blood films of liver, kidney, spleen, and lungs, as well as peripheral blood, should be evaluated upon necropsy.	Laboratory • CBC • Platelet and reticulocyte count • Blood smear Imaging • N/A Procedures • Bone marrow evaluation by aspiration • Biopsy	Laboratory • Microscope exam with thick blood, preferably from capillaries in the ear or tail tip Imaging • N/A Procedures • At necropsy, a smear of heart muscle, kidney, liver, lung, brain, a blood vessel in the leg
Treatment	Medication • Tetracycline Nursing Care/Patient Care • Blood transfusion	Medication • N/A Nursing Care/Patient Care • *Supportive care:* Fluids, blood transfusions, iron supplementation.	Medication • Diminazene aceturate • Imidocarb dipropionate • Long-acting tetracycline • NSAIDs • Antioxidants • Corticosteroids Nursing Care/Patient Care • Supportive care • Blood transfusion
Follow-Up	Avoidance • Keep the tick population to a minimum Complications • N/A Prognosis • Fatal in older animals	Avoidance • N/A Complications • Reaction to transfusion • Death can occur without treatment. Prognosis • Good	Avoidance • Keep the tick population to a minimum Complications • N/A Prognosis • Good
Affected Animals	• Cattle • Sheep • Goats	• Horses • Cattle • Sheep • Pigs • Goats	• Horses • Cattle • Sheep • Pigs • Goats **Note:** Few cases have been seen in humans.
Notes	• N/A	• N/A	• N/A

Disease	Brisket Disease (High-Mountain Disease)	Ventricular Septal Defect	Thrombosis
Definition	Mainly caused by pulmonary hypertension and also seen in high altitude areas. It is a noninfectious, congestive heart failure seen in cattle.	Usually located in the perimembranous portion of the septum, high in the ventricular septum directly below the right and noncoronary aortic valve cusps on the left side and below the cranioseptal tricuspid valve commissure on the right side	Clumping of blood when the blood flow through the arteries or veins is impeded
Presentation	Presenting Clinical Signs • Signs are slow to develop. • Depressed and unwilling to move • Ventral abdominal wall • Diarrhea • Labored breathing	Presenting Clinical Signs • Cattle are prone to showing signs of right-sided heart failure. • Fatigue • Exercise intolerance	Presenting Clinical Signs • *Cattle:* Coughing, lethargic • *Horses:* Normal at rest but, with exercise, show increasing weakness of the hind limbs. They can have unilateral or bilateral lameness, muscle tremor, and sweating, be anxious, appear painful and rapidly go into shock, exercise intolerance, weakness, and atypical lameness. Also the limbs may be cold with a decreased or absent arterial pulse in severe cases.
	Examination Findings • Cyanotic • Distention and pulsation of the jugular vein • Subacute edema in the brisket region extends cranially towards the intermandibular gap and also caudal to the ventral abdominal wall.	Examination Findings • Cyanosis • Loud systolic murmur that is accompanied by a left-sided thrill, absent or faint when a very large defect is present or when shunting right to left.	Examination Findings • *Cattle:* Thrombosis of the caudal vena cava occurs in involvement with hepatic abscesses that wear down into the vein. Also seen is embolic pneumonia with secondary pulmonary abscessation, thromboembolism, and pulmonary arterial aneurysms. • Tachypnea, dyspnea, and abnormal lung sounds • Elevated ibrinogen, anemia • Bacteremia is usually caused by chronic active infection, such as foot abscess, and causes intermittent fever and anorexia. • Bilateral jugular enlargement, which causes edema of the head, submandibular area, and brisket; oral mucosal hyperemia; or lingual, pharyngeal, or laryngeal edema may develop and may cause dysphagia and dyspnea, seen in cranial vena cava thrombosis. • Upper respiratory edema can develop into life-threatening condition and the need for an immediate tracheostomy. • *Horses:* Thrombosis of the cranial vena cava can be the result of embolization of a jugular thrombus or extension of a right atrial endocarditis lesion. • Jugular vein thrombosis is also associated with phlebitis after catheterization or paravenous injection, which cause swelling, heat, and pain and thickening of the jugular vein. • Edema and swelling of the head and neck due to passive congestion are caused by bilateral jugular vein thrombosis.
Disease	Brisket Disease (High-Mountain Disease)	Ventricular Septal Defect	Thrombosis
Diagnosis	Laboratory • N/A Imaging • Echocardiograph Procedures • N/A	Laboratory • N/A Imaging • Contrast study or Doppler echocardiography will show a shunt. Procedures • Surgical closure in animals that have large ventricular septal defects	Laboratory • N/A Imaging • Doppler ultrasound
Treatment	Medication • Diuretics Nursing Care/Patient Care • Move to a lower altitude with minimal restraint, stress, and excitement • If cannot be moved to low altitude, oxygen should be given. • Supportive care	Medication • Treatment is not needed for animals that have small ventricular septal defects. • Use vasodilators for animals with large ventricular septal defects. Nursing Care/Patient Care • Supportive care	Medication • Antibiotics for embolic pneumonia • Antipyretic • Antiinflammatory Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • Locoweed poisoning is linked to the development of congestive heart failure. Take care to minimize the contact of animals at risk. • Do not breed Complications • N/A Prognosis • Fair	Prevention/Avoidance • N/A Complications • N/A Prognosis • For animals with small ventricular septal defects, prognosis is good. • For animals with large ventricular septal defects, prognosis is poor to guarded.	Prevention/Avoidance • N/A Complications • N/A Prognosis • Guarded
Affected Animals	• Cattle	• Horses • Cattle • Sheep • Pigs • Goats	• Horses • Cattle
Notes	• N/A	• Animals with ventricular septal defect should not be bred.	• N/A

Disease	Degenerative Valve Disease (Endocardiosis, Chronic Valvular Disease, Chronic Valvular Fibrosis)	Equine Infectious Anemia	Myocarditis
Definition	An acquired disease that is characterized by nodular thickening of the cardiac valve leaflets. The most commonly affected valves are the mitral valves. • *Horses:* It most often affects the aortic valve and consists of valvular nodulated or fibrous bands on the free borders of the valve.	Caused by an equine-specific lentivirus in the retrovirus family. *Transmission* • Bloodborne; from horseflies, deer flies, and stable flies Reportable disease	A local or spread inflammation of the myocardium with myocyte degeneration or necrosis causing a nearby inflammatory infiltrate.
Presentation	Presenting Clinical Signs • Signs are uncommon in horses.	Presenting Clinical Signs • Weight loss • Depression • Edema	Presenting Clinical Signs • N/A
	Examination Findings • Systolic murmur (grade I-II/VI) • As the disease progresses, increased respiratory rate and effort and cough develop; respiratory crackles and wheezes and dyspnea may be heard. The systolic murmur gets louder.	Examination Findings • Cachexia • Petechial hemorrhages • Most times the infection is seen after routine examination testing for EIA with no clinical signs. • Platelet reductions • Anemia • Fever • The spleen and splenic lymph nodes are enlarged in acute cases. • Upon necropsy and in chronic cases, emaciation, subcutaneous edema, enlarged abdominal lymph nodes, and pale mucous membranes are found.	Examination Findings • Right-sided heart failure • Ascites • Venous blocking • Jugular pulsations • Mitral murmur • Tricuspid regurgitation • Atrial fibrillation • Ventricular and atrial premature complexes
Diagnosis	Laboratory • CBC, serum chemistry profile, and urinalysis Imaging • Thoracic radiographs • Echocardiograph Procedures • N/A	Laboratory • Serology testing • ELISA tests • Agar gel immunodiffusion (Coggins) Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • Echocardiograph Procedures • N/A

Disease	Degenerative Valve Disease (Endocardiosis, Chronic Valvular Disease, Chronic Valvular Fibrosis)	Equine Infectious Anemia	Myocarditis
Treatment	Medication • Diuretics Nursing Care/Patient Care • Supportive care	Medication • N/A Nursing Care/Patient Care • Supportive care	Medication • Digoxin and dobutamine for contractility • Furosemide for pulmonary edema Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • N/A Complications • N/A Prognosis • Survival time is unpredictable. • With the proper therapy, some affected animals may live longer than a year.	Prevention/Avoidance • Isolate from potential vectors. • Insect control • Euthanasia Complications • N/A Prognosis • Mortality and high morbidity rate	Prevention/Avoidance • N/A Complications • N/A Prognosis • N/A
Affected Animals	• Horses • Cattle • Sheep • Pigs • Goats	• Horses	• Horses
Notes	• N/A	• N/A	• N/A

Disease	Patent Ductus Arteriosus	Streptococcal Lymphadenitis
Definition	Congenital disorder in the heart of neonates. The ductus arteriosus does not close after birth.	A contagious disease characterized by abscesses of the cervical, mandibular, and cephalic lymph nodes caused by *Streptococcus porcinus*
Presentation	Presenting Clinical Signs • Lethargy • Exercise intolerance • Collapse	Presenting Clinical Signs • Rarely noticed depression and anorexia
	Examination Findings • Murmurs are usually loudest at the second heart sound and heard best over the aortic valve area. They are frequently associated with a precordial thrill. • Young animals usually do not show clinical signs. • Older animals with a large shunt frequently have signs of left-sided congestive heart failure.	Examination Findings • Abscesses are the only signs seen by the producer. • May cause meningitis, polyarthritis, or septicemia • *Rarely, but can occur:* Temporary fever, leukocytosis
Diagnosis	Laboratory • N/A Imaging • Electrocardiography commonly shows stall R waves in lead II, pinpointing of left ventricular enlargement, and atrial and ventricular premature complexes. • Radiographs may show abnormalities depending on the size of the ductus. Procedures • Surgical ligation	Laboratory • Culture and isolation from abscess exudate • Agglutination test Imaging • N/A Procedures • N/A
Treatment	Medication • N/A Nursing Care/Patient Care • Supportive care	Medication • Tetracyclines are given prophylactically if pig has been exposed Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • N/A Complications • N/A Prognosis • Long-term prognosis is fair.	Prevention/Avoidance • Exposed piglets should be weaned at 21 days and kept isolated. Complications • N/A Prognosis • N/A
Affected Animals	• Horses • Cattle • Sheep • Pigs • Goats	• Pigs
Notes	• N/A	• N/A

Table 4.2 / Dermatology

Disease	Abscess	Alopecia	Dermatophilosis	Dermoid Cysts
Definition	Purulent infection of the foot	Complete absence of hair or wool coat	• Mycotic dermatitis • Infection of the epidermis • Caused by the fungus *dermatophilus congolensis*	Cystic structures lined with skin that accumulate skin, hair, and glandular debris
Presentation	Presenting Clinical Signs • Acute lameness • Discharge from channel of infection • Swelling of the digit	Presenting Clinical Signs • Appears as a bare spot or area lacking hair/wool • Caused by a variety of factors	Presenting Clinical Signs • Exudative dermatitis with scab formation • Hair loss	• N/A
	Examination Findings • Clinical signs • Culture	Examination Findings • History and physical examination • Skin scraping	Examination Findings • Appearance of lesions • Culture	Examination Findings • Presence of hair and glands within the cyst
Diagnosis	• Treatment must be continued for 10–14 days to avoid reoccurrence.	• N/A	• N/A	• N/A
Treatment	• Open the abscess to help with drainage. • If abscess is open, cover the hoof. • Soak with warm water and salt. • Pack with drawing salve. • Antibiotics	• Depends on cause, so successful treatment depends on good diagnoses of causes	• Topical therapy works well for most cases. • *Antimicrobials:* Erythromycin, spiramycin, penicillin G, ampicillin, chloramphenicol, streptomycin, amoxicillin, tetracyclines, and novobiocin • Penicillins/sulfas usually work well as a first line for equine. • Oxylet in cattle	• Surgical procedures • Nursing care
Follow-Up	• Horses should have their hooves wrapped for the duration of treatment.	• N/A	• Affected animals should be isolated from the herd.	• Usually located on the ventral midline
Affected Animals	• Cattle • Horses • Small ruminants	• Cattle • Horses • Pigs • Small ruminants	• Cattle • Horses • Small ruminants	• Horses • Typically thoroughbreds
Notes	• N/A	• N/A	• N/A	• N/A

Disease	Digital Dermatitis (Hairy Warts, Papillomatous Digital Dermatitis)	Epitheliogenesis Imperfecta	Melanoma	Papilloma
Definition	Highly contagious, erosive, and proliferative infection of the epidermis proximal to the skin-horn junction in the flexor region of the interdigital space	A congenital discontinuity of squamous epithelium	Any of several types of skin tumors characterized by the malignant growth of melanocytes	• A white, plaque-like material in the inner ear. It sometimes appears thick and crusty. • Double-stranded DNA viruses of the Papovaviridae family
Presentation	Presenting Clinical Signs • Lesions in the area of the flexor commissure of the interdigital space • Can also be seen on the dorsal surface of the foot and around the dewclaws • Most commonly seen on hind feet, but can be seen in both front and hind • *Small lesions:* Round or oval lesions ~0.5–2.0 cm, flat or concave, raw, yellow, red, or gray and have a finely tufted or granular surface • As they develop, they may have a halo of white tissue. • Mature lesions are raised and covered by gray, brown, or black hair-like papillary growth, very tender to the touch. Animal might hold foot off ground.	Presenting Clinical Signs *Dependent on location:* • May appear as bright red lesions on skin • Skin may also be completely absent in severe cases. • May appear as hoof deformations • Hooves may be affected to the point of nonexistence.	Presenting Clinical Signs • The tumors are often multiple and may appear as coalescent, frequently pedunculated nodules.	Presenting Clinical Signs • White, crusty plaque lesions • Thick, pink skin underneath
	Examination Findings • Based on clinical signs and history	Examination Findings • Based on clinical signs and history	Examination Findings • Based on appearance of characteristics • Biopsy	Examination Findings • Based on appearance characteristics, identification of virus
Diagnosis	• Based on clinical findings	• Based on clinical findings	Laboratory • Cytology • Biopsy	• Based on clinical findings

Disease	Digital Dermatitis (Hairy Warts, Papillomatous Digital Dermatitis)	Epitheliogenesis Imperfecta	Melanoma	Papilloma
Treatment	• *Herd outbreaks:* Footbath containing oxytetracycline or lincomycin-spectinomycin • The heels of the cow should be washed prior to putting in the footbath. • Depending on the extent of the challenges of the environment, a repeat of treatments may be needed after 4–6 wk. • Using copper sulfate, zinc sulfate, or formalin added to footbaths may help in reducing the prevalence of interdigital dermatitis, thus decreasing the susceptibility for digital dermatitis • Individual treatment is required in advanced cases. The foot, particularly the interdigital area, should be cleaned to remove the abundant population of spirochetes. A single dressing of 36% muriatic acid can be used on the infected area and then protected by a waterproof bandage.	• Surgical procedures for smaller affected areas • Nursing care • Additional surgical procedures may be necessary.	• Surgical excision or cryosurgery • Recurrent tumors can be treated with cisplatin	• Self-limiting • Surgical removal
Affected Animals	• Cattle	• Horses • Cows • Sheep • Goats • Pigs	• Cattle • Pigs • Horses • Small ruminants	• Cattle • Horses
Follow-Up	• N/A	*Prognosis:* • When lesions are widespread, prognosis is poor.	• In horses, melanoma is most common in gray horses. • Melanocytic neoplasms of pigs are seen as congenital lesions.	• Located on the nose, lips, eyelids, distal legs, penis, vulva, mammary glands, and inner surfaces of the pinnae, often secondary to mild abrasions.
Notes	• Removal of wet and filthy conditions is important for control. • Isolate new cattle for 1 month. • Highly contagious and erosive • Morbidity within a herd can be >90%.	• N/A	• N/A	• N/A

Disease	Photosensitization	Sarcoids	Saddle Sores
Definition	The skin, which is exposed to light and is missing hair, wool, or pigmentation, is hyperreactive to sunlight due to the presence of photodynamic agents.	• Sarcoids mostly affect the young and are ~40% of all neoplasms. • They are locally destructive and have high recurrence rates after being removed. • Grouped into occult, verrucose, nodular, fibroblastic, mixed, and malignant types	Acute inflammation of the hair follicles, progressing to a purulent folliculitis
Presentation	Presenting Clinical Signs • Photophobic when exposed to sunlight and showing discomfort or beginning to squirm • Scratching or rubbing areas that are lightly pigmented • Causes skin lesions with severe cases of phylloerythrinemia, even on black-coated animals • Erythema develops rapidly and is soon followed by edema. • Lesions will disappear if exposure to sunlight stops. • If prolonged exposure to sunlight, serum exudation, scab formation, and necrosis are seen on the skin. • Exposure of the tongue while licking, especially in cattle, can cause glossitis.	Presenting Clinical Signs • Starting as subcutaneous masses in the eyelids or canthi, they usually enlarge quickly and may attack the skin as red, fleshy masses.	Presenting Clinical Signs • Hair loss • Swollen, warm, and painful based on characteristics of appearance
Diagnosis	Clinical sign • N/A	Examination Findings • N/A	Examination Findings • N/A

Disease	Photosensitization	Sarcoids	Saddle Sores
Treatment	• Shade at all times • Corticosteroids	• Surgery • Hyperthermia • Cryotherapy • Chemotherapy • Radiation • These can be used separately or as a combination of these therapies. • After surgery, recurrence can be rapid and precede wound healing. • Immunotherapy using BCG Bacille Calmette–Guérin (BCG) is often successful (~70%) as a potentiator of the cellular immune system. • After removing large sarcoids, the use of BCG preparation (7.5 mg of purified cell-wall extract suspended in 10 mL of saline solution) is injected into the remaining mass (2 mL/site). The injection should be repeated in 2–4 week intervals until the mass is gone. • Systemic antiprostaglandins and corticosteroids prior to and after the surgery will help decrease the likelihood of systemic anaphylactic reactions.	• Eliminate the use of tack that caused it. • Warm applications and topical or systemic antibiotics
Follow-Up	• N/A	• N/A	• N/A
Affected Animals	• Horses • Sheep • Goats • Cattle	• Horses	• Horses
Notes	• N/A	• N/A	• Healed saddle sores will often show as white hairs in the saddle area.

Table 4.3 / Endocrinology

Disease	Adrenal Medullary Hyperplasia	Goiter	Hyperadrenocorticism
Definition	A diffuse or nodular condition that appears to precede the development of pheochromocytoma in bulls with C-cell tumors of the thyroid gland. Composed of chromaffin cells, they are almost always located in the adrenal glands and are the most common tumors in the adrenal medulla of animals.	Non-neoplastic and noninflammatory enlargements of the thyroid gland that develop in all domestic mammals. The major causes include iodine deficiency, goitrogenic substances, and inherited enzyme defects in the biosynthesis of thyroid hormones.	Excessive secretion of cortisol by the adrenal glands
Presentation	Presenting Clinical Signs • Excessive sweating • Polyuria • Polydipsia • Recurrent colic • Apprehension	Presenting Clinical Signs • Newborns in poor health • Acute death	Presenting Clinical Signs • PU/PD • Polyphagia • Decreased hair shed out • Long, shaggy hair growth is often the first sign of the disease.
	Examination Findings • Tachycardia • Hyperglycemia • Dilated pupils • Hypertension	Examination Findings • Enlarged thyroid glands in the newborn and mare • Grossly enlarged neck • Skin and other tissue may be thickened, flabby, and edematous.	Examination Findings • Chronic or recurrent acute laminitis • Scaling and crusting skin • Muscle wasting • Supraorbital swelling
Diagnosis	Laboratory • Test blood and urinary catecholamine levels. Imaging • Abdominal ultrasound Procedures • N/A	Laboratory • Hyperplastic cytology of thyroid glands Imaging • N/A Procedures • N/A	Laboratory • Dexamethasone suppression test • ACTH challenge test • Insulin tolerance test • Hyperglycemia • Elevated liver enzyme activity • Hypercholesterolemia • Hypertriglyceridemia Imaging • N/A Procedures • N/A
Disease	Adrenal Medullary Hyperplasia	Goiter	Hyperadrenocorticism
Treatment	Medication • N/A Nursing Care/Patient Care • N/A	Medication • N/A Nursing Care/Patient Care • Iodized salt	Medication • Deworming medications every 8 weeks • Peroglide (dopaminergic agonist) Nursing Care/Patient Care • Treat secondary complications • Excellent husbandry and feeding practices • Attention to dentistry
Follow-Up	Prevention/Avoidance • N/A Complications • A pheochromocytoma may exert pressure on and invade adjacent tissues, particularly the vena cava and aorta. Prognosis • Poor	Prevention/Avoidance • Iodized salt in diet • Cook or heat all goitrogens Complications • Thyroid hyperplasia Prognosis • Signs	Prevention/Avoidance • N/A Complications • Infections • Laminitis • Type II diabetes • Parasite burden Prognosis • Good
Notes	• Rare	• Rare in sheep, goats, horses • Certain plants (soybeans, cabbage, rape, kale, and turnips) may cause goiter when ingested in sufficient amounts.	• Directly linked to the degree of hyperglycemia • All species

Table 4.4 / Gastroenterology

Disease	Acute Hepatitis	Blue Tongue	Brachygnathia
Definition	Idiopathic acute hepatic disease (Theiler's disease) is the most common cause of acute hepatitis in horses. About 20% of affected horses show clinical signs of hepatic failure 4–10 wk after receiving an equine origin biologic, such as tetanus antitoxin.	Also referred to as catarrhal fever, it is a noncontagious, nonzoonotic, arthropod-borne viral disease of ruminants, mainly sheep and less frequently in cattle and goats.	A condition where the mandible is shorter than the maxilla. Also referred to as overshot, short lower jaw, or parrot mouth in horses.
Presentation	Presenting Clinical Signs • Anorexia • Lethargy • Aggression • Maniacal behavior • Ataxia • Pica • Yawning	Presenting Clinical Signs • Excessive salivation, • Swelling of the face and tongue • Nasal discharge • Stertorous respiration • Muzzle necrosis	Presenting Clinical Signs • May be impossible if a foal is badly affected • Possible difficult mastication
	Examination Findings • Hepatic encephalopathy • Icterus • Fever • Central blindness • Bilirubinuria • Photosensitivity	Examination Findings • High fever • Cyanosis of the tongue • Foot lesions	Examination Findings • Examination of the oral cavity generally readily reveals the defect.
Diagnosis	Laboratory • Liver biopsy is the only definitive diagnostic. • Increased GGT, AST, SDH, LDH, ALP, and total serum bile acid • Hyperbilirubinemia • Moderate-to-severe acidosis • Hypokalemia • Polycythemia • Increased plasma aromatic amino acids • Hyperammonemia Imaging • The liver may appear shrunken and difficult to visualize on ultrasound exam. Procedures • N/A	Laboratory • Serologic ELISA testing • Leukopenia • Increased serum creatinine Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • Oral examination
Treatment	Medication • IV fluid therapy with dextrose and electrolytes Nursing Care/Patient Care • Supportive therapy • Treatment of the hepatic encephalopathy	Medication • NSAIDs Nursing Care/Patient Care • Non-specific • Supportive care	Medication • N/A Nursing Care/Patient Care • None or various orthodontic or endodontic procedures, depending on severity
Follow-Up	Prevention/Avoidance • Avoid stressful situations. • Avoid tetanus antitoxin to recently parturient mares. Complications • N/A Prognosis • Depends on the degree of hepatocellular necrosis • Good to poor	Prevention/Avoidance • Quarantine • Inoculation with live modified virus vaccine • Control of the midge vector • Vaccine Complications • Abortion • Stillbirth • "Dummy lamb" births Prognosis • Guarded to grave	Prevention/Avoidance • In some species, it is inherited as a polygenetic factor. Complications • May be associated with other anomalies such as impacted molar teeth Prognosis • Good
Notes	• N/A	• Not all animals develop symptoms, but all that do lose condition rapidly and the sickest die within a week. For affected animals that do not die, recovery is very slow, lasting several months.	• N/A

Disease	Campylobacteriosis	Choke	Cleft Palate
Definition	*Campylobacter* species are microaerobic gram-negative spiral bacteria. Ingesting *Campylobacter jejumi* causes acute gastroenteritis.	A condition in which the esophagus is obstructed by food masses or foreign objects	A disturbance of the processes that form the jaw and face during embryonic development. Cleft of the lower lip is rare and usually occurs on the midline. Clefts of the upper lip may be unilateral or bilateral, complete or incomplete, and are often associated with clefts of the alveolar process and palate. It is commonly seen with other defects, such as arthrogryposis.
Presentation	Presenting Clinical Signs • Diarrhea • Enteritis	Presenting Clinical Signs • Difficulty swallowing • Disinterest in food • Coughing • Extension of the neck and head, usually in a downward direction • Nasal discharge • Ptyalism	Presenting Clinical Signs • Initial signs reflect the extent of the malformation but may include difficulty suckling, dysphagia, and evidence of milk dripping from the nostrils when the newborn attempts to nurse.
	Examination Findings • Variable degree of mucopurulent endometritis	Examination Findings • Overflow of esophageal food and regurgitation of that food through the nostrils • Tachycardia • A lump on the side of the neck may be visible or can be palpated where the esophagus is blocked.	Examination Findings • Examination of the oral cavity generally readily reveals the defect, except in foals having only a cleft of the soft palate that may be difficult to see.
Diagnosis	Laboratory • Vaginal culture • ELISA test on vaginal mucus • Fluorescent antibody test and culture of preputial cavity • Cows should be revaccinated halfway through the breeding season. • Bulls are vaccinated for treatment as well as for prophylaxis, but are given twice the dose used for cows, 3 weeks apart. Imaging • N/A Procedures • N/A	Laboratory • Hematology and biochemical serum analyses in the cases of complication Imaging • Thoracic radiography Procedures • Endoscopic evaluation • Esophagotomy • The inability to pass a stomach or nasogastric tube in horses or cattle	Laboratory • N/A Imaging • N/A Procedures • Oral examination
Disease	**Campylobacteriosis**	**Choke**	**Cleft Palate**
Treatment	Medication • Vaccination Nursing Care/Patient Care • N/A	Medication • Antispasmodic • Acepromazine • Oxytocin Nursing Care/Patient Care • Hold off feed and water • Treat with mild sedation and smooth muscle relaxants.	Medication • Antibiotics as needed for secondary infections Nursing Care/Patient Care • Hand or tube feeding to ensure daily nutritional and caloric requirements are met • Occasional need for appropriate antimicrobial therapy to treat secondary infections of the rhinarium or lower respiratory tract
Follow-Up	Prevention/Avoidance • Vaccination ~4 weeks before breeding starts • Screen potential semen donors. Complications • Compromised fertility and potential sterility Prognosis • Good	Prevention/Avoidance • Always provide water. • Soak dry foods before feeding to horses that are prone to choking. • Change feeds gradually. • Discourage the bolting of food so that the horse must slow down or feed smaller meals more often. • Cut apples, carrots, or other treats into small pieces. • Withhold feed material for one hour following sedation. Complications • Aspiration pneumonia • Pressure necrosis and scarring • Esophagitis • Bloat in cattle • Mucosal ulcers Prognosis • Good to poor depending on when treatment is initiated	Prevention/Avoidance • The primary etiology is hereditary, although maternal nutritional deficiencies, drug or chemical exposure, mechanical interferences with the fetus, and some viral infections during pregnancy have also been implicated. • Ingestion of toxic agents may also play a role. • Affected animals should be surgically sterilized or removed from breeding stock to prevent reproducing the anomaly in future offspring. Complications • Respiratory infection due to aspiration of food is common and a grave consequence with a poor prognosis. Prognosis • Good, but death may occur due to secondary complications
Notes	• There are various strains of campylobacter that affect sheep, cattle, and goats. • Zoonotic	• N/A	• Surgical repair should be attempted only after ethical questions have been addressed.

Disease	Clostridium Perfringens	Coccidiosis	Colic
Definition	Clostridium perfringens is a gram-positive, rod-shaped, anaerobic, spore-forming bacterium of the genus *Clostridium*. It is ubiquitous in nature and can be found as a normal component of decaying vegetation, in the intestinal tracts of vertebrates and insects, and in soil. Potent exotoxins, some of which are responsible for specific enterotoxemia, may be produced by one of the 5 types (A, B, C, D, and E) of *clostridium perfringens*.	Gastrointestinal parasites caused by intracellular parasites *isospora* and *eimeria*. The pathogenic *coccidia* can damage the mucosa of the lower small intestine, cecum, and colon. Seen most commonly during or following severely cold weather.	The manifestation of visceral abdominal pain. Many conditions may cause colic in horses.
Presentation	Presenting Clinical Signs • Newborn lambs may stop nursing, become listless, and remain recumbent. • Yellow or hemorrhagic brown diarrhea (types B and C) • Abdominal pain • Convulsions or opisthotonos (calves) (types B, C, or D) • Excitement, incoordination (Type D) • Circling and head pressing against fixed objects (type D)	Presenting Clinical Signs • Watery feces • Dehydration • Anorectic • Weakness	Presenting Clinical Signs • Pawing repeatedly with a front foot • Looking back at the flank region • Curling the upper lip and arching the neck • Repeatedly raising a rear leg or kicking at the abdomen • Lying down • Rolling from side to side • Sweating • Stretching out as if to urinate • Straining to defecate • Distention of the abdomen • Loss of appetite • Depression • Decreased bowel movements
	Examination Findings • Necrotic enteritis (type A) • Toxemia (types B and C) • Enterotoxemia (type C) • Dehydration (type B)	Examination Findings • Weight loss • Tenesmus • Rectal prolapse secondary to tenesmus	Examination Findings • Tachycardia • Weak pulse • Prolonged capillary refill time • Auscultate and percuss the abdomen. Gas sounds may indicate ileus or distention of a viscus. Fluid sounds may indicate impending diarrhea associated with colitis. A complete lack of sounds is usually associated with adynamic ileus or ischemia. Percussion will assist in identifying a grossly distended segment of intestine that may need to be trocarized.
Disease	Clostridium Perfringens	Coccidiosis	Colic
Diagnosis	Laboratory • Contents of the gut may undergo PCR testing • ELISA techniques • Glucosuria in sheep affected by type D • Large numbers of large, gram-positive rods are visible in fecal smears. • Large numbers of *C. perfringens* type A are recovered on anaerobic culture of feces. • Anemia • Confirmation of ε toxin in the small-intestinal fluid is needed. Imaging • N/A Procedures • Diagnosis is based on history, clinical signs, pathologic findings, and differential diagnosis. • Fluid, not ingesta, should be collected in a sterile vial within a few hours after death and sent under refrigeration to a laboratory for toxin identification. Chloroform, added at 1 drop/10 mL of intestinal fluid; this will stabilize any toxin present.	Laboratory • Fecal flotation, direct smear, or by the McMaster's technique Imaging • N/A Procedures • N/A	Laboratory • Blood lactate Imaging • Ultrasound to identify inguinal hernia, renosplenic entrapment of the large colon, sand colic, intussusception, enterocolitis, right dorsal colitis, and peritonitis Procedures • Pass a nasogastric tube. • Auscultate the abdomen and thorax, and percuss the abdomen. • Paracentesis • *Rectal examination:* The intestine should be palpated for size, consistency of contents (gas, fluid, or impacted ingesta), distention, edematous walls, and pain
Treatment	Medication • Oral antibiotics may be helpful. Nursing Care/Patient Care • Treatment is usually ineffective because of the severity of the disease. • Specific hyperimmune serum, if available	Medication • Amprolium • Sulfaquinoxaline • Decoquinate • Monensin • Toltrazuril Nursing Care/Patient Care • Clinically affected animals should be isolated. • Supportive oral and parenteral fluid therapy	Medication • IV fluids • Xylazine • Detomidine • Butorphanol • Flunixin meglumine • Mineral oil • Dioctyl sodium sulfosuccinate • Psyllium hydrophilic mucilloid • Ivermectin/Moxidectin/Fenbendazole Nursing Care/Patient Care • Medical or surgical treatments • Surgery is necessary if there is a mechanical obstruction to the normal flow of ingesta that cannot be corrected medically or if the obstruction also interferes with the intestinal blood supply.

Disease	Clostridium Perfringens	Coccidiosis	Colic
Follow-Up	Prevention/Avoidance • Toxoid vaccines • Antiserum should be administered immediately after birth to newborn animals from unvaccinated dams. Complications • Vascular permeability through endothelial damage Prognosis • High mortality in young lambs, calves, pigs, and foals (types B and C) • Grave	Prevention/Avoidance • Avoid fecal contamination of feed and water • Avoid overcrowding • Mix lasalocid in the milk replacer of calves Complications • Pneumonia Prognosis • Variable, depending on time of detection • Death rate is high	Prevention/Avoidance • Avoid top-dressing • Feed changes increase the risk of colic. • Exercising without access to water can increase the risk of developing colic • Changes in exercise or stabling pattern can increase colic risk. Complications • N/A Prognosis • Good to poor
Notes	• Type A is referred to as yellow lamb disease. • Type B is referred to as lamb dysentery or foal and calf enterotoxemia. • Type C is referred to as pig/goat/calf enterotoxemia or struck in sheep. • Type D is referred to as enterotoxemia, overeating disease, or pulpy kidney disease. It is seen in sheep, less frequently in goats, and rarely in cattle.	• Infection is usually asymptomatic and self-limiting. • Nervous signs (e.g., muscular tremors, hyperesthesia, clonic–tonic convulsions with ventroflexion of the head and neck, nystagmus) and a high mortality rate (80–90%) are seen in calves with acute clinical coccidiosis.	• Once a horse has colic, it is more likely to develop it again in the future. • If a horse is being treated for conditions other than colic, it has a risk of developing colic as a secondary condition. • Ruminants exhibit colic less frequently than horses.

Disease	Left Displaced Abomasum (LDA)	Right Displaced Abomasum (RDA)	Gastric ulcers
Definition	Displacement can occur to the left (LDA) or right (RDA) side of the abdomen. Although each direction is considered different and separate, there is evidence of a common underlying etiology. They may be different manifestations of the same or similar disease process.	In RDA, hypomotility, gas production, and displacement of the partially gas-filled abomasum occur. Rotation of the abomasum on its mesenteric axis leads to volvulus and local circulatory impairment and ischemia. The volvulus is usually in a counterclockwise direction when viewed from the rear and the right side of the animal, far less frequently than LDA.	A hole in the lining of the stomach corroded by the acidic digestive juices that are secreted by the stomach cells. Mild gastric ulcers are seen in ~50% of foals and 30% of adults.
Presentation	Presenting Clinical Signs • LDA occurs most often and is a result of abomasal hypomotility and gas production. The partially gas-distended abomasum becomes displaced upward along the left abdominal wall lateral to the rumen. It is mostly the fundus and greater curvature of the abomasum that become displaced, thus causing displacement of the pylorus and duodenum. The omasum, reticulum, and liver are also rotated to varying degrees. The abomasal obstruction is partial, and although the segment contains some gas and fluid, a certain amount can still escape, and the distention rarely becomes severe	Presenting Clinical Signs • The omasum is displaced medially and can be involved in the volvulus with occlusion of its blood supply. The omasum, reticulum, and liver are also rotated to varying degrees. Distention is rarely severe. A large quantity of fluid accumulates in the abomasum, as well as chloride. RDA occurs far less frequently than LDA.	Presenting Clinical Signs • Diarrhea • Bruxism • Poor nursing/appetite • Dorsal recumbency • Ptyalism • Attitude changes
	Examination Findings • Moderate-to-total anorexia • Decreased fecal output • Decreased milk production • Treading • Temperature, heart rate, and respiratory rate are usually normal. • The caudal part of the rib cage on the left side may appear "sprung." • Hydration appears subjectively normal except in some chronic cases. • Reduced rumen contractions	Examination Findings • Moderate-to-total anorexia • Decreased fecal output • Decreased milk production • Treading	Examination Findings • Abdominal discomfort • Mild weight loss • Poor body condition

Disease	Left Displaced Abomasum (LDA)	Right Displaced Abomasum (RDA)	Gastric ulcers
Diagnosis	Laboratory • Mild metabolic alkalosis • Hypochloremia • Hypokalemia • Secondary ketosis Imaging • N/A Procedures • A "ping" on simultaneous auscultation and percussion of the abdomen in an area between ribs 9 and 13 in the middle to upper third of the abdomen • Rectal examination reveals a medially displaced rumen and left kidney. The abomasum is rarely palpable.	Laboratory • Metabolic alkalosis • Hypochloremia • Hypokalemia Imaging • N/A Procedures • A "ping" on simultaneous auscultation and percussion of the abdomen in an area between ribs 10 and 13 on the right side of the abdomen. A pneumoperitoneum or gas in the rectum, descending colon, duodenum, or uterus can also cause a right-sided "ping." • The abomasum is only occasionally palpable during rectal exam whereas other gas-filled organs can be palpated by rectal exam and distinguished from a RDA.	Laboratory • N/A Imaging • N/A Procedures • Endoscopy is the only reliable method of diagnosis.
Treatment	Medication • Erythromycin at time of surgery Nursing Care/Patient Care • Rolling the cow into dorsal recumbency and rolling her until the abomasum moves back into a normal position. This is usually only a temporary fix. • Right paramedian abomasopexy • Right flank omentopexy • Blind-stitch abomasopexy • Toggle pin fixation	Medication • Erythromycin at the time of surgery Nursing Care/Patient Care • Surgically corrected using paralumbar fossa omentopexy • *Right paramedian abomasopexy:* This is only done if the cow is not able to stand.	Medication • Omeprazole • Cimetidine • Ranitidine • Famotidine • Antacids (effective for only 2 hours) • Sucralfate • Misoprostal Nursing Care/Patient Care • Dietary management • Frequent feedings

Disease	Left Displaced Abomasum (LDA)	Right Displaced Abomasum (RDA)	Gastric ulcers
Follow-Up	Prevention/Avoidance • Exercise • Lead feeding • Avoid high-concentration rations. • Avoid overconditioning. • Avoid feed sorting. • Reduce the occurrence of periparturient inflammatory diseases such as mastitis and metritis. Complications • Fatty liver disease • If the blood supply to the abomasum, omasum and proximal duodenum is compromised, ischemic necrosis of the abomasum, as well as dehydration, will occur. • Abscess • Herniation Prognosis • Good, but death can occur if severe cases are not corrected	Prevention/Avoidance • Exercise • Lead feeding • Avoid high-concentration rations. • Avoid overconditioning. • Avoid feed sorting. • Reduce the occurrence of periparturient inflammatory diseases such as mastitis and metritis. Complications • Abomasal volvulus can develop rapidly or slowly from an uncorrected right displaced abomasum. Prognosis • Guarded; grave if an abomasal volvulus develops without early surgical intervention	Prevention/Avoidance • Try to avoid confinement; infrequent feedings; a high proportion of concentrated feeds; excessive NSAID use; and the stress of shipping, showing, and work. Complications • Rare bleeding ulcers can cause stomach rupture. • Delayed gastric emptying • Gastroesophageal reflux • Esophagitis • Megaesophagus secondary to chronic gastroesophageal reflux • Ulcers in the proximal duodenum or at the pylorus can cause fibrosis and stricture. Prognosis • Good
Notes	• May occur secondary to concurrent disease • Cows in early lactation are at greatest risk.	• Advanced-stage abomasal volvulus is always palpable by rectal exam.	• In most cases, these ulcers heal without treatment or clinical signs.

Disease	Gastrointestinal Neoplasia	Grain Overload	Hepatic Amyloidosis
Definition	Squamous cell carcinoma of the stomach and the alimentary form of lymphosarcoma are the most common forms of neoplasia involving the GI tract in horses; however, the incidence of GI neoplasia is low.	An acute condition of ruminants that is the result of excessive consumption of readily fermentable carbohydrates. Rapid fermentation with a production of lactic acid and a dramatic decrease in rumen pH lead to an increased rumen acidity and osmolality, inhibit or destroy rumen microbes, and cause forestomach dysfunction and metabolic disturbances. The amount of a feed required to produce acute illness depends on the kind of grain. The degree of severity can also vary (lactic acidosis).	A disease that is characterized by the extracellular deposition of amyloid, a proteinaceous fibril substance, in the liver tissue. This can distort normal tissue architecture and function.
Presentation	Presenting Clinical Signs • Chronic weight loss • Chronic diarrhea	Presenting Clinical Signs • Belly kicking • Anorexia • Diarrhea • Recumbent • Staggering • Standing quietly	Presenting Clinical Signs • Chronic diarrhea • Weight loss • Poor productivity • Decreased appetite
	Examination Findings • Hypoalbuminemia	Examination Findings • Simple indigestion • Fatal acidosis • Enlarged rumen • Possible abdominal pain • Reduced to absent rumen movement • Tachycardia • Tachypnea • Decreased response to stimuli • Slight hypothermia	Examination Findings • Generalized or ventral edema
Diagnosis	Laboratory • Histopathologic examination of the tissue collected during exploratory surgery • Cytologic examination of abdominal fluid Imaging • Enlarged mesenteric lymph nodes or thickened bowel may be detected by ultrasonographic examination. Procedures • Biopsy via gastroscopy • Enlarged mesenteric lymph nodes or thickened bowel may be detected by rectal palpation.	Laboratory • Ruminal pH<5 • Microscopic examination of ruminal fluid to look for the absence of protozoa Imaging • N/A Procedures • Auscultation of the abdomen/rumen • Paracentesis	Laboratory • N/A Imaging • N/A Procedures • Liver biopsy

Disease	Gastrointestinal Neoplasia	Grain Overload	Hepatic Amyloidosis
Treatment	Medication • N/A Nursing Care/Patient Care • N/A	Medication • Fluid therapy • Magnesium hydroxide added to warm water and pumped into the rumen in mild cases Nursing Care/Patient Care • Supportive therapy • Mild indigestion may correct itself if water and grain intake are restricted and hay and exercise are provided • Restrict water intake for the first 18–24 hr • Rumen lavage and inoculation for severely affected animals that are standing	Medication • N/A Nursing Care/Patient Care • N/A
Follow-Up	Prevention/Avoidance • N/A Complications • N/A Prognosis • Grave • Treatment of GI neoplasia in horses is generally not attempted.	Prevention/Avoidance • Reduce the amount of readily fermentable carbohydrate consumed at each meal • Feed bunk management • Diets should also be formulated to provide adequate buffering • Feedlot cattle should be introduced gradually to concentrate rations over a period of ~3 weeks Complications • N/A Prognosis • Good to grave depending on the severity • The diagnosis is usually obvious if the history is available and can be confirmed by the clinical findings.	Prevention/Avoidance • N/A Complications • N/A Prognosis • Poor • It has been associated with severe parasitism and chronic infection or inflammation in horses.
Notes	• N/A	• N/A	• N/A

Disease	Hepatic Lipidosis	Winter Dysentery	Intestinal Chlamydial Infection
Definition	Also called fatty liver disease, this occurs during periods when blood non-esterified fatty acid concentrations are elevated. Fatty liver is most common in periparturient cattle.	An acute, highly contagious GI disorder that affects dairy cattle primarily during winter. It results in severe diarrhea containing mucus and/or blood in the feces. The precise etiology is unclear, although a bovine coronavirus has been implicated as the potential agent. The virus is transmitted via the fecal–oral route through ingestion of feed or water contaminated with feces from clinical cases.	An intestinal infection that plays an important role as an initiating event in the pathogenesis of several chlamydia-induced diseases
Presentation	Presenting Clinical Signs • Depression • Anorexia • Lethargy • Decreased milk production	Presenting Clinical Signs • Viral particles present in respiratory secretions of affected animals may further enhance transmission. Transmission of disease is promoted by close confinement. It is highly contagious and easily introduced to barns by visitors, carrier animals, and fomites. There is a rapid onset of diarrheal disease of short duration in a herd with high morbidity but low mortality.	Presenting Clinical Signs • Newborn calves may have a transient watery-to-mucoid diarrhea with slight fever and nasal discharge. • Signs are more severe in colostrum-deprived calves or in those with only a partial transfer of colostral immunity. • Primary chlamydia-induced enteritis
	Examination Findings • Decreased rumen motility	Examination Findings • Dysentery • A profound drop in milk production • Variable anorexia and depression • Mild respiratory signs such as coughing • Mild colic • Dehydration • Weakness • Rectal exam may reveal dilated intestinal loops. • Decreased rumen motility	Examination Findings • Animal may appear normal or sick.
Diagnosis	Laboratory • Increased serum-free fatty acids • Decreased cholesterol and triglycerides • Liver enzymes are often elevated, but not specific. • Leukopenia and a degenerative left shift are possible, but not specific. Imaging • N/A Procedures • Liver biopsy is the only definitive diagnostic test.	Laboratory • Corona viral particles in fecal samples via ELISA Imaging • N/A Procedures • Diagnosis is by exclusion of other causes of epizootic diarrhea	Laboratory • Fecal exam to a reference lab Imaging • N/A Procedures • N/A

Disease	Hepatic Lipidosis	Winter Dysentery	Intestinal Chlamydial Infection
Treatment	Medication • Intravenous glucose and insulin • Choline • Niacin • Corticosteroids • Vitamin E • Selenium Nursing Care/Patient Care • Supportive care as needed	Medication • N/A Nursing Care/Patient Care • Fresh water • Palatable feed • Free-choice salt • IV fluid therapy or blood transfusions may be required in severely affected cattle.	Medication • High doses of tetracyclines Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • Prevent obesity. • Adequate (increased) protein during the dry period • Reduce the severity and duration of negative energy balance. • Dry matter consumption should be 2% of body weight per day. • Supplement with niacin and cobolt. Complications • Ketosis • Hypoglycemia • Hyperammonemia • Altered endocrine profiles Prognosis • Good to poor	Prevention/Avoidance • N/A Complications • N/A Prognosis • Good. Fatalities are rare.	Prevention/Avoidance • Good husbandry • Clean environment Complications • Infection may spread to the eyes, lungs, or joints. Prognosis • Good
Notes	• Hepatic lipidosis is likely to develop concurrently with another disease such as metritis, mastitis, displaced abomasum, acidosis, and hypocalcemia. • Once fatty liver has developed, it will persist for an extended period.	• N/A	• Chlamydiae have been isolated from fecal samples of clinically normal cattle, goats, sheep, and pigs. Animals with clinically inapparent intestinal infections may shed chlamydiae in the feces for months and possibly years.

Disease	Nonsteroidal Antiinflammatory Drug Toxicosis	Prognathia	Rectal Prolapse
Definition	Toxicosis can develop from oral or parenteral administration of an NSAID. Usually seen when phenylbutazone is administered at high doses or for prolonged periods. Causes right dorsal colitis in horses.	A condition when the mandible is longer than the maxilla. Also referred to as undershot, or monkey mouth or sow mouth in horses.	The result of an increase in the pressure gradient between the abdominal or pelvic cavity and the anus. One or more layers of the rectum protrude through the anus due to persistent tenesmus. Prolapse may be classified as incomplete (where only the rectal mucosa is everted) or complete (where all rectal layers are protruded).
Presentation	Presenting Clinical Signs • Anorexia • Lethargy • Weight loss • Diarrhea • Colic	Presenting Clinical Signs • Possible difficult mastication	Presenting Clinical Signs • An elongated, cylindrical mass protruding through the anal orifice
	Examination Findings • Oral ulceration • Ventral edema	Examination Findings • Examination of the oral cavity reveals that the mandibular incisors are in contact with or rostral to the maxillary incisors.	Examination Findings • Passing a probe, blunt instrument, or finger between the prolapsed mass and the inner rectal wall may be necessary to differentiate from a prolapsed ileocolic intussusception.
Diagnosis	Laboratory • N/A Imaging • Gastric ulceration can be confirmed by gastroscopy. Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • Oral examination	Laboratory • N/A Imaging • N/A Procedures • See examination findings

Disease	Nonsteroidal Antiinflammatory Drug Toxicosis	Prognathia	Rectal Prolapse
Treatment	Medication • Sucralfate • Reduce the production of gastric acid with cimetidine, ranitidine, or omeprazole. Nursing Care/Patient Care • Discontinue the use of phenylbutazone or any other NSAID.	Medication • N/A Nursing Care/Patient Care • Rarely requires any specific treatment • Rasp or shear the offending points and projections if necessary.	Medication • Fecal softeners as needed • Antibiotics postoperatively • Caudal epidural anesthesia is suggested to reduce straining, facilitate repositioning of the prolapse, and permit surgical manipulations. Nursing Care/Patient Care • Reduction by way of lubrication and massage, as well as retention with a purse-string suture, are recommended. • More aggressive treatment of the prolapse is dictated by the condition of the rectum. • The prolapse may be salvaged by conservative measures, unless obvious deep necrosis or trauma to the tissue exists or unless the everted tissue is firm, indurated, and cannot be reduced. • Submucosal resection or amputation should be considered. • Amputation of the rectum should be reserved for severe cases.
Follow-Up	Prevention/Avoidance • N/A Complications • Protein-losing enterocolopathy in horses • Gastric and colonic ulceration Prognosis • Good	Prevention/Avoidance • N/A Complications • Severe anomalies can impair the ability to graze and masticate and, therefore, can have more serious repercussions. Prognosis • Good	Prevention/Avoidance • Avoid estrogens, estrogenic fungal toxins • Deworm Complications • Recurrence of prolapse • Obstipation • Formation of a pararectal abscess • Peritonitis • If neglected, rectal prolapse in mares can lead to prolapse of the small colon. • Complete amputation has a higher incidence of rectal stricture formation, especially in swine. Prognosis • Variable, based on early detection of the prolapse and its reduction. • A fair-to-guarded prognosis, depending on the extent of the tissue involved and its viability, the skill of the surgeon, and postoperative complications.
Notes	• N/A	• N/A	• Causal factors include severe enteritis, endoparasitic, disorders of the rectum (e.g., foreign bodies, lacerations, diverticula, or sacculation), neoplasia of the rectum or distal colon, urolithiasis, urethral obstruction, cystitis, dystocia, colitis, and prostatic disease. • Perineal hernia or other interruption of normal innervation of the external anal sphincter may also produce prolapse.

Disease	Rotavirus Enteritis	Ruminant Acidosis	Salmonellosis
Definition	*Rotavirus* is the most common viral cause of diarrhea in calves, lambs, and foals. Groups A and B rotavirus are involved, but group A is most prevalent and clinically important and contains several serotypes of differing virulence. Transmission through fecal–oral contamination, damaging the tips of the villi in the small intestine, causing maldigestion and malabsorption.	A condition of drastically decreased gastric pH (~<5.5) that occurs after ruminants ingest excessive amounts of rapidly fermentable carbohydrates in conjunction with inadequate fiber. It is characterized by periods of low ruminal pH, decreased feed intake, and subsequent health problems.	An infection caused by many species of salmonellae and characterized clinically by one or more of the following 3 major syndromes: septicemia, acute enteritis, and chronic enteritis. This disease is seen in all animals.
Presentation	Presenting Clinical Signs • Diarrhea • Poor growth rate	Presenting Clinical Signs • Reduced or cyclic feed intake • Decreased efficiency of milk production • Unexplained diarrhea	Presenting Clinical Signs • Diarrhea
	Examination Findings • Dehydration	Examination Findings • Reduced fat test • Poor body condition score despite adequate energy intake • Unexplained laminitis	Examination Findings • Enteritis • Septicemia
Diagnosis	Laboratory • Electron microscopy • ELISA test • Latex agglutination (Virogen Rotatest) Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • Measurement of pH in the ruminal fluid	Laboratory • Fecal cultures • Blood cultures Imaging • N/A Procedures • N/A
Treatment	Medication • Intestinal protectants/adsorbents • Systemic antibiotics Nursing Care/Patient Care • Fluid therapy	Medication • N/A Nursing Care/Patient Care • No specific treatment • Secondary conditions may be treated as needed.	Medication • Flunixin meglumine • Parenteral broad-spectrum antibiotics treat septicemia. Nursing Care/Patient Care • 5% sodium bicarbonate IV in horses
Disease	Rotavirus Enteritis	Ruminant Acidosis	Salmonellosis
Follow-Up	Prevention/Avoidance • Vaccinate mares to stimulate passive immunity to the offspring via colostrum. • Avoid crowding and stress. • Good hygiene • Phenolic disinfectants are needed to kill the virus. Bleach is not effective. Complications • Malnutrition • Emaciation Prognosis • Good to guarded	Prevention/Avoidance • Periparturient cows are at risk of subacute ruminal acidosis. • Dairy cattle, feedlot cattle, and feedlot sheep are all at high risk. • Reduce the amount of readily fermentable carbohydrate consumed at each meal. • Feed bunk management • Diets should also be formulated to provide adequate buffering. Complications • Rumen hypomotility • Sporadic nosebleeds due to caudal vena cava syndrome may be observed. Prognosis • Good	Prevention/Avoidance • Avoid stressors that precipitate clinical disease, include deprivation of feed and water, minimal levels of nutrition, long transport times, calving, and mixing and crowding in feedlots. • Vaccination • Limitation of spread within the herd through good husbandry Complications • Pregnant animals may abort. • Septicemia • Severe acidosis and hyponatremia Prognosis • Good
Notes	• Rotavirus can live in the environment for 9 months. • Rotavirus may be normal in the intestines of adult animals. • Zoonotic • Affects foals	• The ruminal pH has probably been restored to normal by the time an animal is observed to be off feed.	• Many horses may be carriers. In adults, most cases develop after the stress of surgery or transport. Mares may be inapparent shedders and may shed the bacteria at parturition and infect the newborn foal. • The usual route of infection is oral. The organism multiplies in the intestine and causes enteritis. • Greater susceptibility of the young may be due to high gastric pH, absence of a stable intestinal flora, and limited immunity. • Equine salmonellosis epidemics are particularly high in veterinary teaching hospitals. • Zoonotic

Disease	Sand Entercolopathy	Stomatitis
Definition	Consumption of large amounts of sand, which accumulates in the large intestine. Sand is ingested when the horse or foal is kept on sandy pasture or is fed hay or grain in a sandy area.	Severe gingival inflammation, multiple sites of gingival recession and dehiscence, and large areas of ulcerated labial mucosa adjacent to the surfaces of large teeth. May be the result of oral trauma or contact with chemical irritants.
Presentation	Presenting Clinical Signs • Diarrhea • Weight loss • Colic	Presenting Clinical Signs • Frothy salivation • Reluctance to eat • Resistance to oral examination
	Examination Findings • Sand in the feces	Examination Findings • Gingival ulcers, inflammation
Diagnosis	Laboratory • N/A Imaging • Abdominal radiographs that reveal the presence of sand in the large colon Procedures • "Sand sounds" on auscultation of the ventral abdomen	Laboratory • N/A Imaging • N/A Procedures • Oral exam with a speculum under sedation • Curette ulcers to expose embedded foreign material
Treatment	Medication • N/A Nursing Care/Patient Care • Hemicellulose product (psyllium seed hull) administered via nasogastric tube or added to the grain daily	Medication • 0.050–0.125% chlorhexidine oral rinse Nursing Care/Patient Care • N/A
Follow-Up	Prevention/Avoidance • N/A Complications • N/A Prognosis • Good	Prevention/Avoidance • Remove possible causes of the irritation. • Change the quality and quantity of the hay Complications • N/A Prognosis • Good
Notes	• N/A	• Must be differentiated from actinobacillosis, foot-and-mouth disease, malignant catarrhal fever, and bovine viral diarrhea. • Epidemic diseases such as bluetongue in ruminants, swine vesicular disease, and vesicular stomatitis in horses must be ruled out.

Disease	Tyzzer's Disease	Watery Mouth Disease
Definition	A sporadic, acute, focal bacterial hepatitis that occurs in foals from 7–40 days of age and is caused by *Clostridium piliforme.*	A disease of lambs and kids that develops after ingestion of gram-negative bacteria E. coli from contaminated fleece or bedding. The strains involved do not possess the K99 antigen and are normally regarded as nonenteropathogenic and nonenterotoxigenic. The unique digestive physiology of the newborn lamb and absence of gut or systemic antibodies allow ingested bacteria to survive and translocate from the gut to the bloodstream
Presentation	Presenting Clinical Signs • May have no signs of illness • Depression • Anorexia • Diarrhea • Seizures	Presenting Clinical Signs • Dull • Stop feeding • Long strings of saliva drooling from the mouth • Wet muzzle
	Examination Findings • Fever • Icterus	Examination Findings • Mouth may be cold to the touch and contain frothy saliva. • Lacrimation may be seen. • Hypothermia • Gut motility is depressed or absent.
Diagnosis	Laboratory • Increased liver enzymes • Hyperbilirubinemia • Hypoglycemia • Hyperfibrinogenemia Imaging • N/A Procedures • Postmortem exam is the only way to make a definitive diagnosis.	Laboratory • Biochemical and hematologic changes consistent with endotoxemia Imaging • N/A Procedures • N/A
Treatment	Medication • Antimicrobial therapy Nursing Care/Patient Care • Supportive care • IV fluid therapy to correct hypoglycemia and acidosis	Medication • Parenteral antibiotics daily • Minimum of 50 mL electrolyte and 10% glucose solution, containing a water-soluble, oral antibiotic preparation (neomycin and/or streptomycin) fed by stomach tube 3 times a day (TID). Nursing Care/Patient Care • No specific treatment • Enemas may help overcome gut stasis and expel the infecting bacteria.

Disease	Tyzzer's Disease	Watery Mouth Disease
Follow-Up	Prevention/Avoidance • Transmitted through the fecal-oral route. Practice good husbandry. Complications • Death Prognosis • Guarded to poor	Prevention/Avoidance • Avoid intensive indoor lambing systems. • Ewes should be well nourished to ensure a plentiful supply of colostrum. • Pens, ewes, and equipment should be kept as clean as possible throughout lambing to help control the buildup of *E. coli*. Complications • Endotoxic shock Prognosis • Poor to grave • Newborn lambs deprived of adequate colostrum because of sibling competition, weakness, poor mothering, or inadequate maternal supply are at greatest risk. • Twins and triplets are more susceptible than single lambs, particularly when born to ewes in poor body condition. • All colostrum-deprived lambs born indoors become bacteremic within 4–8 hours of birth.
Notes	• N/A	• N/A

Table 4.5 / Musculoskeletal

Disease	Angular Limb Deformities	Bucked Shins	Downer Cow (Problematic Bovine Recumbency)
Definition	Distal portion of the limb turns laterally or medially in early neonatal life. This can be either congenital or acquired.	Cranial surface of the large metacarpal or metatarsal bone is an acute painful periostitis.	After calving, the mature dairy cow is recumbent for 3 hours or more, even after treatment for hypocalcemia. Sternal involuntary recumbency is uncommon and is usually caused by trauma causing nerve paralysis.
Presentation	Presenting Clinical Signs • Lameness • Swelling • Limb is turned.	Presenting Clinical Signs • Area is warm. • Painful swelling • Short strides • Increasing lameness after exercise	Presenting Clinical Signs • Found in lateral recumbency • Listless
	Examination Findings • Based on clinical findings	Examination Findings • Based on clinical findings	Examination Findings • Based on clinical findings • Hypocalcemia
Diagnosis	Laboratory • N/A Imaging • Radiographs Procedures • Correctional Surgery	Laboratory • N/A Imaging • Radiographs Procedures • Physical exam • Lameness exam	Laboratory • CBC Imaging • N/A Procedures • Physical Exam • Vaginal Exam • Rectal exam • Mammary gland exam
Treatment	Medication • N/A Nursing Care/Patient Care • Surgery • Supportive care	Medication • NSAIDs Nursing Care/Patient Care • Rest • Cold packs • Placing screws may also be beneficial.	Medication • N/A Nursing Care/Patient Care • Calcium , phosphorus, magnesium, and potassium therapy • Lateral recumbency must be fixed. • Wet piles of straw over manure
Follow-Up	Prevention/Avoidance • N/A Complications • N/A Prognosis • Poor if not corrected	Prevention/Avoidance • N/A Complications • Lameness Prognosis • Good	Avoidance/Prevention • Monitor during postpartum. • Maternity pens are 12 ft × 12 ft or 10 ft × 14 ft Complications • N/A Prognosis • Fair
Affected Animals	• Foals	• Horses	• Dairy cattle
Notes	• N/A	• N/A	• N/A

Disease	Laminitis (Founder)	Navicular Disease (Podotrochlosis, Podotrochlitis Heel Pain Syndrome)	Osteochondrosis
Definition	Swelling or inflammation of the lamina of the hoof; breakdown of the space between the horny and sensitive laminae	Condition that is chronic and causes degeneration of the navicular bursa and bone. Damage to the flexor area of the bone and the deep digital flexor tendon with osteophyte formation on the proximal and lateral borders of the bone	Can be caused by fast growth, overnutrition, or mineral imbalance. Genetics may also play a role.
Presentation	Presenting Clinical Signs • Anorexic • Depression • Exercise resistant • Taking weight off the affected limb	Presenting Clinical Signs • Takes pressure off the affected foot by pointing or advancing, and the heel is off the ground. • Not consistently lame • When walking, the stride is reduced and the animal may also be likely to stumble.	Presenting Clinical Signs • Distention of the affected joint that is nonpainful • *In foals:* Trouble keeping up with others in the pasture; recumbent; joint swelling; stiffness; and lameness • *Yearlings and older:* Lameness that is severe, muscle atrophy, pain in the joint flexion
	Examination Findings • Heat • Bounding pulse	Examination Findings • Lameness appears on the distal forelimb after a flexion test. • Brachiocephalic muscle may be sore due to change in gaits and posture.	Examination Findings • Based on clinical findings
Diagnosis	Laboratory • N/A Imaging • Radiographs Procedures • Lameness test • Flexion test • Blocks	Laboratory • N/A Imaging • Degenerative changes concerning the navicular bone (enlarged synovial fossae and marginal osteophytes) are seen on radiographs. Procedures • Physical exam • Palmar digital nerve block	Laboratory • N/A Imaging • Radiographs • Ultrasound • Nuclear imaging Procedures • Synovial fluid analysis
Treatment	Medication • Flunixin meglumine • Phenylbutazone • Phenoxybenzamine hydrochloride Nursing Care/Patient Care • Nerve blocks • Ice packing • Heart-bar shoes	Medication • NSAIDs (phenylbutazone) • Isoxsuprine hydrochloride (peripheral vasodilator) • Intrabursal injection of corticosteroid Nursing Care/Patient Care • Hoof trimming • Rest • Wedge pad in the shoe • Palmar digital neurectomy can be done but is not recommended.	Medication • Injection of long-acting corticosteroids Nursing Care/Patient Care • Arthroscopic surgery • Supportive care

Disease	Laminitis (Founder)	Navicular Disease (Podotrochlosis, Podotrochlitis Heel Pain Syndrome)	Osteochondrosis
Follow-Up	Prevention/Avoidance • Keep animal at optimal weight. • Decrease stress. • Prevent grain overload. Complications • N/A Prognosis • Good	Prevention/Avoidance • N/A Complications • Lameness Prognosis • Guarded to Poor	Prevention/Avoidance • N/A Complications • N/A Prognosis • Good
Affected Animals	• Horses • Cattle • Sheep • Goats	• Horses	• Horses
Notes	• N/A	• N/A	• N/A

Disease	Sandcracks (Vertical Fissures)	*Sarcocystis*	Seedy Toe (Hollow Wall, Dystrophia Ungulae)
Definition	Hoof cracks or fistulas are caused.	*Sarcocystis* is a protozoan that attacks the endothelium, muscles, and other soft tissues.	The hoof wall and toe region lose substance and change in the horn area.
Presentation	Presenting Clinical Signs • Cracks in the hoof	Presenting Clinical Signs • Most are asymptomatic, and the parasite is found at slaughter. • *Severe cases:* Anorexia, decreased milk production, diarrhea, spasm of the muscles, hyperexcitabilty, weakness • After recovery, sheep lose their wool.	Presenting Clinical Signs • The outer surface of the wall of the hoof is sound, but the inner surface is dry and crusty.
	Examination Findings • Based on clinical findings	Examination Findings • Fever • Abortion • Cachexia	Examination Findings • Based on clinical findings

Disease	Sandcracks (Vertical Fissures)	*Sarcocystis*	Seedy Toe (Hollow Wall, Dystrophia Ungulae)
Diagnosis	Laboratory • N/A Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • N/A
Treatment	Medications • Methyl methacrylate in type II and III once tied with wire Nursing Care/Patient Care • Type I should be dressed with an antibiotic dressing.	Medications • Amprolium Nursing Care/Patient Care • Supportive Care	Medications • N/A Nursing Care/Patient Care • Pack the foot with juniper tar and oakum.
Follow-Up	Avoidance/Prevention • N/A Complications • Septic infection can occur in type I. Prognosis • Good	Avoidance/Prevention • Do not allow animals to eat raw or dead animals. Complications • N/A Prognosis • Fair if disease is caught	Avoidance/Prevention • N/A Complications • N/A Prognosis • Good
Affected Animals	• Dairy cattle	• Horses • Cattle • Goats • Sheep • Pigs	• Horses • Cattle • Goats • Sheep
Notes	Classified into 5 Categories • *Type I fissures:* Caused mainly by traumatic injury limited to the coronary band • *Type II fissures:* From the coronary band to the center of the dorsal wall • *Type III fissures:* Whole wall is involved. • *Type IV fissures:* Very rare • *Type V fissures:* Only the central region of the hoof is involved.	• Humans can serve as intermediate hosts.	• N/A

Disease	Sheared Heel	Thrush	White Line Disease
Definition	Imbalance of the foot and unevenness of the heels. One side of the heel hits the ground before the other side and shears the bulb.	Secondary bacterial infection that starts in the central and collateral sulci and is a degeneration of the frog.	The corium becomes infected by the opening of the fibrous junction between the sole and the wall on the abaxial border of the sole.
Presentation	Presenting Clinical Signs • Lameness • Painful heels • Non–weight-bearing	Presenting Clinical Signs • Moist sulcus, with a thick black discharge and a very distinct odor	Presenting Clinical Signs • Lameness • Pain • Buckling of the hoof • Discharge/Pus • Swelling of the heal bulb
	Examination Findings • Based on clinical findings	Examination Findings • Based on clinical findings	Examination Findings • Based on clinical findings
Diagnosis	Laboratory • N/A Imaging • N/A Procedures • Based on clinical findings	Laboratory • N/A Imaging • N/A Procedures • History of wet pastures and the owner's neglect in cleaning the hoof	Laboratory • N/A Imaging • Radiographs Procedures • Physical Exam
Treatment	Medication • N/A Nursing Care/Patient Care • Trimming of the hoof and shoeing	Medication • Astringent lotion Nursing Care/Patient Care • Dry, clean pasture • Cleaning out the foot daily • Bar shoes after the disease has been fixed.	Medication • N/A Nursing Care/Patient Care • Draining the abcess
Follow-Up	Prevention/Avoidance • Proper shoeing • Proper trimming Complications • N/A Prognosis • Good	Prevention/Avoidance • Keep in dry pastures • Clean hoofs regularly Complications • N/A Prognosis • Favorable	Prevention/Avoidance • N/A Complications • N/A Prognosis • Good
Affected Animals	• Horses • Cattle • Goats • Sheep	• Horses	• Horses • Cattle
Notes	• Deep fissuring between the bulbs of the heel, as well as thrush, hoof crack, and navicular disease, are all common.	• Most common in the hind feet	• N/A

Table 4.6 / Neurology

Disease	Bovine Spongiform Encephalopathy (BSE)	Equine Dysautonomia (Grass Sickness)	Equine Protozoal Myeloencephalitis (EPM)
Definition	Connected with an irregular form of membrane protein—PrP (prion protein)	Reduction of gastrointestinal motility because of degeneration of the autonomic nervous system. Only found in Europe.	EPM of horses that affects the central nervous system. The protozoa that causes this disease is *Sarcocystis neurona*. Myeloencephalitis refers to that portion of the animal that is affected. "Myelo" refers to the spinal cord and "encephalitis" refers to an infection/inflammation of the brain.
Presentation	Presenting Clinical Signs • At the start of the disease, signs are faint, within weeks to months onset can become fatal • Nose licking • Sneezing • Snorting • Wrinkling of the nose • Tossing and rubbing of the head • Teeth grinding • Animals in pasture spook easily. • Starring • Head kept low • Weight loss • Milk production decreases. • Tremors	Presenting Clinical Signs • Patches of sweat • Penile prolapse • Drooling • Thoracic and pelvic limbs are held close together.	Presenting Clinical Signs • Slight lameness • Weakness • Ataxia, incoordination • Muscle atrophy • Head tilt • Facial paralysis on both sides, difficulty swallowing • Behavioral abnormalities • Seizures • Recumbent
	Examination Findings • Based on clinical findings • Animals that are restrained show exaggerated reaction to the menace reflex, corneal reflex, head shyness, and kicking. • Ataxia	Examination Findings • Tachycardia • Colic • Dysphagia • Stomach tube is hard to pass • Barium pools in the thoracic esophagus. • The mucosa is dry and tacky on rectal palpation, and feces are hard.	Examination Findings • Diseases affecting the CNS (brain and spinal cord) • May be acute or slow onset. • Can include the brain, brain stem, and/or spinal cord • Can develop very rapidly or slowly • May see improvement but symptoms will resume days, weeks, or months later • Normally bright and alert throughout the disease
Diagnosis	Laboratory • N/A Imaging • N/A Procedures • *Hindbrain:* Histopathology, immunohistochemistry (IHC), and electron microscopy	Laboratory • N/A Imaging • N/A Procedures • Physical exam and history	Laboratory • Blood work • Differential diagnosis Imaging • Radiographs of neck Procedures • Physical exam including a neurologic exam • Spinal tap • Rule out any other neurological diseases.

Disease	Bovine Spongiform Encephalopathy (BSE)	Equine Dysautonomia (Grass Sickness)	Equine Protozoal Myeloencephalitis (EPM)
Treatment	Medication • N/A Nursing Care/Patient Care • N/A	Medication • N/A Nursing Care/Patient Care • Supportive Care	Medication • ReBalance® oral suspension • NAVIGATOR® oral paste • Marquis® oral paste Nursing Care/Patient Care • Supportive Care
Follow-Up	Avoidance/Prevention • N/A Complications • N/A Prognosis • Fatal	Avoidance/Prevention • N/A Complications • N/A Prognosis • Fair	Avoidance/Prevention • N/A Complications • N/A Prognosis • Poor
Affected Animals	• Cattle	• Horses	• Horses
Notes	• Animals must be euthanized. • Humans can contract BSE by eating infected meat. In humans, it is variant Creutzfeldt-Jakob disease (vCJD).	• N/A	• N/A

Disease	Laryngeal Hemiplegia	Louping Ill (Ovine Encephalomyelitis)	Sporadic Bovine Encephalomyelitis (Chlamydial Encephalomyelitis)
Definition	The left arytenoid cartilage and vocal folds become partially paralyzed or completely paralyzed because of the loss of the large myelinated fibers in the distal portion of the recurrent laryngeal nerves, resulting in neurogenic atrophy of the intrinsic laryngeal musculature, the most crucial of which is the cricoarytenoideus dorsalis muscle.	A viral disease that effects the central nervous system and is transmitted by ticks. It is a European disease that is found mostly in Europe.	*Chlamydophila pecorum* causes this disease.
Presentation	Presenting Clinical Signs • Exercise intolerance. • There is inspiratory noise, asymptomatic during rest, but a tendency to have a strange whinny.	Presenting Clinical Signs • Nibbling due to nervousness • Weakness • Fine muscular tremors	Presenting Clinical Signs • Depression • Anorexia after a few days of the virus • Oversalivation • Diarrhea • Weight loss • Calves are wobbly and unable to stand straight. • In the end stages, calves are recumbent.

Disease	Laryngeal Hemiplegia	Louping Ill (Ovine Encephalomyelitis)	Sporadic Bovine Encephalomyelitis (Chlamydial Encephalomyelitis)
	Examination Findings • Based on clinical findings	Examination Findings • Ataxia • Collapse	Examination Findings • High fever • Based on clinical findings
Diagnosis	Laboratory • N/A Imaging • Endoscopic Procedures • N/A	Laboratory • N/A Imaging • N/A Procedures • Histopathology of the brain, virus isolation from CNS tissue, and serology	Laboratory • N/A Imaging • N/A Procedures • Based on clinical findings
Treatment	Medication • N/A Nursing Care/Patient Care • Supportive Care • Rest • Prosthetic laryngoplasty	Medication • N/A Nursing Care/Patient Care • Supportive Care • Nursing • Hand feed	Medication • *Antibiotics:* Tetracyclines, oxytetracyclines, and Tylosin Nursing Care/Patient Care • Supportive care
Follow-Up	Avoidance/Prevention • N/A Complications • N/A Prognosis • Good	Avoidance/Prevention • Insecticides • *Inactive vaccine:* A single injection given every 2 years. When breeding, vaccinate at 6–12 months of age. Complications • N/A Prognosis • Fair	Avoidance/Prevention • N/A Complications • N/A Prognosis • Guarded
Affected Animals	• Race horses	• Sheep • Cattle • Goats • Horses • Pigs	• Cattle
Notes	• N/A	• Animals with high titers can pass the virus to ticks.	• Seen in cattle from 3 months to 3 years of age • Lasts 10–14 days

Disease	Stringhalt
Definition	• One or both hind limbs have spasmodic overflexion of the joints. • Endemic form and postinjury form are possible.
Presentation	Presenting Clinical Signs • The nimal will experience moments of mild hyperflexion by lifting the foot and dropping it, as well as extreme hyperflexion where the animal lifts its foot to its stomach and drops it quickly. They may also have atrophy of the lateral thigh muscles.
	Examination Findings • Based on clinical findings
Diagnosis	Laboratory • N/A Imaging • Endoscopic Procedures • Electromyography
Treatment	Medication • N/A Nursing Care/Patient Care • Supportive Care
Follow-Up	Avoidance/Prevention • N/A Complications • N/A Prognosis • Good to guarded
Affected Animals	• Horses
Notes	• This disease has been connected to lathyrism (sweet pea poisoning).

Table 4.7 / Ophthalmology

Disease	Chlamydial Conjunctivitis	Equine Recurrent Uveitis (Periodic Ophthalmiac, Moon Blindness, Equine Uveitis)	Infectious Keratoconjunctivitis (Pink Eye)

Definition	Inflammation of the conjunctiva, characterized by redness and often accompanied by a discharge	Frequent immune-mediated ocular disease	• Characterized by conjunctivitis, lacrimation, corneal opacity and ulceration, and twitching of the eyelid
			• Possible causative agents:
			  • Bovine: Gram-negative rod *Moraxella bovis*, *Mycoplasma species*
			  • *Ovine: Chlamydophila psittaci* and *Chlamydophila pecorum*
			• Ulceration can cause keratoconjunctivitis as well.

Presentation	Presenting Clinical Signs • Serous to mucopurulent conjunctivitis and rhinitis • In the beginning, the infection is unilateral. The sclera is red and somewhat swollen, and the conjunctiva is somewhat swollen. • After a few days, bilateral conjunctivitis develops with defined follicles on the inside of the third eyelid in more severe cases.	Presenting Clinical Signs • Painful eye • Blepharospasm • Watering eye • Inflammation • Retinal bleeding • Hazy look to the eye • Can be bilateral but usually one eye is more inflamed than the other • Closed eyes	Presenting Clinical Signs • Sensitive to light • Eye twitching • Overproduction of tears • Discharge becomes mucopurulent later in the infection. • Conjunctivitis • Anorexia due to discomfort or inability to see the food

	Examination Findings
	• Based on clinical findings
		Examination Findings
		• Chronic cases:
		  • Fibrosis in the iris
		  • Glaucoma
		  • Cataracts
		  • Retinal degeneration
		  • Corneal scarring
			Examination Findings
			• Blepharospasm
			• Epiphora

Diagnosis	Laboratory • N/A Imaging • N/A Procedures • With a spatula or sharp teaspoon, scrape the conjunctiva and smear scrapings onto a glass slide.	Laboratory • CBC • Chemistry panel Imaging • N/A Procedures • Conjunctival biopsies • Based on clinical findings • Find a possible underlying cause.	Laboratory • Cytologic evaluation Imaging • N/A Procedures • Conjunctival scrapings • Rule out other eye diseases.
Disease	Chlamydial Conjunctivitis	Equine Recurrent Uveitis (Periodic Ophthalmiac, Moon Blindness, Equine Uveitis)	Infectious Keratoconjunctivitis (Pink Eye)
Treatment	Medication • *Oxytetracycline:* Treat for 7–10 days after the last sign. Nursing Care/Patient Care • N/A	Medication • Cyclopsorine • Atropine • Topical steroidal and nonsteroidal • Flunixin meglumine • After the initial treatment, this can be switched to phenylbutazone. Nursing Care/Patient Care • Supportive care	Medication • Ampicillin, penicillin, gentamicin, and kanamycin—topically • Atropine ointment • NSAIDs Nursing Care/Patient Care • Eye patch may be used. • Isolation
Follow-Up	Prevention/Avoidance • N/A Complications • If left untreated, complications can be severe. Prognosis • Good	Prevention/Avoidance • Fly control • Change the bedding frequently. • Routine worming and vaccinations • Keep contact with cattle or wildlife to a minimum. • Keep away from swampy pastures. • Good nutrition Complications • N/A Prognosis • Good	Prevention/Avoidance • Isolation of new animals • Fly control Complications • N/A Prognosis • Good
Affected Animals	• Lambs • Goats	• Horses	• Sheep • Goats • Horses • Cattle
Notes	• Rarely can be transmitted to humans	• Caused by trauma or systemic disease	• Can be caused by traumatic ulcerations

Disease	*Thelazia*
Definition	Eye worm of large animals. The vector is face fly, *Musca autumnalis*. • *Horses: Thelazia lacrymalis* • *Cattle: Thelazia gulosa, Thelazia skrjabini* , and *Thelazia rhodesii*
Presentation	Presenting Clinical Signs • Mild conjunctivitis • Increased lacrimation • Edema • Clouding of the cornea
	Examination Findings • Subconjunctival cysts occasionally
Diagnosis	Laboratory • N/A Imaging • N/A Procedures • Clinical signs
Treatment	Medication • *Horse:* Potassium iodide, topically • Antibiotic-steroid ointment • Levamisole at 5 mg/kg • Ivermectin doramectin for anthelmintics Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • Fly control Complications • N/A Prognosis • Good
Affected Animals	• Horses • Cattle
Notes	• N/A

Table 4.8 / Respiratory

Disease	Acute Bronchointerstitial Pneumonia	Aspiration Pneumonia
Definition	Sporadic and rapid disease characterized by acute respiratory distress and high mortality	Caused by inhalation of foreign material, causing pulmonary infection characterized by inflammation and necrosis
Presentation	Presenting Clinical Signs • Foals are reluctant or unable to move and are usually cyanotic. • Respiratory distress	Presenting Clinical Signs • A sweetish, fetid breath characteristic of gangrene may be detected. • Purulent nasal discharge may be tinged reddish-brown or green.
	Examination Findings • High Fever • Cyanotic • Hypoxemia • Hypercapnia • Respiratory acidosis	Examination Findings • Cyanosis • Bronchospasm • Horses may develop a fever of 104–105°F. • Fever is uncommon but may be seen in cattle.

		• Dyspnea • Tachypnea • Tachycardia • Wheezing sounds, pleuritic friction rubs, and crackling sounds of subcutaneous emphysema may be heard.
Diagnosis	Laboratory • Blood gas • CBC • Serum chemistry Imaging • Thoracic radiographs Procedures • N/A	Laboratory • CBC Imaging • Thoracic radiographs Procedures • Physical exam
Treatment	Medication • Antiinflammatory • Broad-spectrum antibiotics • Bronchodilators Nursing Care/Patient Care • Thermoregulation • Oxygen • Fluids	Medication • Atropine to control salivation • Antibiotics • Cough suppressant Nursing Care/Patient Care • Kept quiet • Fluids
Follow-Up	Prevention/Avoidance • N/A Complications • N/A Prognosis	Prevention/Avoidance • When tube feeding, make sure the tube is in the esophagus and not in the trachea. • Make sure the endotracheal tube is inflated during surgery. • Oxygen

	• Fair	Complications • N/A Prognosis • Poor
Affected Animals	• Foals	• Horses • Cattle • Pigs • Sheep • Goats
Notes	• N/A	• Pigs that are fed particulate food in a dry environment are prone to inhalation of the feed granules. • Pigs and cattle recover more often than horses. Animals that recover may develop pulmonary abscess. • Toxemia is usually fatal within 1–2 days in cows that aspirate ruminal contents.
Disease	**Bovine Respiratory Syncytial Virus**	**Epiglottic Entrapment**
Definition	RNA virus classified as a pneumovirus in the paramyxovirus family	Causes respiratory noise and exercise intolerance because the aryepiglottic fold completely encases the apex and lateral margins of the epiglottis.

Presentation	Presenting Clinical Signs • Depression • Decreased eating • Cough • Nasal and eye discharge • Open-mouth breathing	Presenting Clinical Signs • Inspiratory and expiratory sounds during exercise • Reduced exercise performance • Cough • Nasal discharge • Head shaking
	Examination Findings • N/A	Examination Findings • Diagnosis • Based on clinical findings
Diagnosis	• Often, when in combination with other viral agents and bacteria, the diagnosis is presumptive due to the number of animals affected and their ages and circumstances (e.g., housed).	Laboratory • N/A Imaging • Endoscopic Procedures • Surgical correction to fix the folds
Treatment	• Treatment with antibiotics is often used to treat secondary infections, to lessen clinical signs, and to help the body focus on eliminating the virus.	Medication • N/A Nursing Care/Patient Care • Reduce exercise until surgery • Supportive care
Follow-Up	• N/A	Prevention/Avoidance • N/A Complications • N/A

		Prognosis • Good
Affected Animals	• Bovine	• Horse
Notes	• N/A	• N/A
Disease	**Lungworm Infection**	**Nasal Polyps**
Definition	Infection of the lower respiratory tract, causing bronchitis or pneumonia. It is caused by: • *Cattle:* The parasitic nematode *Dictyocaulus viviparus* • *Horses: Dictyocaulus Filaria* • *Sheep and goats: Muellerius capillaries* • *Pigs: Metastrongylus apri*	Pedunculated growths that come from the mucosa of the nasal cavity, nasal septum, or tooth alveolus due to chronic inflammation
Presentation	Presenting Clinical Signs • Coughing • Respiratory distress • Weight loss • Reduced milk production • Subclinical signs can be seen. • *Cattle:* Coughing with rapid, shallow breaths. Standing with their heads stretched forward and mouths open and drooling	Presenting Clinical Signs • Airflow does not easily go through the affected nasal passage. • Inspiratory dyspnea • Malodorous, mucopurlent nasal discharge from one nostril • Small nose bleeds
	Examination Findings • *Cattle:* Tachypnea, high infestation. Lung sounds are particularly loud at the bronchial bifurcation, with abnormal lung sounds in caudal lobes.	Examination Findings • Based on clinical findings

Diagnosis	Laboratory • ELISA tests Imaging • Thoracic radiograph Procedures • Bronchoscopy • Fecal exam • Bronchial lavage	Laboratory • Biopsy Imaging • Radiographs Procedures • Endoscopic • Surgical repair
Treatment	Medication • Antibiotic • Antiparasitic Nursing Care/Patient Care • Supportive Care	Medication • N/A Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • Clean up feces Complications • N/A Prognosis • Good	Prevention/Avoidance • N/A Complications • N/A Prognosis • Good
Affected Animals	• Horses • Cattle • Sheep • Goats • Pigs	• Horses
Notes	• The lungworm is coughed up, then swallowed.	• N/A
Disease	***Pasteurella* and *Mannheimia* Pneumonias**	**Pasteurellosis**
Definition	Cranioventral lung divison. Bronchopneumonia is caused by	Complication of mycoplasmal pneumonia can be caused by

	Pasteurella multocida or *Mannheimia haemolytica*.	swine influenza, Aujeszky's disease, *Bordetella bronchiseptica* , or *Haemophilus parahaemolyticus*.
Presentation	Presenting Clinical Signs • Serous to mucopurulent eye and nasal discharge • Anorexia • Coughing • Lethargy	Presenting Clinical Signs • See Pneumonia.
	Examination Findings • Fever of 104–106°F • Dyspnea • Harsh lung sounds	Examination Findings • See pneumonia
Diagnosis	Laboratory • N/A Imaging • N/A Procedures • *Acute cases:* Tracheal swabs, or washes • Histopathologic examination	Laboratory • N/A Imaging • N/A Procedures • On necropsy, *Pasteurella* is found.
Treatment	Medication • Antibiotics • NSAIDs Nursing Care/Patient Care • Supportive care	Medication • Control pneumonia Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • Control ventilation, crowding, mixing of animals from different	Prevention/Avoidance • N/A Complications

	farms, poor nutrition, and transportation.	• N/A Prognosis • Guarded
Affected Animals	• Sheep • Goats • Cattle	• Swine
Notes	• Group breakouts usually occur 10–14 days after stress • *Feedlot situation:* The outbreaks are anticipated 2 weeks following the arrival in the feedlot.	• Outbreaks have been seen in pigs that have been in contact with sheep.
Disease	**Pharyngitis**	**Pneumonia**
Definition	The walls of the pharynx are inflamed. This may appear with most upper airway viral and bacterial respiratory infections.	Infection of the lower respiratory tract; acute or chronic inflammation of the lungs and bronchi
Presentation	Presenting Clinical Signs • Wanting to eat and drink with trouble swallowing	Presenting Clinical Signs • Lethargy • Deep cough • Anorexia • “Blowing” of the lips
	Examination Findings • Based on clinical findings	Examination Findings • Progressive dyspnea • Cyanosis, usually on exercise • Fever • Leukocytosis • Auscultation of the lungs—consolidation, which may be patchy but is more commonly diffuse
Diagnosis	Laboratory	Diagnosis

	• Culture of fluids draining Imaging • Radiographs of the throat Procedures • Endoscopic of the throat	• CBC Imaging • Thoracic radiograph Procedures • Bronchoalveolar lavage
Treatment	Medication • Antibiotics • *Intranasal sprays:* Dimethyl sulfoxide [DMSO], local anesthetic, and antimicrobial agents Nursing Care/Patient Care • Supportive care • Removing the foreign body, if needed	Medication • Bronchodilators • Antibiotics Nursing Care/Patient Care • Keep in a warm, dry place.
Follow-Up	Prevention/Avoidance • N/A Complications • Choking Prognosis • Prognosis is good, but death can occur.	Prevention/Avoidance • Decrease stress and travel. • Prevention of other infectious diseases • Vaccines are available. Complications • N/A Prognosis • Fair
Affected Animals	• Horse • Cattle • Sheep • Goats • Pigs	• Horse • Cattle • Sheep • Goats • Pigs

Notes	• N/A	• N/A
Disease	**Recurrent Airway Obstruction (RAO) (Heaves, Chronic Obstructive Pulmonary Disease [COPD])**	**Sheep Nose Bot**
Definition	Performance-limiting, allergic respiratory bronchitis	*Oestrus ovis* is a broad-based parasite. When it is in the larval stage, it moves into the nasal passages and sinuses.
Presentation	Presenting Clinical Signs • Flared nostrils • Productive cough that usually occurs during feeding • Heave line • The characteristic breathing pattern is a prolonged, labored expiratory phase of respiration.	Presenting Clinical Signs • When the larvae start to move throughout the nasal passages, a large amount of discharge occurs—clear and mucoid at first, mucopurulent and commonly tinged with streaks of blood produced by the hooks and spines of the larvae. • Ongoing movement of the larvae, especially if they are numerous. They cause thickening of the nasal mucosa, which causes the mucopurulent discharge and difficult respiration. • Sneezing caused by migrations of the larger larvae
	Examination Findings • *On auscultation:* Extended expiratory phase, wheezing, tracheal rattle, overexpanded lung fields,	Examination Findings • Based on clinical findings

	and crackles can be present. • Tachypnea	
Diagnosis	Laboratory • Based on clinical findings Imaging • Thoracic radiographs can be taken, but aid little in diagnosis. Procedures • Bronchoalveolar lavage is rarely used.	Laboratory • N/A Imaging • N/A Procedures • N/A
Treatment	Medication • Combination of bronchodilating agents (to aid in relief of airway obstruction) and corticosteroids (to decrease pulmonary inflammation)	Medication • Ivermectin Nursing Care/Patient Care • Supportive care
Follow-Up	Prevention/Avoidance • *Reduce allergen exposure:* Pasture with fresh grass. If the horse must be stalled, the stall should be cleaned daily and the horse should not be kept in the indoor arena or where hay is kept. Soak the hay prior to feeding. Straw bedding should be avoided. Complications • Secondary respiratory infections are common.	Prevention/Avoidance • N/A Complications • N/A Prognosis • Larvae that are unable to escape die, usually become calcified, and can lead to septic sinusitis.

	Prognosis • This disease generally progresses as the animal ages, so it may eventually lead to death.	
Affected Animals	• Horses	• Sheep • Goats
Notes	• Horses in the Southeastern US may show signs in late summer, which is most likely caused by molds and grass pollens. This is referred to as summer pasture–associated obstructive pulmonary disease.	• May run around with their nose to the ground with their head shaking, sneezing, and stomping their feet, particularly in warm weather. • Sheep may gather with their faces in the center of a circle and their heads down. • The inflammation in the sinuses may infrequently spread to the brain and be fatal.
Disease	**Sinusitis**	**Tracheal Edema Syndrome**
Definition	An infection involving the frontal sinus (due to dehorning) and maxillary sinus (due to infected teeth)	Mucosa and submucosa edema in the dorsal membrane and lower trachea
Presentation	Presenting Clinical Signs • Anorexia • Nasal discharge—unilateral or bilateral • Bad breath • Protrusion of the eyeball • Neurologic signs	Presenting Clinical Signs • Increased respiration in hot weather • Loud inspiratory noise
	Examination Findings • Fever	Examination Findings • Cyanosis in severe cases

	• Deformation of the frontal bone	• Based on clinical findings
Diagnosis	Laboratory • Cytology of aspirated material Imaging • Radiographs Procedures • Percussion of sinus may cause a dull sound.	Laboratory • N/A Imaging • N/A Procedures • Based on clinical findings
Treatment	Medication • NSAIDs • Lavaged daily with antiseptic solutions • Antibiotics Nursing Care/Patient Care • Draining the affected sinus • Tooth removal, if infected	Medication • Antibiotics • Corticosteroids Nursing Care/Patient Care • Tracheostomy • Keep in cool place with fans or in the shade. • Movement should be limited.
Follow-Up	Prevention/Avoidance • Dehorn when young. Complications • N/A Prognosis • Guarded	Prevention/Avoidance • N/A Complications • N/A Prognosis • Fair
Affected Animals	• Cattle	• Cattle
Notes	• N/A	• Cattle that recover but are prone to

			reoccurrence should be sent to slaughter.

Table 4.9 / Urology

Disease	Bovine Cystitis and Pyelonephritis (Contagious Bovine Pyelonephritis)	Porcine Cystitis	Swine Kidney Worm Infection	Urolithiasis
Definition	Inflammation of the urinary bladder that may move up the ureters and cause infection of the kidneys (pyelonephritis). This is often seen after giving birth.	*Escherichia* coli, *Arcanobacterium (Actinomyces)* pyogenes, *Streptococcus* spp , and *Staphylococcus* spp. are all bacterias that have been isolated in this disease. These inhabit the lower urinary tract and are often responsible for nonspecific urinary tract infections.	*Stephanurus dentatus* are thick-bodied worms (2–4.5 cm long) found encysted in pairs up the ureters from the kidney to the bladder.	Uroliths can be found anywhere in the urinary tract; and urethroliths that obstruct cause urine retention, which leads to bladder distention, abdominal pain, and perforation of the urethral and can cause the bladder to rupture.
Presentation	Presenting Clinical Signs • The first sign is blood-stained urine in an otherwise normal cow. • Anorexia • Loss of milk • Colic with restlessness • Tail switching	Presenting Clinical Signs • *Acute:* Animal is often found dead, most likely from acute renal failure. • *Symptomatic:* Animals that are symptomatic usually have a fever. • Anorexia • Hematuria • Urine is characteristically reddish-brown with a strong odor of ammonia.	Presenting Clinical Signs • Decreased weight gains • Unthrifty	Presenting Clinical Signs • Can either be partial or complete urethral occlusion • *Partial obstruction:* Urine-tinged blood dribbles after extended stranguria attempts at urination. • Before complete occlusion occurs, urine may have dried on the preputial hairs and leave noticeable mineral deposits. • *Complete urethral obstruction:* Tenesmus, tail twitching, weight shifting, colic-like signs, anorexia, bloat, depression, and rectal prolapse. • Steers might raise their tails and demonstrate urethral pulsations just ventral to the rectum. • Goats might vocalize. • Sloughing may occur causing pseudouethra.
	Examination Findings • Fever • Pyuria • Polyuria • Hematuria	Examination Findings • Pyuria • Urinary pH can increase from normal values (5.5–7.5) and can rise to 8–9. • Animals that are symptomatic usually have a fever. • Struvites may be found in the lumen.	Examination Findings • N/A	Examination Findings • Clinical Signs
Disease	Bovine Cystitis and Pyelonephritis (Contagious Bovine Pyelonephritis)	Porcine Cystitis	Swine Kidney Worm Infection	Urolithiasis
Diagnosis	Laboratory • Urinalysis Imaging • N/A Procedures • N/A	Laboratory • Urinalysis • CBC Imaging • N/A Procedures • N/A	Laboratory • Ova present Imaging • N/A Procedures • Necropsy	Laboratory • Urinalysis Imaging • Ultrasound Procedures • Abdominocentesis • Palpation
Treatment	Medication • Antibiotics Nursing Care/Patient Care • Supportive care	Medication • Antibiotics are given in the early stages of the disease. Penicillin and ampicillin are most often the drugs of choice. Nursing Care/Patient Care • Supportive care	Medication • Ivermectin • Fenbendazole • Levamisole Nursing/Patient Care • Sanitization	Medication • Antispasmodics • Tranquilizers Nursing Care/Patient Care • Perineal urethrostomy • Electrolyte replacement and fluids • Cystotomy after dietary management in sheep and goats
Follow-Up	Avoidance/Prevention • N/A Complications • N/A Prognosis • Good	Prevention/Avoidance • Maintain outstanding hygiene during breeding and parturition. • Facilities must be correctly planned to lower the spread of pathogens throughout the breeding herd and to allow for well-organized removal of feces from the environment. • Free-choice water should be accessible at all times. • Proper removal of older sows is important because they are at higher risk of urinary tract disease. Complications • N/A Prognosis • Guarded	Prevention/Avoidance • "Gilts only" breeding programs help prevent obvious infections. Young boars from clean herds replace older boars 2 years and older. Gilts are bred, weaned, then sold. Complications • N/A Prognosis • Air	Avoidance/Prevention • Provide a calcium:phosphorus ratio of 2:1 in the total ration. • Add sodium chloride up to 4% of the total ration. • Ammonium chloride can be added as a urinary acidifying agent. • Urine acidification antagonizes magnesium-ammonium-phosphate crystal. Complications • Ruptured bladder Prognosis • Guarded if bladder ruptures
Affected Animals	• Cattle	• Pigs	• Pigs	• Cattle • Sheep • Goats
Notes	• N/A	• N/A	• N/A	• N/A

Disease	Uroperitoneum
Definition	Urine that has leaked into the peritoneal space
Presentation	Presenting Clinical Signs • Seen to be normal at birth but increasingly becomes lethargic in a 24- to 48-hour span • As the disease get worse, the abdomen becomes obviously distended. • Tries to urinate often, with only small amounts of urine produced • Anuric
	Examination Findings • Tachycardic and tachypneic in a 24- to 48-hour span • A fluid wave may be felt upon palpation.
Diagnosis	Laboratory • Analysis of blood and peritoneal fluid Imaging • N/A Procedures • EKG
Treatment	Medication • N/A Nursing Care/Patient Care • Surgery to fix the defect • Supportive care • Fluids
Follow-Up	Avoidance/Prevention • N/A Complications • N/A Prognosis • Fair
Affected Animals	• Foals
Notes	• N/A

Chapter 5

Reproduction

Katie Brown, Ryan Healy, and Maria Ferrer

Key Terms and Phrases		Abbreviations	
Abomasum	Meconium	AI: Artificial insemination	GnRH: Gonadotropin releasing hormone
Allantochorion	Metritis	AV: Artificial vagina	IEPF: Immunosuppressive early pregnancy factor
Chorioallantois	Ova	BCS: Body condition score	IgG: Immunoglobulin G
Corpus luteum	Ovaries	BSE: Breeding soundness examination	LH: Luteinizing hormone
Diestrum	Oviduct	CASA: Computer assisted semen analysis	MLV: Modified live virus
Dystocia	Oxytocin	CL: Corpus luteum	MRP: Maternal recognition of pregnancy
Endometrium	Parturition	CMT: California Mastitis Test	N/A: Not applicable
Estrogen	Progesterone	Dop: Doppler ultrasound	PAG: Pregnancy-associated glycoproteins
Estrus	Prostaglandin	DSO: Daily sperm output	PBS: Phosphate-buffered saline
Fetal loss	Rotaviral diarrhea	eCG: Equine chorionic gonadotropin	$PGF_{2\alpha}$: Prostaglandin $F_{2\alpha}$
Fetus	Scrotum	EPF: Immunosuppressive early pregnancy factor	PSPB: Pregnancy-specific protein B
Fetotomy	Septicemia	EEE: Eastern equine encephalitis	RR: Respiratory rate
Follicle stimulating hormone	Spermatozoa	EVA: Equine viral arteritis	SC: Scrotal circumference
Hemorrhage	Spirette	FSH: Follicle stimulating hormone	TSW: Total scrotal width
Infundibulum	Stillbirth		WEE: Western equine encephalitis
Insemination	Strangles		
Intramuscular	Testicles		
Ketone	Testosterone		
	Vas deferens		

Introduction

The veterinary technician can play a significant role in the assessment and management of reproductive processes in large animals. A technician can help manage herds and contribute to sustaining the country's meat and milk production, as well assist in maintenance of the animals' overall health. Knowing what vaccines are applicable to breeding stock and applicable during gestation are vital to both the offspring's and the dam's health. Understanding reproductive processes in large animals will help the technician manage herds more efficiently, so that the individual animals meet the breed standard. This understanding will also aid in producing offspring that will fit a specific market in order to command a maximum price.

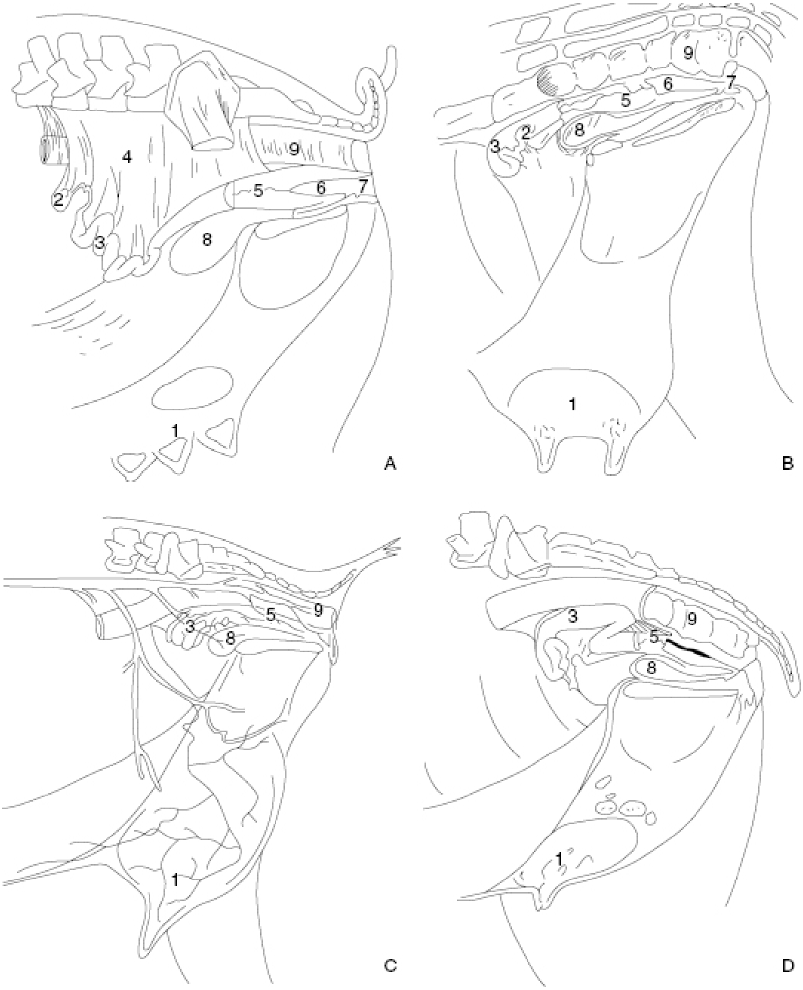
Female Reproductive Anatomy

Table 5.1 / Female Reproductive Anatomy. (See Figure 5.1.)

Organ	Definition/Reproductive Importance
Ovaries	Follicles with oocytes develop within the outer ovarian cortex and produce estrogen. The central part or medulla contains the vasculature, nerves, and lymphatics. An ovarian bursa surrounds the oval-shaped ovary in ruminants. In mares, the medulla is superficial, while the cortex is internal. The cortex reaches the surface only at the ovulation fossa, which is located on the ventral border of the ovary. This is the only area where ovulation occurs in mares.
Oviduct	Site of fertilization and early embryonic development. The infundibulum secures and guides the ovulated oocyte into the oviduct. The oviducts open into the uterine horns. The mare and camelid have a papilla at the utero-tubal junction that allows passage of embryos into the uterus, but does not allow passage of unfertilized oocytes.
Uterus	Bicornuate organ, with a short body that bifurcates into a left and right horn. The muscular layer or myometrium aids in expulsion of the fetus at parturition, sperm transport, and evacuation of inflammatory contents. The uterus is lined by epithelium called endometrium, which is responsible for production of uterine milk to nurture the embryo, for placentation, and for fetal support. The endometrium releases prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) in the nonpregnant female. The endometrial surface of the mare has longitudinal folds that provide the surface for placentation. In ruminants, it has multiple

	protuberances called caruncles, which are the maternal contribution to the placenta.
Cervix	The cervix connects the uterus with the vagina. It isolates the uterus from the external environment during pregnancy by tightening under the influence of progesterone and producing a mucus plug. During estrus, it produces mucus that lubricates the vagina for copulation and flushes out bacteria. In ruminants and swine, several rings protrude into the cervical canal and interlock. In mares, longitudinal cervical folds are continuous with the endometrial folds.
Vagina	Copulatory organ and part of the birth canal at parturition. It extends from the cervix to the transverse fold, which lies over the urethral orifice.
Vestibule	The vestibule extends from the transverse fold to the vulva. A suburethral diverticulum is present in the floor in cows and sows, immediately ventral to the urethral opening. The submucosa houses the Bartholin's or vestibular glands, which secrete mucus during estrus.
Vulva	The vulva consists of two labia and a clitoris, located in the fossa clitoris at the ventral commissure. It is the first anatomic barrier between the external environment and the uterus.
Broad Ligaments	These suspend the ovaries, oviducts, and uterus from the abdominal wall. Each broad ligament consists of two layers that are continuous with the lining of the peritoneal cavity. Arteries, veins, lymphatics, and nerves that supply the genital tract, as well as smooth muscle, are located between these two layers. The right and left ligaments converge over the uterine body and cervix.

Figure 5.1 Lateral view of the reproductive tract of the (A) sow, (B) cow, (C)doe, and (D) mare. 1 = Mammary glands; 2 = Ovary; 3 = Uterus; 4 = Broad ligament; 5 = Cervix; 6 = Vagina; 7 = Vestibule; 8 = Bladder; 9 = Rectum. Illustration by Nathan Davis.



Male Reproductive Anatomy

Spermatozoa are produced from division and differentiation of stem cells called spermatogonia within the seminiferous tubules in a process called spermatogenesis. Spermatogenesis occurs throughout adult life; its length varies with the species (Table 5.3). After being released from the testes, spermatozoa are transported to the epididymis, where they acquire fertilizing capability. Sperm maturation and transport through the epididymis take about 10–14 days.

Table 5.2 / Male Reproductive Anatomy. (See Figure 5.2, Figure 5.3, and Figure 5.4.)

Organ	Definition/Reproductive Importance
Scrotum	Located in the perineal area in boars and camelids and in the inguinal area in ruminants and stallions, the scrotum aids in thermoregulation for spermatogenesis. The spermatic cord houses the pampiniform plexus, the efferent ducts, and the cremaster muscle, and it extends from the inguinal ring to the testes.
Testicles	They contain the seminiferous tubules where spermatogenesis occurs. Sertoli cells within the seminiferous tubules regulate spermatogenesis, and Leydig cells in the interstitial compartment produce testosterone. The seminiferous tubules converge into the rete testis.
Epididymis	The efferent ducts connect the rete testis with the epididymis, which is the site of sperm transport, maturation, and storage. The epididymis is divided into a head, body, and tail. The tail is caudal in stallions and camelids, ventral in ruminants, and dorsal in swine.
Vas Deferens	Spermatozoa reach the urethra through the deferent ducts, which enlarge to form an ampulla before opening into the urethra. The tail of the epididymis, deferent ducts, and ampulla form the extragonadal sperm reserves.
Accessory Sex Glands	They produce seminal plasma, which is the liquid, noncellular portion of the ejaculate. The paired vesicular glands or seminal vesicles are located dorsal to the pelvic urethra. They produce the majority of the seminal plasma in boars and the gel fraction in stallions. The prostate gland lies dorsal to the neck of the bladder. The paired bulbourethral glands or Cowper's glands are located over the pelvic urethra near the ischial arch. In boars, they produce the gel fraction. All accessory sex glands are present in large animals, except for camelids, which have no vesicular glands.
Penis And Prepuce	Copulatory organ. Ruminants, boars, and camelids have a fibroelastic penis with a sigmoid flexure that extends during erection. Small ruminants have a urethral process that is thought to aid in spraying semen around the cervix. Camelids have a cartilaginous process, and boars have a corkscrew configuration that

	helps penetrate the cervix. Boars also have a preputial diverticulum in the dorsal aspect of the cranial prepuce. This cavity collects urine, semen, and bacteria. The contents empty onto the penis providing lubrication for intromission. The equine penis is vascular and contains a large amount of erectile tissue. Erection occurs by engorgement of this tissue with an increase in penile diameter. Semen is forced through the cervix by urethral pulses and prevention of retrograde loss by the engorged corona glandis.

Figure 5.2 Male reproductive tract of the (A) buck, (B) boar, and (C) bull. Illustration by Nathan Davis.

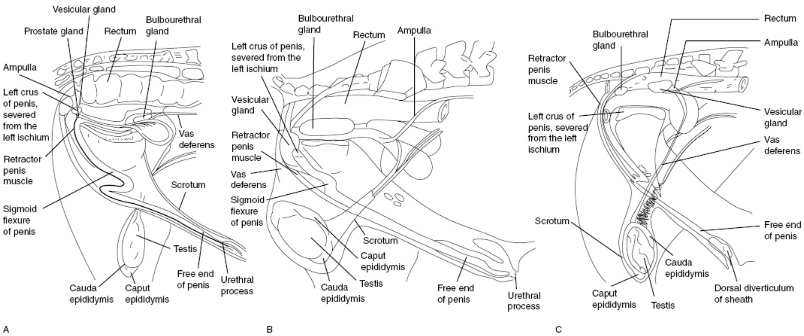


Figure 5.3 Disposition and location of the (A) bovine, (B) equine, and (C) camelid scrotum.

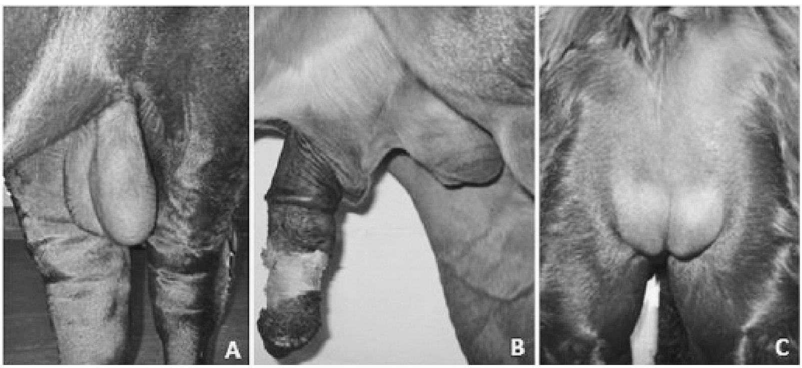


Figure 5.4 Anatomy of the (A) bovine, (B) equine, and (C) camelid penis. 1 = Penis shaft; 2 = Prepuce; 3 = Corona glandis; 4 = Cartilaginous process; Arrow = Urethra.

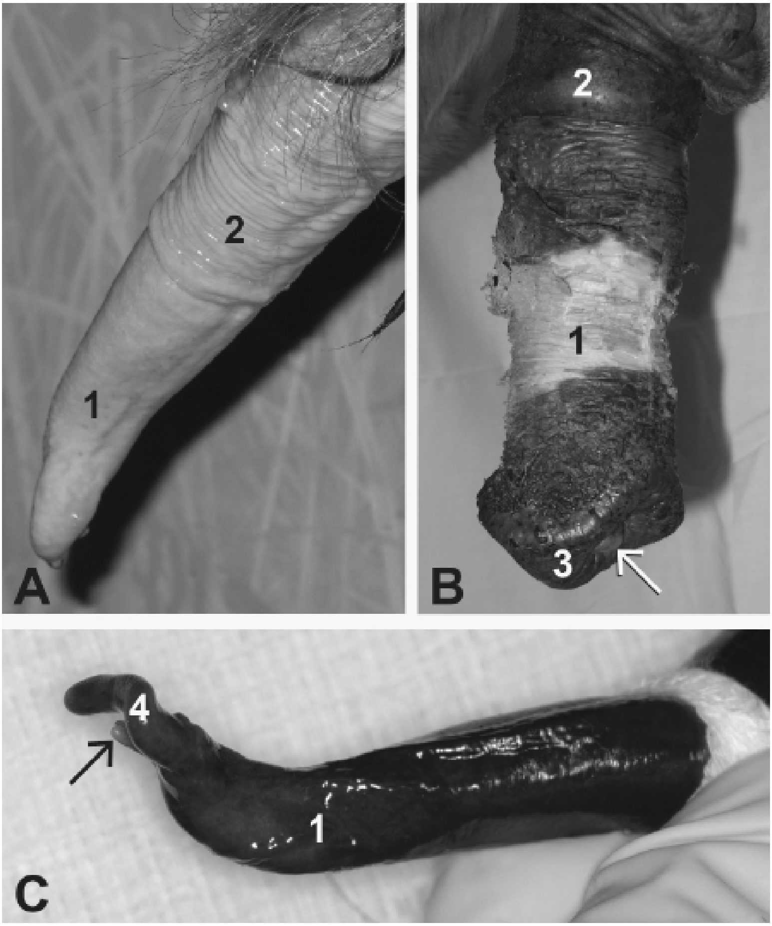


Table 5.3 / Reproductive Parameters in the Male

Parameter	Stallion	Bull	Ram	Boar	Camelid
Length of Spermatogenesis (days)	57	61	47	39	N/A
Length of Copulation	20–60 seconds	1–3 seconds	1–2 seconds	5–20 minutes	20–40 minutes
Site of Semen Deposition	External cervical os	Vagina	External cervical os	Cervix uterus	Uterus
Ejaculate Volume (ml)	60–100	3–5	0.8–1.0	200–250	2–3
Total Sperm ($\times 10^9$)	5–12	4–5	3–4	10–100	0.05–0.27

Boars and stallions ejaculate in three fractions (Table 5.4). Camelid semen is highly viscous since it contains a gel material produced by the bulbourethral glands.

Table 5.4 / Ejaculatory Fractions in Boars and Stallions

Fraction	Definition/Reproductive Importance
First or Pre-Sperm Fraction	Watery secretion that cleans the urethra prior to ejaculation. Its origins are the bulbourethral glands in stallions.
Second or Sperm-Rich Fraction	Milky fluid that contains mostly spermatozoa. It originates from the epididymis, ampulla, and prostate glands (stallions) or the vesicular glands (boars).
Third or Gel Fraction	Clear gel from the vesicular glands (stallions) or bulbourethral glands (boars) that flushes out sperm remaining in the urethra.

Female Reproductive Physiology

After puberty, the female begins estrous cycles that continue throughout most of her life. Some species display estrous cycles year-round, while others have seasonal reproductive activity (Table 5.5). Photoperiod is the main factor regulating seasonality, but temperature and nutrition may also play roles.

Table 5.5 / Large Animal Reproductive Physiology

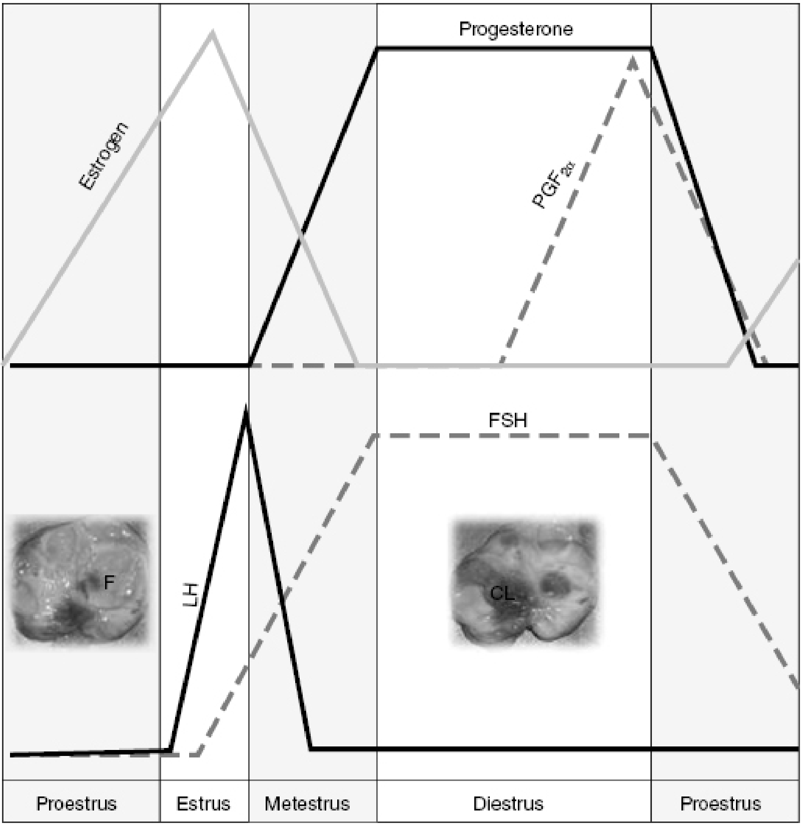
Species	Puberty (Months)	Seasonality	Estrous Cycle Length (Days)	Estrous Duration	Ovulation
Equine	12–15	Long day breeder	21	5–7 d	1–2 d before end of estrus
Bovine	10–15	Nonseasonal	21	12–18 hr	12–18 hr after end of estrus
Small Ruminant	6–9	Short day breeder	Sheep: 21 Goats: 21	30 hr	24–30 hr after start of estrus
Porcine	6–9	Nonseasonal	21	2–3 d	36–44 hr after start of estrus
Camelid	12–15	Nonseasonal	Induced ovulator	1–36 d	24–48 hr after mating

Table 5.6 / Phases of the Large Animal Estrous Cycle. (See Figure 5.5.)

Phase	Definition/Explanation
Proestrus	Inputs from the brain initiate release of gonadotropin-releasing hormone (GnRH) from the hypothalamus. GnRH reaches the anterior pituitary gland to induce the release of luteinizing hormone (LH) and follicle stimulating hormone (FSH). FSH reaches the ovaries through the bloodstream and initiates follicular growth. Proestrus lasts 2–5 days.

Estrus	Phase dominated by estrogen. As follicles grow, they produce estrogen and inhibin. Estrogen induces behavioral and anatomical changes that facilitate mating, transport of semen within the female tract, and fertilization. Estrogen stimulates further GnRH release, which results in a surge of LH toward the end of estrus. When LH reaches the ovary, it induces ovulation. Inhibin prevents further FSH release so that only one follicle continues to grow and is available for ovulation. In pigs, multiple follicles ovulate during each estrus.
Metestrus	The oocyte is released from the follicle into the oviduct at ovulation, and the follicle undergoes transformation into a corpus hemorrhagicum first and then a corpus luteum (CL). Metestrus lasts 2–5 days.
Diestrus	Diestrus lasts 12–16 days. It is characterized by high concentrations of progesterone produced by the CL. Progesterone induces the behavioral and anatomical changes needed to support a pregnancy. If pregnancy does not occur, the endometrium releases prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$), which lyses the CL and allows for a return to proestrus and a new opportunity for mating.
Anestrus	Some females display lack of estrous cycles. Anestrus is seasonal in mares (winter) and small ruminants (summer). Suckled sows remain in anestrus until weaning, while cows may do so for 45–60 days after parturition.

Figure 5.5 Diagram of hormonal changes during the estrous cycle. CL = Corpus luteum; F = Follicle.

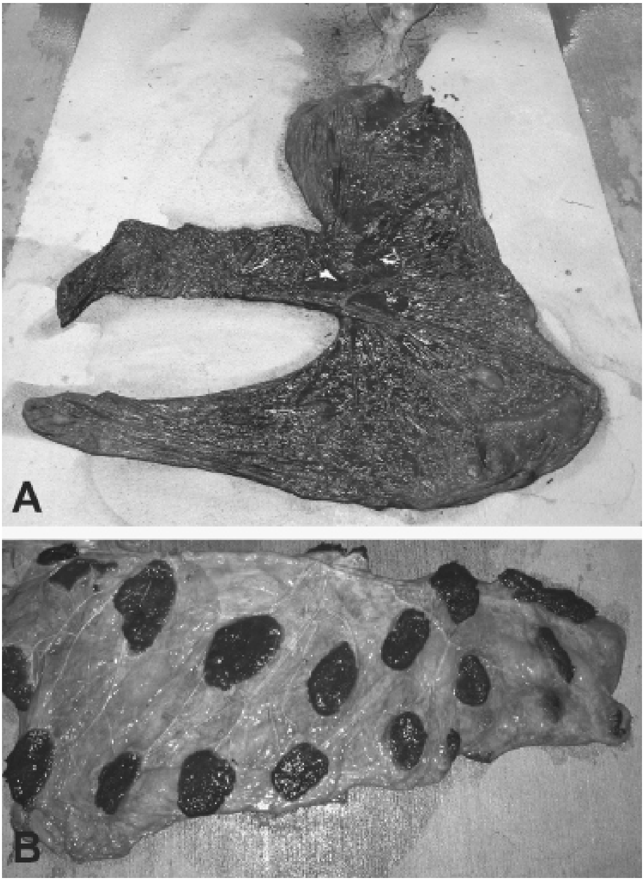


Progesterone is the hormone responsible for pregnancy maintenance. If pregnancy occurs, lysis of the CL is prevented by the embryo to ensure continuous progesterone secretion. This process is called maternal recognition of pregnancy (MRP) (Table 5.7). The placenta is the organ of maternal and fetal exchange of gases, nutrients, and waste. The distribution of the areas of attachment varies with the species (Table 5.7, Fig. 5.6).

Table 5.7 / Large Animal Gestation. (See Figure 5.6.)

Species	Maternal Recognition of Pregnancy (Days)	Source of Progesterone (Gestation Day)	Placenta	Mean Gestation Length (Days)
Equine	12–14 Embryo mobility	CLs (0–150), placenta (>150)	Diffuse	340
Bovine	15–16 IFN-τ	CL (0–150), placenta (150–250), both (>250)	Placentomes	283
Caprine	13–14 IFN-τ	CL	Placentomes	150
Ovine	13–14 IFN-τ	CL (0–50), placenta (>50)	Placentomes	150
Porcine	11–12 Estrogen	CL	Diffuse	114
Camelid	8–10 Embryo in left horn	CL	Diffuse	335

Figure 5.6 (A) Equine chorioallantoic membrane with diffuse distribution of the chorionic villi. (B) Bovine chorioallantoic membrane with round cotyledons. The cotyledons interdigitate with the uterine caruncles to form the placental unit called placentome.



Male Breeding Soundness Examination

A breeding soundness examination (BSE) is an assessment of the male's ability to establish pregnancy in a group of females. It evaluates factors that influence that ability, such as quality and quantity of spermatozoa, libido and mating ability, physical defects or lesions of the genital tract, venereal infectious diseases, and heritable defects (Table 5.8, Table 5.9, Table 5.10, and Table 5.11). Fertility is assumed for the time of the examination only.

Table 5.8 / Genital Examination

Step	Procedures
History	Includes information about pregnancy rate, number of females mated, use for natural mating or artificial insemination, previous illnesses or infectious diseases, and intended use of the male.
Physical Examination	Presence of conformational abnormalities, lameness or neurological signs, and body condition score are assessed. A complete physical examination is then performed with the animal physically restrained. Special attention is paid to vision and teeth in ruminants.
Screening for Venereal Diseases	Samples are collected to screen for *Tritrichomonas foetus* and *Campylobacter* spp. (bulls), *Taylorella equigenitalis, Klebsiella pneumoniae, Pseudomonas aeruginosa*, and equine viral arteritis virus (stallions), *Brucella ovis* (rams), or classic swine fever, *Leptospira* spp., PRRS virus, pseudorabies virus (boars).
Scrotal Evaluation	The scrotal skin is inspected for dermatitis, insect bites, lacerations or edema. Presence of two scrotal testes is confirmed with palpation, as well as their mobility within the scrotum, symmetry, size, shape, consistency, temperature, and sensitivity. Epididymes and spermatic cords are also palpated. The size of the testes is correlated with sperm output, age at puberty of female offspring, and ovulation rate. It is a heritable trait in ruminants and varies with breed, season, and age. Depending on the species, the scrotal circumference (ruminants) or width (stallions and boars) is measured to estimate testicular size. The expected daily sperm output (DSO) can be predicted from testicular measurements in stallions.
Penile Evaluation	The penis is exteriorized manually or during semen collection. The surface should be free of vesicular, proliferative, or inflammatory lesions.
Evaluation of Accessory Sex Glands	The accessory sex glands and ampullae are evaluated with transrectal palpation for symmetry, size, consistency, and sensitivity.
Semen Collection	Semen is collected most commonly by electroejaculation (ruminants), artificial vagina (AV) (stallions), gloved hand

and Evaluation	technique (boars), or postcoital aspiration (camelids). A complete semen evaluation is performed.
Serving Capacity Test	Since semen collection in bulls is typically done with electroejaculation, evaluation of mating ability is not possible. A serving capacity test can be performed where bulls are introduced to a pen with restrained sedated cows for 20 minutes. Bulls have low, medium, or high service capacity if they service 0–1, 2–3, or ≥ 4 cows, respectively, in 20 minutes.

Table 5.9 / Semen Collection Techniques. (See Figure 5.7.)

Electroejaculation	
Materials: • Electroejaculator with 3-electrode probe (19 cm × 3.5 cm for small ruminants; 6.5–7.5 cm in diameter for bulls <2000 lb; 9 cm in diameter for older bulls), lubricant, and collection cup or cone	*Technique:* • The pelvic urethra is massaged for 60 seconds. The lubricated probe is inserted into the rectum with the electrodes facing ventrally. Intermittent electrical stimulation is applied by rotating the knob of the electroejaculator for 2–3 seconds, with a rest period of 2–3 seconds between stimuli.
Gloved hand	
Materials: • Vinyl or nitril gloves, estrus or phantom sow, Styrofoam cup with capacity for 300–500 ml with gauze placed over the opening	*Technique:* • The boar mounts an estrous or phantom sow. After initial thrusting, the sheath is massaged to evacuate preputial fluid and exteriorize the penis. Constant pressure is applied to the glans penis with the gloved hand, while the Styrofoam cup is held close to the glans with the other hand. The sperm-rich and gel fraction are collected. The gel fraction is filtrated with the gauze.
Artificial Vagina	
Materials: • Artificial vagina, thermometer, hot	*Technique:* • The AV is filled with hot water to an inner temperature of 45–48°C. When the stallion

water, nonspermicidal lubricant, collection bottle, and estrous or phantom mare	mounts the estrous or phantom mare, the penis is deviated to the side; and the AV is slid over the penis. The stallion thrusts and ejaculates within the AV. All semen fractions are collected. The gel fraction is filtrated with a gel filter.

Figure 5.7 (A) Materials used for breeding soundness exam, semen collection, and evaluation in ruminants. 1 = Small ruminant probe; 2 = Bovine probes; 3 = Electroejaculator; 4 = Scrotal tape; 5 = Collection cone; 6 = Microscope; 7 = Slide warmer; 8 = Hancock stain and immersion oil; 9 = Slides, coverslips, and transfer pipettes; 10 = Cell counter. (B) Assembled small ruminant (sr) and equine (eq) artificial vaginas.

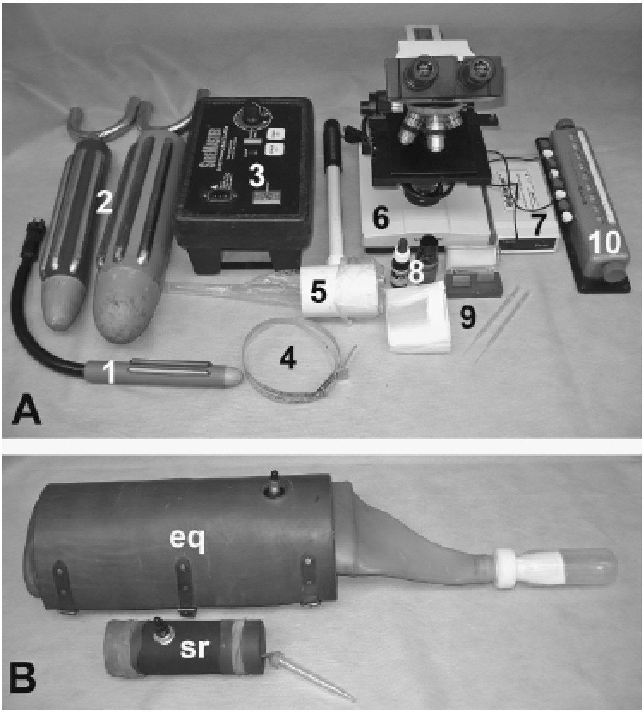


Table 5.10 / Semen Evaluation

Parameter	Procedures and Interpretation

Volume	Measured in a graduated vial. Not reliable for ejaculates collected with electroejaculation.
Color	Normally white.
Aspect	Aspect correlates with sperm concentration and can be cloudy, milky, or creamy.
Gross or Mass Sperm Motility	Estimated in ruminants. A drop of raw semen (10 µl) is placed on a warm slide (37°C) without a coverslip. The wave motion is observed under light microscopy at 10X. The vigor of the wave is graded as very good (vigorous swirls), good (slow swirls), fair (no swirls but prominent individual cell motion), or poor (little or no individual cell motion).
Individual Sperm Motility	Evaluated with a phase contrast or light microscopy. A drop of semen is placed on a warm slide and covered with a coverslip. The percentage of progressively motile sperm is subjectively estimated to the nearest 5–10% at 40 X. If sperm concentration is high, semen may be diluted in prewarmed phospate-buffered saline (PBS)or 2.9% sodium citrate solution to distinguish individual sperm more easily. Sperm motility can be assessed objectively with computer assisted semen analysis (CASA).
Sperm Concentration	Not reliable in samples collected with electroejaculation. Raw semen is diluted 1:100 in formalin buffer solution. Sperm are counted in the central grid of both chambers of the hemacytometer. The average number counted is the concentration in 10^6/ml. Densimeters, CASA, and nucleocounter systems can also be used.
Sperm Morphology	A drop of semen is mixed with a drop of Hancock stain, and a smear is prepared and air dried. The sample is examined under oil immersion and 100–200 spermatozoa are classified as normal, as having primary abnormalities, or as having secondary morphological abnormalities. Primary abnormalities arise from the testes, while secondary abnormalities arise from the epididymis. Abaxial attachment of the midpieces is normal in boars and stallions. Phase contrast microscopy can be used with unstained samples.
Total Sperm Numbers	In stallions, two ejaculates are collected one hour apart. The total sperm numbers in the second ejaculate are the most significant parameters in the semen evaluation of stallions. Ejaculates from fertile stallions contain >1.1 billion normal motile spermatozoa.

Table 5.11 / Sperm Abnormalities

Primary Abnormalities	Secondary Abnormalities
Head • Micro- or macrocephalic, pyriform, round, elongated Acromosome Knobbed Midpiece Abaxial, double, swollen, coiled, kinked, looped Principal piece Coiled, looped Fractured neck Proximal cytoplasmic droplet	Acromosome Missing, swollen, folded Distal cytoplasmic droplet Bent principal piece Terminally coiled tail Detached heads

Males are classified as satisfactory potential breeders if they are free of lameness or neurologic signs that may impair mating ability, venereal diseases, and lesions of the genital tract and if they meet the minimum requirements for testes size (Table 5.12) and semen quality (Table 5.13). A satisfactory potential breeder is expected to achieve acceptable pregnancy rates in a group of sound, disease-free, fertile females. Failure to reach the minimum requirements results in a classification as a questionable or unsatisfactory potential breeder. Classification can be deferred and males can be re-examined >2 months later to determine if the changes were permanent or temporary. Culling is recommended for males that are consistently classified as unsatisfactory potential breeders. No guidelines are currently available for interpretation of BSEs in camelids.

Table 5.12 / Minimum Acceptable Testicular Size in Satisfactory Potential Breeders

Species (Method)	Age (m)	Testicular Size (cm)
Bull (SC)	≤15	30
	15–18	31
	18–21	32
	21–24	33
	≥24	34
Stallion (TSW)	Any	8

Buck (SC)	5	14
	8	20
	21	26
	36	30
Ram (SC)	6–12	30
	12–18	33
Boar (Width x Length)	6–7	4.5 × 7
	8–9	5 × 8
	10–12	5.5 × 8.5
	12–15	6 × 9.5
	>15	6.5 × 10

SC = Scrotal circumference; TSW = Total scrotal width.

Table 5.13 / Minimum Acceptable Semen Quality in Satisfactory Potential Breeders

Parameter	Bull	Stallion	Buck	Ram	Boar
Motile Sperm (%)	30	N/A	70	30	60–70
Morphologically Normal Sperm (%)	70	N/A	80	70	75–80
Total Sperm ($x10^9$)	N/A	N/A	1	N/A	15
Total Normal Motile Sperm ($x10^9$)	N/A	1.1	N/A	N/A	N/A

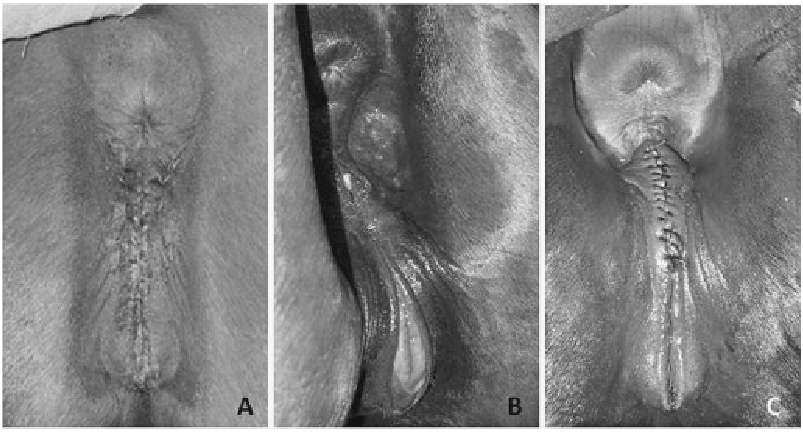
Female Breeding Soundness Examination

Table 5.14 / Steps of the Female Breeding Soundness Examination. (See Figure 5.8.)

Step	Description

History	Fertility, medications, previous pregnancies, regularity of estrous cycles, illness or injury
Physical Exam	The female is restrained in hand, chutes, or stocks. A complete physical exam is done noting any lameness, systemic disease, or heritable conditions.
External Genital Exam	The tail is wrapped and tied to the side. The perineum is cleansed with antiseptic, rinsed with water, and dried. The vulva is examined for discharge that may indicate infection or for urine staining that may indicate urovagina. The vulvar labia should meet evenly and firmly. In mares, the vulva should have a cranial-to-caudal slope of ≤10° with 2/3 of the vulvar cleft below the ischial arch. Poor conformation can result in ascending endometritis.
Internal Genital Exam	The mucosae of the vestibule, vagina, and cervix are examined visually with a vaginal speculum. The ovaries and uterus are evaluated with transrectal palpation and ultrasound to assess location, size, tone, and symmetry, as well as presence of physiologic and pathologic structures.
Screening for Venereal Diseases	In mares, samples for endometrial culture and cytology are collected transcervically using a culture swab or low-volume lavage. *Streptococcus zooepidemicus* and *Escherichia Coli* are most commonly isolated from mares with endometritis, while *Klebsiella pneumoniae, Pseudomonasa aruginosa* and *Taylorella equigenitalis* may have venereal transmission.
Additional Laboratory Tests	In mares, an endometrial biopsy is collected with an alligator biopsy forceps. Endometrial biopsies receive a score depending on the severity and frequency of inflammatory and degenerative changes. The scores are correlated with foaling rate. Uterine endoscopy, endocrine and cytogenetic tests, or exploratory laparoscopy or laparotomy may be indicated.
Interpretation	No standardized guidelines are available for interpretation. Management or treatment of the female is determined based on presence of anatomical, inflammatory, infectious, or degenerative conditions identified during the BSE. Interpretation of endometrial biopsies provides a prognosis for a mare's ability to carry a foal to term.
Notes	Indicated in cases of infertility or pregnancy loss, or as part of a pre-purchase exam of breeding stock. Aimed at identifying the cause of subfertility, elaborating a treatment or management plan, and giving a prognosis for future fertility.

Figure 5.8 Mare with (A) normal and (B) poor vulvar conformation and (C) with a Caslick's suture placed.



Estrous Detection

Estrous detection is an important component of artificial insemination programs. Appropriate identification of the estrous female allows insemination to occur at the optimal time to ensure conception. Errors in estrous detection are the most important problems in breeding management of any species.

Table 5.15 / Estrous Detection Techniques

Technique	Definition/Description/Signs
Visual Detection (Ruminants, Equine, Swine)	• *Cow:* Cows are kept in groups and allowed to interact with each other. Their behavior is observed twice daily for 30 minutes. A heat detector animal can be used to improve the accuracy. Vasectomized bulls, bulls with a surgically altered penis (gomer bulls), androgenized steers, cows, or heifers can be used. • *Mare:* The mare is teased across a barrier (stall door, fence, or teaser rail). • *Sow:* Groups of 6–12 gilts are taken to the boar, or the boar is walked along individual sow stalls.

Mount Markers (Ruminants)	• A halter with a paint reservoir (chin-ball marker) located under the chin of the teaser animal leaves a stripe of paint on the rump of the mounted cow. Alternatively, chalk or livestock paint is applied to the tailhead. Mounting results in rubbed-off markings. In sheep, teaser rams wearing a harness with chalk leave a colored mark on the top of the ewes after mounting.
Pressure-Activated Mount Detectors (Bovine)	• Pressure during mounting activates mount detectors glued to the cow's rump. The “Kamar heatmount detector” turns from white to red after activation. Pressure-sensing radiotelemetric devices transmit information about frequency and duration of mounts to a computer.
Evaluation of Electrical Resistance (Bovine)	• Electrical resistance of vaginal fluids is measured with a probe and is minimal at estrus.
Pedometry (Bovine)	• Devices placed on the neck or legs of the cows measure physical activity, which is maximal at estrus.
Transrectal Palpation and Ultrasound (Equine)	• Ovarian structures, uterine echogenicity, and tone are evaluated. Findings during estrus are a ≥25-mm follicle, uterine edema, flaccid uterus, and cervix.

Table 5.16 / Behavioral Signs of Estrus in Large Animals

Species	Signs of Estrus
Bovine	Standing to be mounted (primary sign), mounting or trailing other cows, mucous vulvar discharge, swollen red vulva, restlessness, vocalization, chin resting, lip curling, and sniffing the genitalia of other cows (secondary signs)
Equine	Winking, tail raising, squatting, urinating, posturing
Ovine	Standing to be mounted
Caprine	Standing to be mounted

Swine	Lordosis or standing heat, standing for back pressure, boar seeking, vocalization, erect ears
Camelid	Cushing (ventral recumbency)

Artificial Insemination

Artificial insemination (AI) is the procedure where semen is deposited into the female's reproductive tract by a technician, farm personnel, or a veterinarian. The advantages of AI include being able to use genetically superior males, improve the overall health of the herd, and give the ability to record breeding. A successful AI program requires enrollment of fertile females and adequate quantity and quality of spermatozoa deposited at the right time and place (Table 5.17, Table 5.18, Table 5.19, Table 5.20, and Table 5.21). Knowledge of the female reproductive tract and accurate estrous detection or synchronization programs are vital to a successful insemination. Estrous synchronization can be implemented to minimize the time spent detecting heat.

Table 5.17 / Proper Timing, Dose, and Site of Semen Deposition during Artificial Insemination

Species	Timing of AI	Site of Semen Deposition	Insemination Dose ($x10^6$)
Bovine	12 hr after first detection of estrus	• Intrauterine transcervical	N/A
Caprine	12 hr after first detection of estrus	• Vaginal • Cervical • Intrauterine transcervical • Intrauterine laparoscopic	300 100–180 60 20
Ovine	AI timed with estrous synchronization	• Vaginal • Cervical • Intrauterine transcervical • Intrauterine laparoscopic	400 200 50–100 20–40
Porcine	2–3 times during estrus	• Cervical • Postcervical • Deep uterine	2500 (C) 6000 (F) 1000 (C) 600 (C) 1000 (F)
Equine	Within 48 hr preovulation (f,C) or 12 hr preovulation to 6 hr postovulation (F)	• Intrauterine transcervical	500 (f,C) 240–300 (F)

C = cooled; F = frozen; f = fresh semen.

Table 5.18 / Bovine Artificial Insemination Technique

Step	Procedures
1	The cow is physically restrained. A lubricated obstetrical sleeve is placed on one arm. The arm is introduced into the rectum, and the cervix is identified. The vulva is cleansed, and the plastic sleeve is removed from the insemination gun.

2	The gun is introduced vaginally up to the cervix. Grasping the cervix and pushing it forward straightens the vagina and facilitates advancing the insemination gun.
3	Once the gun is in contact with the external cervical opening, the cervix is manipulated onto the gun, while the device is advanced through the 3 cervical rings. Once in the uterus, the gun is pulled back in front of the internal cervical opening. The semen is deposited in the uterine body over 5 seconds by pushing the plunger. The gun is removed from the vagina, and the arm is removed from the rectum.

Table 5.19 / Small Ruminant Artificial Insemination Methods

AI Method	Technique
Vaginal Insemination	Fresh semen is deposited into the anterior vagina with an insemination pipette. Frozen semen should not be used with this method.
Cervical Insemination	The cervix is identified with a vaginal speculum. The insemination pipette is introduced into the cervix, and the semen is deposited into the cervical canal.
Transcervical Intrauterine Insemination	The cervix is identified with a vaginal speculum, and it is locked within the lumen of the speculum with slight pressure. The insemination pipette is advanced through the cervix with moderate pressure and rotation. Semen is deposited into the uterine body once the pipette has been advanced to a depth of 32–38 mm. In sheep, the cervix is retracted and stabilized with Bozeman forceps. An angled-tip insemination pipette is used to pass through the ovine cervix.
Laparoscopic Intrauterine Insemination	Semen is surgically placed into both uterine horns through the uterine wall with the help of an endoscope. Feed and water are withheld for at least 12 hours prior to AI. Females are sedated and placed in dorsal recumbency in a cradle with the head down at an angle of 40°. The abdomen is surgically prepared and local anesthetic is used at the ports of entry of the laparoscope and the cannulas. This procedure is usually done by a veterinarian.
Notes	The ability of frozen/thawed sperm to penetrate the cervix is impaired; therefore, frozen semen must be deposited into the uterus.

Table 5.20 / Swine Artificial Insemination

Step	Technique	Side Notes

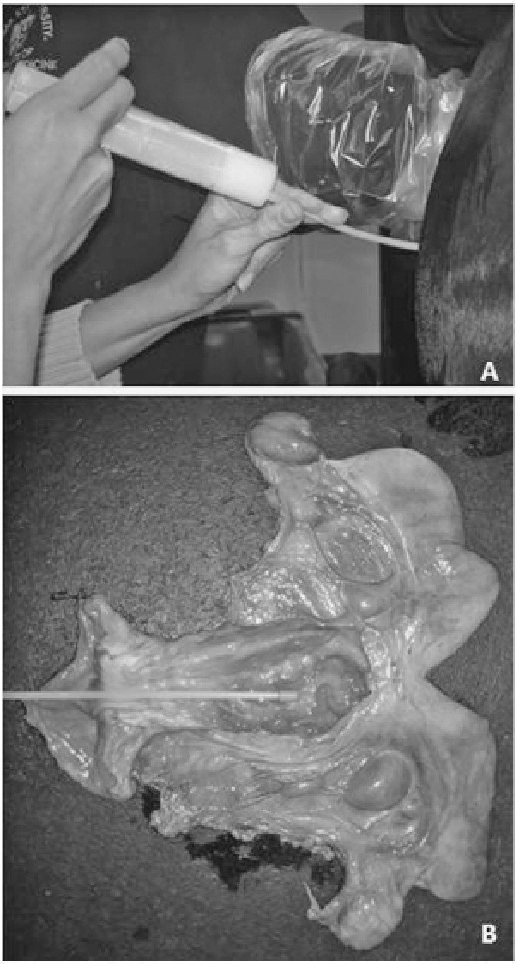
1	Physically restrain the female and cleanse the vulva.	Cleansing the vulva minimizes ascending bacterial contamination of the reproductive tract.
2	Lubricate the spirette or catheter with nonspermicidal sterile lubricant.	Avoid placing lubricant into the opening of the pipette.
3	Introduce the insemination pipette into the vagina and cervix.	If the pipette is inadvertently introduced into the urinary bladder, a backflow of urine may be seen in the pipette.
4	As the pipette is advanced though the cervix, it is rotated counterclockwise to pass through the cervical folds.	Resistance may be felt by pulling back on the pipette.
5	Once the pipette is in place, gently mix the semen container and attach it to the pipette. Semen is deposited into the posterior portion of the cervical canal.	The semen container is attached at this time to minimize bacterial contamination of the pipette while advancing it through the reproductive tract.
6	Allow the semen to flow by gravity over 3–5 minutes.	If backflow of semen is observed, deposition may be occurring too rapidly or the pipette may be placed against the wall of the cervix. The pipette is rotated or pulled back slightly to reposition it.
7	After depositing the semen, the pipette is rotated clockwise and removed. It is best to keep the female in a quiet area after AI for 20–30 minutes.	Any distress to the female may disrupt sperm transport and fertilization.
Notes	For swine, cooled semen is used more frequently for AI than frozen semen.	

Table 5.21 / Equine Artificial Insemination. (See Figure 5.9.)

Step	Procedures
1	The mare is physically restrained in stocks. The tail is wrapped, and the perineum is scrubbed with antiseptic solution, rinsed with water, and dried.

2	An 18–20 inch sterile plastic insemination pipette is manually inserted into the vagina with the operator wearing a sterile obstetrical sleeve. A finger is introduced through the cervix, and the pipette is guided through the cervical canal and into the uterus.
3	The semen is deposited into the uterine body. A minimum insemination dose of 240 (frozen) to 500×10^6 (cooled or fresh) progressively motile sperm is used. The volume infused can range between 10 and 100 ml.
4	The pipette and hand are slowly withdrawn from the vagina. Some operators massage the cervix or clitoris for a few minutes to stimulate uterine contractions and aid in sperm transport to the oviducts.
Notes	Timing of insemination is vital for success. Breeders may inseminate on day 2 or 3 of estrus and then every other day until the end of estrus. More accurate timing is achieved with monitoring of ovarian activity using transrectal ultrasound. Mares are inseminated with fresh or cooled semen when a follicle $\geq$ 35 mm in diameter is present. Human chorionic gonadotropin or deslorelin is given at insemination to induce ovulation within 48 h. With frozen semen, mares are ultrasounded every 6 hours and inseminated when ovulation is detected.

Figure 5.9 (A) Deposition of semen during AI in a mare by pushing the plunger of the syringe. Notice the use of an all-plastic syringe to avoid spermicidal residues contained in rubber plungers. (B) Correct site of semen deposition within the uterine body in mares.

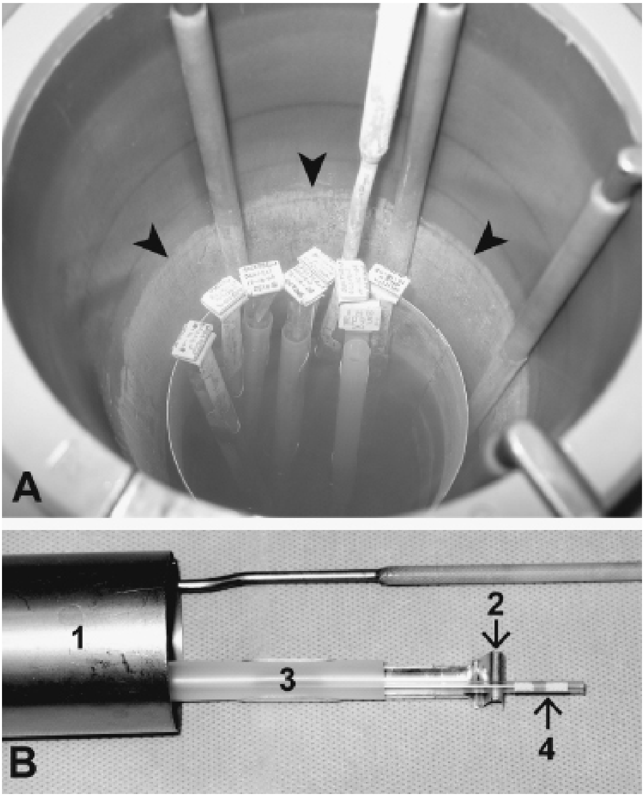


Frozen semen is routinely used for AI in ruminants and horses. Proper semen storage and handling is required to avoid damaging spermatozoa and to maintain their viability (Table 5.22). Frozen semen is kept in tanks containing liquid nitrogen at −196°C (Fig. 5.10). As long as ≥2 inches of liquid nitrogen are present, the semen can be stored indefinitely. The tank is maintained in a dry, well-ventilated environment, elevated from the floor to protect it from corrosion. An accurate inventory of stored semen is essential.

Table 5.22 / Handling and Preparation of Frozen Semen for Artificial Insemination

Step	Procedure/Technique	Supplies
1	Prepare the female for AI. Record the animal's identification, date, time, and any observational information at this time. Physically restrain the female in a chute, crate, or stocks.	Herd or individual records, physical restraint equipment
2	Determine the location of the straws within the tank in the inventory. Avoid raising the canes into the neck of the tank for more than 10 seconds during searching.	Liquid nitrogen tank with frozen semen, semen inventory
3	Thaw the straws following the protocol provided by the semen processor. If no protocol is provided, use a water bath at 35–37°C for 40 seconds.	Electric thaw unit, thermometer, timer
4	Dry the exterior of the straw. Flick it until the air bubble is against the sealed end and cut the sealed end squarely. Rub the insemination pipette to warm it, load it, and keep it warm and tucked under clothing until AI.	Thawed semen, straw cutter or sharp scissors, insemination pipette
5	Inseminate the female within 15 minutes of thawing the semen.	Varies with species

Figure 5.10 (A) Canister containing the canes with semen straws temporarily raised to the neck of the liquid nitrogen tank. The canes should not be raised above the frost line (arrowheads) for more than 10 seconds. (B) Storage system within the tank. A (1) canister holds (2) several canes. (3) Two goblets containing (4) the straws typically fit into each cane.



Pregnancy Diagnosis

Early pregnancy diagnosis allows early detection of nonpregnant females and provides time to rebreed the female during the following estrus. In mares, early pregnancy diagnosis also allows manual reduction of twin embryos at the optimal time. Ultrasonography is the method of choice since it provides one of the earliest and most accurate means for pregnancy diagnosis and allows assessment of fetal numbers, viability, and growth (Table 5.23). While early pregnancy diagnosis is desirable, pregnancy loss is not uncommon within the first 60 days of gestation. Confirmation of pregnancy is recommended after 60 days.

Table 5.23 / Earliest Time or Ideal Time Range (Days Post-Ovulation) for Pregnancy Diagnosis in Large Animals

Species	Ultrasound	Transrectal Palpation	Progesterone	Estrone Sulfate	Other
Bovine	>14	>30	20–24	>100	PSPB >15;IEPF 1
Equine	>14	>35	18–20	>150	eCG 40–110
Ovine	>18	N/A	20–24	>70	PSPB >18;Dop >60
Caprine	>20	>28 (abdominal)	20–24	>50	PSPB >24;PAG >21;Dop >40
Porcine	>18	>21	17–20	25–30	IEPF 1-2;Dop >30
Camelid	>16	>90	>11	21–27	N/A

PSPB = Pregnancy-specific protein B; IEPF = Immunosuppressive early pregnancy factor; PAG = Pregnancy-associated glycoproteins; Dop = Doppler ultrasound; eCG = Equine chorionic gonadotropin.

Abortion

Abortion is defined as the loss of a fetus after organ development (45–55 days) but before the fetus is capable of extrauterine life (Tables 5.24 and Table 5.25).

Table 5.24 / Common Causes of Abortion

Species	Infectious	Noninfectious
Bovine	• Bluetongue • Bovine rhinotracheitis • Bovine viral diarrhea • Brucellosis • Campylobacteriosis • Chlamydiosis • Epizootic bovine abortion • *Haemophilus somnus* • Leptospirosis • Listeriosis • Neosporosis • Toxoplasmosis	• Broomweed • Hydrops • Pine tree needles
Equine	• Aspergillosis • Equine rhinopneumonitis • Equine viral arteritis • Leptospirosis • Mare reproductive loss syndrome • Neosporosis • Placentitis	• Fescue toxicosis • Hydrops • Twins • Umbilical cord torsion • Uterine torsion • Ventral ruptures

Small ruminants	• Bluetongue • Border disease • Brucellosis • Campylobacteriosis • Chlamydiosis • Leptospirosis • Listeriosis • Q fever • Toxoplasmosis	• Copper toxicosis • Locoweed
Porcine	• Brucellosis • Chlamydiosis • Classical swine fever • Encephalomyocarditis virus • Eperythrozoonosis • Erysipelosis • Leptospirosis • Porcine parvovirus • Porcine reproductive and respiratory syndrome • Pseudorabies • Toxoplasmosis	• Carbon monoxide intoxication • Mycotoxins (fumonisin)
Camelids	• Bovine viral diarrhea brucellosis • Chlamydiosis • Neosporosis	• Twins • Uterine torsion

Table 5.25 / Management of Abortion

Prevention	If clinical signs are present, prepartum diagnosis may help initiate treatment and prevent pregnancy loss. In mares, observance of thickening of the uterus and placenta, separation between the uterus and placenta or exudate present between the uterus and placenta are indications of placentitis, which is the most common cause of equine abortion. Mares with placentitis can have premature mammary gland enlargement, lactation and relaxation of the cervix, with or without mucopurulent vulvar discharge. Treatment consists of systemic antibiotics and antiinflammatory and tocolytic drugs.
Diagnosis	After abortion, the fetus and fetal membranes should be submitted (fresh or cooled) to a laboratory. If this is not possible and a field

	necropsy is performed, the following should be submitted: fetal membranes, lung, liver, spleen, kidney, stomach contents, lymph nodes, thymus, and adrenal and fetal serum, together with maternal serum.
Zoonotic Potential	Many of the infectious causes of abortion have zoonotic potential. Gloves, protecting clothes, boots, and filter masks should be worn when handling fetuses, fetal membranes, vulvar discharges, or the aborting females or when cleaning the barn. Clients should be warned of the zoonotic potential and advised to wear protective gear.
Management of Aborting Females	The aborting females should be separated from the herd and handled at the end of the day.

Twin pregnancy is a common cause of abortion in mares. Because of the risk of abortion and dystocia in a mare carrying twins, reduction to a singleton pregnancy is necessary. Early detection with manual reduction before embryo fixation (day 16) is the method of choice (Table 5.26).

Table 5.26 / Twin Reduction in Mares

Method	Days of Gestation	Success Rate (%)
Crushing	14–15	95
	16–60 (bicornual)	50
Ultrasound-guided allantocentesis	25–36	50
Pinching	35–60	50
Craniocervical dislocation	65–110	60
Ultrasound-guided fetal injection	115–130	50

Parturition

Adequate breeding records and estimation of the date of parturition ensure adequate time to move the pregnant female into a birthing pen, stall, or pasture. The area should be kept dry and large enough for the female to move around freely and accommodate the newborn. Knowledge of the different stages of parturition is important to recognize birthing complications and provide early assistance to the parturient female. Parturition is divided into three stages (Table 5.27 and Table 5.28).

Table 5.27 / Definition of the Stages of Parturition

Stage	Definition/Events
1	Preparatory stage. Myometrial contractions begin, and the cervix dilates passively by a decrease in muscle tone. The fetus rotates into its final disposition. As intrauterine pressure increases with myometrial contractions, the fetal membranes and fetus are forced against the cervical canal causing active dilatation. Pressure against the cervix initiates reflex release of oxytocin, which increases the force of the myometrial contractions. The fetus enters the cervical canal and the chorioallantois ruptures.
2	Delivery of the fetus begins with the rupture of the chorioallantois. The fetus enters the birth canal, and myometrial contractions increase with continuous stimulation of oxytocin release. This stage ends when the fetus is completely delivered.
3	Expulsion of fetal membranes. Uterine contractions continue, the chorionic villi detach from the endometrial crypts, and the fetal membranes are expelled.

Table 5.28 / Clinical Parameters of Parturition

Stage	Signs	Species	Duration
1	Anorexia, restlessness, weight shift, arched back with raised tail, isolation from the herd, abdominal straining, pacing, sweating, rolling, pawing	• Bovine • Small ruminant • Equine • Porcine • Camelid	2–4 hr 2–12 hr 50 m 12–24 hr 2–6 hr
2	Female standing or in lateral recumbency, forceful abdominal straining, vocalization, fetus expelled in anterior longitudinal presentation, dorsosacral position with extended extremities.	• Bovine • Small ruminant • Equine • Porcine • Camelid	2–4 hr 0.5–3 hr 5–30 m 1–5 hr, piglets every 15 m 5–60 m
3	Fetal membranes at the vulva, mild abdominal straining.	• Bovine • Small ruminant • Equine • Porcine • Camelid	8–12 hr 1–12 hr 30 m–3 hr Between/After piglets 30 m–3 hr

Note: hr = hour; m = minutes.

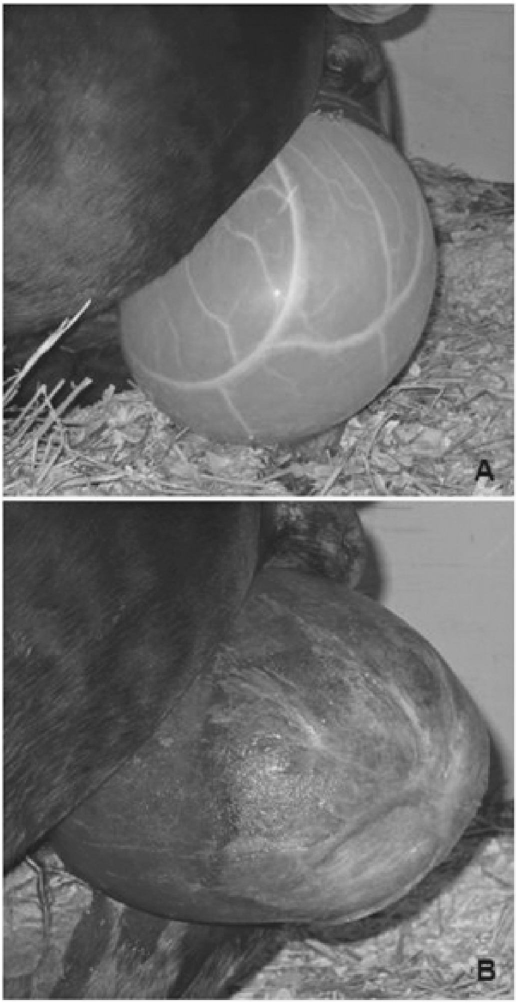
Dystocia

Dystocia is an abnormal, slow, or difficult birth (Table 5.29). Most dystocias occur during stage 2 of parturition in large animals. The most critical time is from rupture of the chorioallantois to fetal expulsion. Chances of delivering a live offspring that survives the neonatal period are decreased after 60 minutes in mares. However, a healthy bovine fetus can survive up to 8 hours.

Table 5.29 / Signs of Dystocia in Large Animals. (See Figure 5.11).

Species	Signs of Dystocia
Bovine	• Calving not complete within 2 hours after the amnion appears at the vulva. • Forceful straining without progress. • Fetal head, neck, or limbs flexed. • Fetal hoof soles facing up. Calf in dorsopubic position or posterior presentation.
Equine	• The red chorioallantois appears unruptured at the vulva (red bag delivery). • No fetus or amnion appears at the vulva within 10 minutes of breaking water. • Strenuous contractions with no progress for 10 minutes • Foaling not complete within 20 minutes of breaking water • Fetal head, neck, or limbs are flexed. • Fetal hoof soles facing up. Foal in dorsopubic position or posterior presentation.
Small Ruminants	• Forceful straining without the first kid/lamb appearing at the vulva within 1 hour or at 20 minutes between kids/lambs • Lambing/kidding is not complete within 30 minutes (singleton) or 2 hours (triplets) of breaking water.
Porcine	• Prolonged gestation (>116 days) • Farrowing is not complete within 2 hours of the onset of labor. • Interval longer than 1 hour between piglets
Camelids	• Parturition is not complete within 45 minutes of breaking water. • Forceful straining without progress for 5 minutes • Fetal head, neck or limbs are flexed. • Fetal hoof soles are facing up. Cria is in dorsopubic position or posterior presentation.

Figure 5.11 (A) The transparent bluish white amnionic membrane appears at the vulva during normal foaling. (B) Unruptured, red, velvety chorioallantoic membrane during a “red bag” delivery.



Methods of resolution of dystocia vary with the species, cause of dystocia, viability of the fetus, condition of the birth canal and systemic condition of the dam. Dystocias can be resolved vaginally using mutation and traction, fetotomy, or Cesarean section. The objective is to deliver the fetus as soon as possible, causing the least trauma to the female's genital tract in order to preserve the female's reproductive potential.

Postpartum Complications

Postpartum complications have a negative impact on breeding operations and productivity. Most disorders are potentially life threatening medical emergencies, and can also affect milk production and reproductive performance, resulting in significant economic losses (Table 5.30, Table 5.31, Table 5.32, Table 5.33, and Table 5.34). Early detection and treatment is essential to minimize the economic impact of postpartum diseases.

Table 5.30 / Retained Fetal Membranes

	Ruminants	Equine and Camelids
Definition	• Failure to expel all or parts of the fetal membranes within 12 hours of delivery of the fetus	• Failure to expel all or parts of the fetal membranes within 3 hours of delivery of the fetus
Clinical Signs	• Fetal membranes protruding from the vulva • Malodorous vulvar discharge, depression, fever and anorexia if metritis developed	• Fetal membranes protruding from the vulva • Malodorous vulvar discharge, depression, fever, and anorexia if metritis developed
Risk Factors	• Dystocia, uterine trauma at parturition, twins, imbalance of calcium and phosphorous (milk fever), and selenium and vitamins E and A deficiency	• Dystocia, Cesarean section, placentitis, hydrops, fescue toxicosis, and debilitating conditions
Treatment	• Fetal membranes are expelled within 10 days after necrosis of the caruncles.	• *Oxytocin therapy:* IV drip (50 IU in 500 ml of saline over 30 minutes); IM or IV boluses (10–20 IU) every 2 hours until the fetal membranes are expelled.

	• Oxytocin in small ruminants, questionable efficacy in cows • Systemic antibiotics until the fetal membranes are released or until sepsis is controlled. • Intrauterine antibiotics may decrease the odor associated with bacterial putrefaction. • *Supportive treatment:* Tetanus prophylaxis, NSAIDs, treatment of hypocalcemia	• *Burn's technique (equine):* A stomach tube is inserted into the chorioallantoic space, which is distended with fluids. • *Systemic antibiotics:* Potassium penicillin, gentamicin, and metronidazole • *Supportive treatment:* Tetanus prophylaxis, NSAIDs, treatment of endotoxemia and laminitis

Table 5.31 / Uterine Prolapse

Definition	• Invagination of the uterus with protrusion through the vulva during the immediate postpartum period
Clinical Signs	• Uterus protruding from the vulva with the mucosal surface exposed. The caruncles (ruminants) or endometrial folds (equine and camelids) are visible, and fetal membranes may still be attached. • Accompanying signs are straining, abdominal pain, cardiovascular shock, and paresis if associated with hypocalcemia. • Affected animals typically present within 24 hours following parturition.
Causes	• Difficulty birthing (dystocia) • Hypocalcemia (bovine) • More common in older or multiparous females • Supporting structures of the uterus may have become weak, or the uterus may lack tone.
Treatment	• The animal is restrained where it is found in order to prevent further tissue damage. The prolapsed tissue is wrapped with a wet towel. The exposed uterine tissue is washed with mild iodine povidone solution and water. Loosely attached fetal membranes are removed. Edema is reduced by soaking the

	tissue in a hypertonic solution (salty water, sugar, or dextrose). If the tissue is dehydrated, an emollient ointment can be applied. • With the animal standing or in sternal recumbency, the uterus is replaced. If sternal, the hind legs are extended out behind. If there is straining, epidural anesthesia can be administered. • Replacement is initiated at the cervical pole until both uterine horns are back in normal position. • Oxytocin may be administered to increase uterine tone. Temporary suture of the vulva is not necessary but may prevent straining associated with pneumovagina. • Treatment of metritis and hypocalcemia is initiated. • The uterus can be amputated if there is severe tissue damage or replacement is unsuccessful.

Table 5.32 / Ketosis, Acetonemia, or Pregnancy Toxemia

Definition	• Accumulation of ketone bodies (β-hydroxybutyric and acetoacetic acid, and acetone) within body fluids and tissues
Clinical Signs	• Animals usually present 1–2 weeks postpartum. • Gradual loss of appetite and decrease in milk production • Lethargy, dehydration, weight loss, firm dry feces, decreased rumen motility • Nervous form with circling, head pressing, apparent blindness, wandering, pica, excessive grooming or salivation, hyperesthesia, bellowing, tremors and tetany
Causes	• Negative energy balance during late pregnancy or early lactation (primary) or decreased dietary intake (secondary), reduction in blood and liver glucose, and increased fat mobilization. • Predisposing factors are high milk production that exceeds energy intake, twins, systemic disease with anorexia, cobalt deficiency, and fluorosis.
Treatment	• Aimed at increasing blood glucose concentrations by providing a source of glucose (IV bolus of 50% dextrose solution, oral glucose precursors propylene glycol, glycerol, sodium propionate or lactate, ammonium lactate), decreasing glucose uptake and prolonging hyperglycemia (dexamethasone or betamethasone), and increasing

	availability of the glucose precursor propionate in the rumen (chloral hydrate, monensin). Insulin also can be used to suppress fatty acid mobilization and stimulate hepatic glycolisis • Treat primary condition, if secondary ketosis, and provide supportive care.

Table 5.33 / Displaced Abomasum

Definition	• Displacement of the abomasum to the left or right of the abdomen secondary to gas accumulation
Clinical Signs	• Decreased appetite, milk production, fecal output and rumination • Dehydration (sunken eyes and loss of skin turgor) and pain (arched back and treading) • Distended abdomen and bloating, especially if volvulus occurred • Ketosis
Causes	• Hypocalcemia or increased volatile fatty acids result in atony of the abomasum. Fermentation of the ingesta and accumulation of gas result in distention and displacement.
Treatment	• Aimed at returning the abomasum to its normal anatomical position • Nonsurgical treatment involves casting and rolling, but relapsing is common. • Surgical treatment involves placing a toggle pin or nonabsorbable suture to fix the abomasum in its normal position.

Table 5.34 / Mastitis

Definition	Inflammation of the Mammary Glands
Clinical Signs	• Clinical (acute or chronic) mastitis is associated with grossly abnormal milk and varying degrees of signs of inflammation of the mammary gland. • *Acute:* Severe inflammation manifested by swelling, redness, pain, and edema. Accompanied by fever, anorexia, and depression. Milk contains flakes or clots and may be watery, serous, or purulent.

	• *Acute gangrenous:* Initial presentation resembles acute mastitis. Within a few hours, the teat becomes cold and exhibits a blue discoloration; and it is sloughed within 10–14 days. Milk is sanguineous. *Staphylococcus aureus* and *Clostridium perfringens* are most commonly associated with gangrene. • *Chronic:* Systemic or local signs of inflammation are not present, but milk has flakes, clots, or fibrin. • *Subclinical:* No visible signs in the mammary gland and grossly normal milk. However, the number of WBCs is increased. With time, fibrosis of the mammary gland occurs, leading to a firm and enlarged gland. • A California Mastitis Test (CMT) determines the amount of somatic cells within the milk.
Causes	• After the female is nursed or milked, the teat canal stays dilated and bacteria can ascend through the sphincter of the teat and cause infection. • Faulty milking machines, an unhygienic environment, or teat trauma reduce the natural defenses or increase the exposure to pathogens that overwhelm the defense mechanisms. • The most common pathogens are *Streptococcus agalactiae* and *S. aureus* (ruminants), *E. coli, K. pneumonia, Citrobacter freundii*, and *Enterobacter aerogenes* (swine).
Treatment	• Intramammary antibiotic therapy. Systemic antibiotics in swine, equine, and camelids • Complete removal of milk from the infected animal • Supportive care of the systemic condition • The best way to reduce mastitis in a herd is environmental sanitation.

Initial Care of the Neonate

Table 5.35 / Initial Care of the Neonate. (See Figure 5.12.)

Parameter	Description
Nursing	Neonates stand up within 0.5–1 hour and nurse within 1–2 hours of birth. Colostrum is the only source of immunoglobulins and

	nutrients, and it has a laxative effect that aids in passage of meconium.
Passage of Meconium	Neonates pass their first stool (meconium) within 12 hours of birth. Meconium is dark green to black and is then replaced with yellow feces. If it can become impacted causing colic. A soapy water enema is often administered for mild impactions. A veterinarian may prescribe mineral oil or milk of magnesia as well.
Care of the Umbilical Cord	The umbilical cord breaks spontaneously at birth. The umbilicus is dipped in a 0.5% chlorhexidine solution 2–3 times during the first 24 hours of life.
Physical Examination	Normal temperature is 100–102°F; heart rate is >60 bpm immediately at birth, but increases within the first few hours; and normal respiratory rate is >30 RR. If resuscitation is needed, about 90% of neonates respond to hyperventilation alone with 100% oxygen. In foals, nasotracheal intubation and resuscitation can be initiated while the foal is in the birth canal in cases of dystocia.
Other Management Practices	In areas deficient in selenium, supplemental selenium and vitamin E are given to lambs and crias at birth. Piglets should receive iron supplementation within the first 5 days of birth, and tail docking is also performed at that time. The needle teeth may be clipped at birth to prevent damage to the sow's nipples.
Other Observations	Camelid neonates are born covered by the epidermal membrane. This membrane is connected to the mucocutaneous junctions of the fetal lips, eyes, nose, and coronary bands. It is thought to play the role of lubricant during parturition and to protect the newborn from dehydration. The membrane dries off and is shed soon after birth.

Figure 5.12 Newborn alpaca partially covered by the epidermal membrane.

Vaccination Schedule for Breeding Stock

Transplacental transfer of immunoglobulins in large animals is minimal. The neonate must acquire protective immunoglobulin G (IgG) from colostrum. Production of good quality and good quantity of colostrum and appropriate quantity nursed at the time of maximum intestinal absorption are essential for adequate transfer of protective amounts of IgG (Fig. 5.13). Prepartum vaccination of the pregnant female helps minimize the risk of abortion and ensures the presence of adequate concentrations of IgG against specific pathogens in colostrum (Table 5.35, Table 5.36, Table 5.37, Table 5.38, and Table 5.39).

Figure 5.13 Factors affecting passive transfer of IgG.

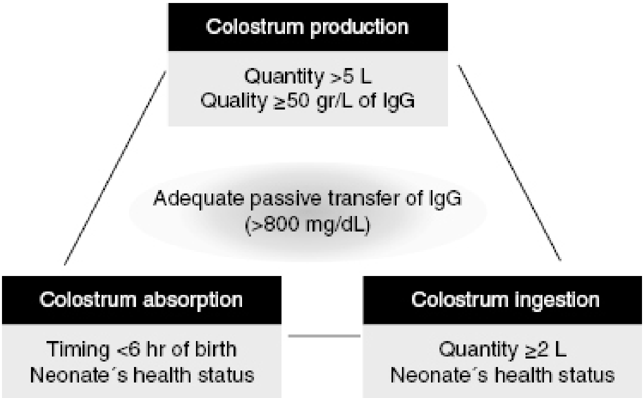


Table 5.36 / Core Vaccine Schedule for Previously Vaccinated Horses

Disease/ Vaccination	Pregnant Mares	Stallions and Open Mares
Rabies	• Annually, 4–6 weeks before foaling; or before breeding	• Annually
Tetanus	• Annually, 4–6 weeks before foaling	• Annually
West Nile Virus	• Annually, 4–6 weeks before foaling, only inactivated vaccines	• Annually in the spring
WEE/EEE	• Annually, 4–6 weeks before foaling	• Annually in the spring
Notes	• Previously unvaccinated animals should receive 2 immunizations of the corresponding core vaccine 4–6 weeks apart. It is preferable to administer West Nile Virus vaccines to naive mares when not pregnant.	

Table 5.37 / Risk-Based Immunizations during Breeding/Pregnancy

Vaccine	Pregnant Mares	Stallions and Open Mares
Strangles	• Semi-annual with 1 dose 4–6 weeks prepartum • Only killed vaccine containing M-protein	• Annual to semi-annual based on

		risk assessment
Equine Influenza	• Semi-annual with 1 dose 4–6 weeks prepartum • Inactivated or canary pox vector vaccine	• Annual to semi-annual based on risk assessment
Equine Herpes Virus	• 3 doses at 5, 7, and 9 months of gestation • Inactivated EHV-1 vaccine licensed for prevention of abortion • Many veterinarians also recommend a dose during the third month of gestation, and some recommend a dose at the time of breeding.	• Annual to semi-annual based on risk assessment
Equine Viral Arteritis	• Not recommended unless an outbreak is occurring	• Annual, 2–4 weeks prior to the breeding season
Anthrax	• Not recommended	• Annual
Botulism	• Annual, 4–6 weeks before foaling	• Annual
Potomac Horse Fever	• Semi-annual with 1 dose 4–6 weeks prepartum	• Annual to semi-annual based on risk assessment
Rotavirus	• 3 doses given 4 weeks apart, starting at 8 months of gestation	• N/A
Notes	• Horses that have not been previously vaccinated against strangles, equine influenza, botulism, and Potomac horse fever should receive 2–3 doses of the corresponding vaccine 4 weeks apart. • In pregnant mares, the last dose should be given 4–6 weeks prior to foaling.	

Table 5.38 / Recommended Vaccine Schedule for Cattle

Disease/ Vaccination	Cows	Bulls
Bovine Infectious Rhinotraqueitis	*Heifers:* 2–3 doses at least 1 month prior to breeding with MLV parenteral vaccine. Annual booster with MLV parenteral vaccine prebreeding. If given during gestation, use MLV intranasal or killed vaccine.	2–3 doses prior to the first breeding season. Annual boosters. Avoid MLV parenteral vaccine.
Bovine Virus Diarrhea	Semi-annual if killed vaccine. If MLV vaccine, annual 3 weeks prebreeding in open cows.	Semi-annual if killed vaccine, annual 3 weeks pre-breeding with MLV vaccine
Leptospirosis	Semi-annual or annual at 2–4 months of gestation	Not routinely used
Campylobacteriosis	Annual prior to breeding (within 4 months to 10 days depending on adjuvant)	Annual 4 weeks before breeding. If naive, 8 weeks and 4 weeks before breeding.
Notes	Modified live vaccines should be avoided in pregnant cows. Vaccines against *Tritrichomonas foetus*, anaplasmosis, rotavirus-coronavirus, footrot, *E. coli*, *Clostridium hemolyticum*, *Leptospira hardjo*, enterotoxemia, anthrax, and *Clostridium novyi* may be recommended depending on risk assessment.	

Table 5.39 / Recommended Vaccine Schedule for Small Ruminants

Disease/Vaccination	Ewes	Rams	Does/Bucks
Enzootic abortion of ewes	• Prebreeding	• Prebreeding	• April–July
Vibriosis	• Breeding	• N/A	• N/A
Clostridium perfringens C/D	• Bagged ewes at shearing	• Shearing	• December–March, booster April–July
Tetanus	• Bagged ewes at shearing	• Shearing	• December–March, booster April–July
Caseous lymphadenitis	• Bagged ewes at shearing	• Shearing	• N/A
Footrot	• Bagged ewes at shearing; booster yearlings at lambing	• Lambing	• N/A
Bluetongue	• Prebreeding	• Prebreeding	• N/A

Table 5.40 / Recommended Vaccine Schedule for Swine

Disease/Vaccination	Gilts and Sows	Boars
Leptospirosis	Prior to breeding	Semi-annually

Porcine Parvovirus	Prior to breeding	Semi-annually
Erysipelas	Prior to breeding	Semi-annually
E. coli	Prior to farrowing	• N/A
Atrophic Rhinitis	Prior to farrowing	• N/A

Chapter 6

Nursing Care

Barbara Dugan

Key Terms and Phrases	Abbreviations		
Alpha2-agonist	bpm: Beats per minute	KCl: Potassium chloride	RR: Respiratory rate
Clinimix	CMPK: Calcium, magnesium, phosphorous, potassium	MM: Mucous membranes	SQ or SC: Subcutaneous
Enteral	CVP: Central venous pressure	N/A: Not applicable	TP: Total parenteral nutrition
Esophagostomy tube	d: Days	NGT: Nasogastric tube	TPR: Temperature, pulse, respiratory rate
Fibroblasts	DIC: Disseminated intravascular coagulation	NPO: Nothing by mouth	TS: Total solids
Nasogastric tube	DMSO: Dimethyl sulfoxide	NSAIDs: Nonsteroidal antiinflammatory drugs	USG: Urine specific gravity
Nutrition	GI: Gastrointestinal	OGT: Orogastric tube	
Opioids	HR: Heart rate	PCV: Packed cell volume	
Orogastric tube	Hx: History	PO: Per os/administer orally	
Parenteral	IM: Intramuscular	PPN: Partial parenteral nutrition	
Phagocytosis	IV: Intravenous	q: Every	
Piloerection	IVC: Intravenous catheter	RE: Respiratory effort	
Transfaunation	IVF: Intravenous fluids	RF: Replacement fluids	
Vasoconstriction	JRT: Jugular refill time	rpm: Respirations per minute	
Vasodilatation			

Nutritional Support

Nutritional support is an important part of large animal care. All body functions rely on the intake of proteins, fats, carbohydrates, and other essential nutrients. A hospitalized animal is at risk for weight loss and malnutrition due to a decrease in food consumption. This decrease in consumption can be due to an underlying disease, an inability to eat, or the stress of an unfamiliar environment. The ideal way for provision of nutritional support for large animals is oral consumption, where the animal intakes food on its own. If the animal is unable to consume orally, there are other routes of administration available to provide necessary nutritional support, such as orogastric, nasogastric, or intravenous routes.

Table 6.1 / Enteral Nutrition

Method	Advantages	Disadvantages	Indications	Contraindications
Syringe	• Not invasive	• Not practical in adult equine or bovine patients	• Small ruminants, porcine, or neonatal patients • Patients requiring appetite stimulation	• Patients who are having difficulty swallowing • Aspiration risk
Orogastric Tube (Fig. 6.1)	• Easy to perform on bovine, ovine, caprine, porcine, and camelid patients • Easy placement and removal • Excellent way to get nutrition into the patient	• Can be stressful on the patient due to increased restraint necessary to perform the procedure	• Patient unable or unwilling to consume necessary nutrients • Prevents onset of anorexia	• Patients with esophageal, pharyngeal, or laryngeal issues • Difficult to perform in equine patients
Nasogastric Tube (NGT)(Fig. 6.2)	• Easy to perform in equine patients • Tube can be left in place. • Patient can drink normally with monitoring. • Easy to remove	• Stressful due to increased restraint. • Can cause significant nosebleed in patients, especially equine • Tube can become clogged with food.	• Patients unable or unwilling to eat	• Patients with esophageal, pharyngeal, or laryngeal issues. • Difficult to perform in bovine, caprine, ovine, and porcine patients • It is not recommended that patients with indwelling NGT be allowed to eat due to the aspiration risk.
Esophagostomy Tube	• Easy placement • Usually well tolerated • Slurries can be administered through tube. • Easy to maintain	• Heavy sedation or general anesthesia	• Anorexic patients • Patients with fractures or trauma that causes an inability to consume food via the oral route	• Patients with esophageal issues like stricture or inflammation

Figure 6.1 Ruminant orogastric tubing (photo courtesy of Tiffany Matthews).

Figure 6.2 Equine nasogastric intubation.

Table 6.2 / Enteral Nutrition Procedures

Method	Set-Up	Sedation	Procedure	Complications	Removal
• Syringe (Not Practical in Adult Equine or Bovine Patients Except for Medication Administration)	• 60 ml catheter-tip syringe • Slurried food	• None	• Once properly restrained, gently insert syringe into the cheek pouch. Ensure the syringe is over the tongue. Slowly fill the mouth with slurried food.	• Aspiration • Spitting out food	• None
• Orogastric Tube	• Speculum • Orogastric tube. Size of tube is dependent upon size of animal.	• None	• Once properly restrained, insert speculum over tongue, pass orogastric tube through speculum and down esophagus. Ensure tube is in esophagus by seeing and feeling tube pass in esophagus. Once you are sure tube is in proper place, feed slurry.	• Reflux or regurgitation around tube • Aspiration	• Kink tube to prevent any residual feed in tube from becoming an aspiration risk. Pull tube in swift, steady, downward motion. Remove speculum.
• Nasogastric Tube	• Proper NGT diameter for patient	• None, if patient tolerates • Can use xylazine butorphanol detomadine (Note: Dose dependent on withdrawal time of drug as well as animal's weight and tolerance	• Procedure explained in Skills Box 6.1. • Once you are sure tube is in proper place, feed slurry. • Can be left indwelling in foals that are unable to nurse for a variety of reasons (Fig. 6.3)	• Nosebleed • Reflux • Esophageal or pharyngeal irritation • Aspiration	• Kink tube to prevent any residual feed in tube from becoming an aspiration risk. Pull tube in swift, steady, downward motion.
• Esophageal tube	• Proper diameter for long-term placement in esophagus of patient	• General anesthesia	• Surgical (performed by veterinarian)	• Reflux • Esophageal irritation • Tube blockage • Infections at insertion site • Patient removes tube on its own.	• Once patient is able to eat on own, remove immediately, if infection occurs.

Figure 6.3 Foal feeding with fresh mare's milk via indwelling nasogastric tube.

Table 6.3 / Enteral Feeding Procedures

Method	Maintenance	Feeding
Syringe	• Clean syringe thoroughly with water.	• Fill syringe with slurried food, such as baby food, soaked pellet feeds, or alfalfa meal. Administer small amounts slowly. Gradually increase amount as tolerated.
Orogastric Tube	• Clean thoroughly after each tubing.	• Fill bucket with desired amounts of soaked alfalfa meal, pellet feeds, rumen

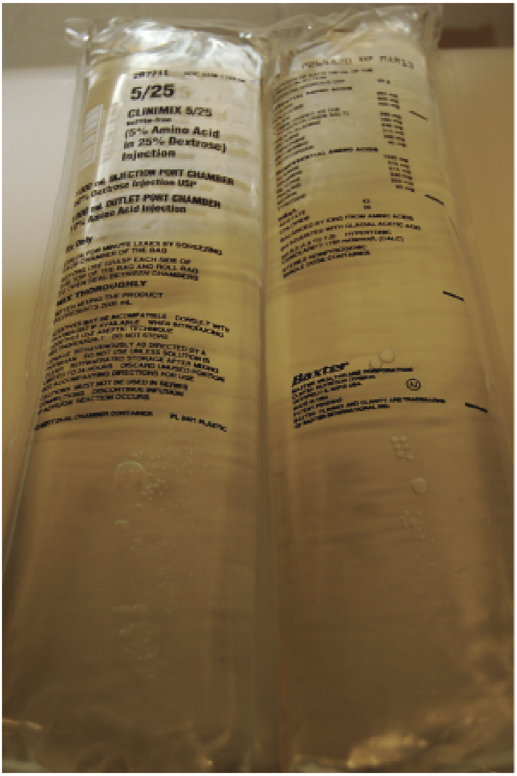
		content (transfaunation), or whatever feed is prescribed by veterinarian. Administer via 450 ml dose syringe. Monitor for tube blockage. Add water to thin out if food is too thick. Feed every 3–4 hours depending on size and tolerance of patient. Gradually increase amount as tolerated.
Nasogastric Tube	• Clean tube thoroughly with water after each tubing. If tube is indwelling, flush with one 450 ml dose syringe full of water.	• Fill bucket with veterinarian-prescribed diet soaked in water (~6 L of water). Administer via 450 ml dose syringe or using a funnel. Monitor tube for blockage. Add water to thin out if food is too thick. Feed every 3–4 hours depending on size and tolerance of patient. Gradually increase amount as tolerated.
Esophagostomy Tube	• Flush tube with water and leave some water in tube to ensure blockage does not occur. Clean any feed material from portion of tube that is exposed. Keep insertion site clean. Roll exposed portion of tube and secure to help prevent accidental removal of tube by horse.	• Fill bucket with veterinarian-prescribed diet soaked in water (~6 L of water). Administer via 450 ml dose syringe or using a funnel. Monitor tube for blockage. Add water to thin out if food is too thick. Feed every 3–4 hours depending on size and tolerance of patient. Gradually increase amount as tolerated.

Table 6.4 / Parenteral Nutrition

Type	Advantages	Disadvantages	Indications	Contraindications
Total Parenteral Nutrition (TPN) (Fig. 6.4)	• Complete caloric intake • 100% nutritional support	• Expensive • 3 or more days to reach desired energy intake • Blood glucose can reach very high levels. • Thrombosis and sepsis at IV catheter site • May cause gastric ulcers	• Neonates who cannot nurse or with compromised GI tracts • Adult animals with GI dysfunction or an inability to eat • Those animals who require more calories than enteral feedings can achieve	• Animals able to meet nutritional needs on their own • Severely malnourished animals
Partial Parenteral Nutrition (PPN) (Fig. 6.5)	• Available pre-prepared (Clinimix) • Less expensive	• Hyperlipemia • Infection at catheter insertion site • Bacterial contamination of fluids	• Adult animals with GI dysfunction or an inability to eat • Those animals that require more calories than enteral feedings can achieve • Patients off feed for >7 days	• Animals able to meet nutritional needs on their own • Severely malnourished animals • Patients who are severely dehydrated • Patients with liver or kidney disorders

Figure 6.4 Intravenous nutritional supplementation with total parenteral nutrition (photo courtesy of Christopher Rizzo).

Figure 6.5 Bag of intravenous Clinimix (partial parenteral nutrition).



Pain Management

Pain management is the process of providing medical care that alleviates or reduces pain. Pain management is an important, yet difficult, aspect of veterinary medicine. Unlike humans who can verbalize pain, animals cannot. Adequate treatment of pain requires recognition of a variety of cardiovascular, respiratory, and behavioral changes associated with pain in animals. Mild-to-moderate pain can usually be treated with analgesic medications. For chronic or severe pain, opiates and other narcotics are often used, sometimes in conjunction with analgesics and steroids or nonsteroidal antiinflammatory drugs (NSAIDs) when the pain coincides with inflammation. Preemptive treatment of pain is popular in veterinary medicine due to the difficulty identifying pain in animals. Veterinarians and technicians need to rely on observation and physical examination to assess pain.

Be advised, pharmaceuticals are used in many species. Many drugs are used as off-label use or extra-label use and have different withdrawal times, while some drugs are only used in approved species. The attending DVM needs to give the appropriate dose and approve the off-label use, extra-label use, and withdrawal times.

Table 6.5 / Nonsteroidal Antiinflammatory Drugs (NSAIDs) That Are Commonly Used to Reduce or Alleviate Pain (Fig. 6.6)

Drug	Indications	Contraindications	Dose/Duration	Comments
Flunixin Meglumine	• Control of inflammation and pain associated with abdominal pain, musculoskeletal issues, and postoperative issues • Reduces fever	• Use with caution in patients with renal, hepatic, or hematologic diseases or GI ulcers	• *Cattle:* 1.1–2.2 mg/kg q 12–24 hr • *Horses:* 1.1 mg/kg q 12–24 hr • *Sheep and Goats:* 1.1 mg/kg q 12–24 hr • *Camelid:* 1–1.5 mg/kg q 12–24 hr	• *Drug concentration:* 50 mg/ml • *Routes of administration:* IV, IM, SQ, PO • *Milk withdrawal:* 72 hr • *Meat withdrawal:* 10 d
Phenylbutazone	• Control of inflammation and pain associated with the musculoskeletal system, particularly lameness in horses	• Use with caution in patients with GI ulceration, renal disease, or hematological disorders. • Use in food production animals.	• *Cattle:* 4 mg/kg q 24 hr • *Horses:* 4.4–8.8 mg/kg q 12 hr • *Swine:* 4 mg/kg q 24 hr	• *Drug concentration:* IV = 200 mg/ml; PO = 100 mg tablets; PO = 6 g or 12 g/tube paste • Prohibited in food production animals older than 20 months • *Routes of administration:* IV or PO
Ketoprofen	• Control of inflammation and pain associated with musculoskeletal system, particularly lameness in horses	• Use with caution in patients with GI ulceration or bleeding, renal disease, or hematological disorders. • Use with caution in breeding animals.	• *Cattle:* 3.3 mg/kg q 24 hr • *Horses:* 2.0–2.5 mg/kg q 24 hr • *Camelids:* 1 mg/kg q 24 hr	• *Drug concentration:* 100 mg/ml • *Routes of administration:* IV or IM • *Meat withdrawal:* 4–7 d
Carprofen	• Control of inflammation and pain, although reports of safety and effective pain control are scarce	• Use with caution in patients with GI ulceration, renal disease, or hematological disorders	• *Horses:* 0.7–1.4 mg/kg q 12–24 hr	• *Drug concentration:* IV = 50 mg/ml; PO = 25, 50, and 100 mg tablets • Use and dosage in other large-, food-, and fiber-animal species unknown at this time due to limited information.
Meloxicam	• Management of pain and inflammation	• Reports of safe and effective use are limited.	• *Horses:* 0.6 mg/kg q 12–24 hr	• *Drug concentration:* 5 mg/ml • Off-label use in cattle and horses • Reports of safe and effective use are limited.
Acetylsalicylic Acid (Aspirin)	• Analgesic, antiinflammatory, and antipyretic activity • Possesses antithrombotic activity	• Hematological disorders, bleeding ulcers, and renal insufficiency	• *Cattle:* 50–100 mg/kg q 12 hr • *Horses:* 5–20 mg/kg q 12–24 hr • *Swine:* 10 mg/kg q 4–6 hr • *Sheep and Goats:* 100 mg/kg q 12 hr	• *Drug concentration:* 240 gr., 480 gr. boluses • *Route of administration:* PO • *Milk and meat withdrawal time:* 24 h
Naproxen	• Relieves inflammation, pain, and lameness associated with soft-tissue disease	• Use with caution in patients with GI ulceration, renal disease, or hematological disorders.	• *Horses:* 5 mg/kg IV; 10 mg/kg PO	• First slow IV bolus followed by oral dose every 24 hr for up to 14 d

Figure 6.6 Common large animal nonsteroidal antiinflammatory drugs.

Table 6.6 / Alpha 2-Agonists Commonly Used to Reduce or Alleviate Pain (Fig. 6.7)

Drug	Indications	Contraindications	Dose/Duration	Comments
Xylazine	• Sedation with a short period of analgesia	• Animals receiving epinephrine or with ventricular arrhythmias • Use cautiously in animals with cardiac, respiratory, or renal dysfunction.	• *Horses:* 0.2–1 mg/kg q 30 min-1 hr • *Cattle:* 0.05 mg/kg q 2 hr • *Sheep and goats:* 0.05 mg/kg q 2 hr • *Swine:* 1–2 mg/kg • *Camelids:* 0.25–0.5 mg/kg. (Use low dose when administering IV.)	• *Drug concentration:* 100 mg/ml • *Routes of administration:* IV, IM, and SQ • Not approved for use in food animals • Use with extreme caution in all ruminants. • *Milk withdrawal:* 72 h • *Meat withdrawal:* 5 d • *Horses:* May cause muscle tremors, sweating, bradycardia, reduced RR, and inappropriate stimulation to noise • *Camelids:* More sensitive to this drug than horses
Detomidine	• Sedation, analgesia	• Animals with cardiac, respiratory, or renal disease or failure	• *Horses:* .02–.04 mg/kg q 1–2 hr • *Cattle:* 0.01 mg/kg q 2 hr	• *Drug concentration:* 10 mg/ml • *Routes of administration:* IV or IM • Not approved for use in ruminants • *Milk withdrawal:* 72 hr • *Meat withdrawal:* 7 d • Can cause initial increase in blood pressure followed by bradycardia and heart block • Piloerection, sweating, muscle tremors, and penile prolapse may also occur.

Figure 6.7 Common large animal injectable sedation (noncontrolled substances).

Table 6.7 / Opioids Commonly Used to Reduce or Alleviate Pain

Drugs	Indications	Contraindications	Dose/Duration	Comments
Morphine	• Treatment of acute pain	• Renal disease, hypothyroid, geriatric, or severely debilitated • Use with extreme caution in patients with head trauma or intracranial pressure.	• *Horses:* 0.1–0.7 mg/kg q 4–6 hr • *Cattle:* 0.05–0.4 mg/kg q 6–8 hr • *Swine:* 0.2 mg/kg q 4–6 hr • *Sheep and Goats:* 0.1 mg/kg q 6–8 hr • *Camelids:* 0.5 mg/kg q 8 hr	• *Drug concentration:* 0.5–50 mg/ml. Dose varies depending on manufacturer. • *Routes of administration:* IV or IM • Opioids have an effect on respiratory function. • Can cause mild colic and decreased fecal production in horses • Can cause hyperthermia in horses, cattle, and goats
Butorphanol (Fig. 6.8)	• Analgesia in horses, cattle, small ruminants, and camelids	• Renal disease, hypothyroid, geriatric, or severely debilitated. • Use with extreme caution in patients with head trauma or intracranial pressure.	• *Horses:* 0.01–0.4 mg/kg q 2–4 hr • *Cattle:* 0.02–0.25 mg/kg q 2–3 hr • *Ruminants:* 0.02 mg/kg q 4–6 hr • *Camelids:* .02–.04 mg/kg q 4–6 hr	• *Drug concentration:* 10 mg/ml • *Routes of administration:* IV, IM, and SQ • Transitory ataxia, hyperesthesia, and sedation. Rare, but may also experience nystagmus, hypersalivation, seizure, hyperthermia, or decreased GI motility. • *Milk withdrawal:* 72 h • *Meat withdrawal:* 4 d
Buprenorphine	• Pre- and postoperative analgesia in horses, cattle, ruminants, and swine	• Renal disease, hypothyroid, geriatric, or severely debilitated. • Use with extreme caution in patients with head trauma or intracranial pressure.	• *Horses:* 0.006–0.02 mg/kg q 6–8 hr • *Ruminants:* 0.005–0.01 q 4–6 hr • *Cattle:* 0.0015–0.006 mg/kg q 1–3.5 hr • *Swine:* 0.005–0.1 mg/kg q 4–12 hr	• *Drug concentration:* 0.3 mg/ml • *Routes of administration:* IV, IM, and SQ • Monitor for respiratory depression.
Meperidine	• Analgesia	• Renal disease, hypothyroid, geriatric, or severely debilitated. • Use with extreme caution in patients with head trauma or intracranial pressure.	• *Horses:* 1–2 mg/kg q 4–6 hr • *Cattle:* 3.3–4.4 mg/kg q 6–8 hr • *Ruminants:* 5 mg/kg q 1 hr	• *Drug concentration:* 100 mg/ml • *Routes of administration:* IV, IM • Respiratory depression. CNS depression. Decreased GI motility. Tachycardia and sweating. Irritation can occur if administered SQ.

Figure 6.8 Common large animal injectable sedation (DEA controlled substances).

Table 6.8 / Miscellaneous Drugs Commonly Used to Reduce or Alleviate Pain

Drug	Indications	Contraindications	Dose/Duration	Comments
Ketamine	• Dissociative drug that disrupts the central nervous system and induces a cataleptic state • Inhibits sensation of pain	• Animals that are hypersensitive to the drug • Animals with renal dysfunction or cardiac issues	• *Horses:* 1–2 mg/kg q 4–6 hr • *Cattle:* 2.2 mg/kg • *Small ruminants:* 2 mg/kg • Swine: 4.4 mg/kg • *Camelids:* 6–8 mg/kg	• *Drug concentration:* 100 mg/ml • *Routes of administration:* IV and IM • Respiratory depression and muscle tremors may occur. Monitor animals closely.
Gabapentin (Fig. 6.9)	• Neuropathic pain	• Information lacking	• *Horse:* 5–20 mg/kg q 8–12 hr	• *Drug concentration:* 100 mg/tab or 300 mg/tab • *Route of administration:* PO • May cause mild sedation and tranquilization

Figure 6.9 Common large animal oral pain management medications.

Behaviors Suggesting Pain in Large Animals

Table 6.9 / Postures Suggesting Pain in Large Animals

Posture	Description	Significance
Tucking up Abdomen (Fig. 6.10)	• Abdomen held tight and back appears hunched	• Pain, chronic disease process
Wide Stance	• Fore and hind legs are spread out away from center	• Pain, chronic disease process

Reluctance to Lie Down	• Difficulty lying down and finding a comfortable position	• Pain, anxiety
Down	• Unusually long periods of time down (generally horses)	• Pain, chronic disease process
Resting in Unusual Position	• Position of body or head position is abnormal. (Example: Body is in right sternal recumbency, and head is curled to left or over back.)	• Pain
"Dog Sitting"	• Hind end sitting on floor with front end up, like a dog sitting	• Pain, chronic disease process
Head Position	• Head is hung low or looking at abdomen.	• Pain, chronic disease process; normal
Leaning	• Leaning body or pressing head against wall or stall door	• Pain, chronic disease process

Figure 6.10 Horse stretched out with abdomen tucked up—a common sign of pain.

Table 6.10 / Gaits Suggesting Pain in Large Animals

Gait	Description	Significance
Limping (Fig. 6.11)	• Ambulates with difficulty. (Example: Hops at walk to move around the stall)	• Pain
Non-Weight Bearing (Partial or Complete)	• Unwilling to bear weight; may point, toe touch, or hold limb up	• Pain
Mobility	• Reluctant to move around stall	• Pain, anxiety

Figure 6.11 Horse with head low, neck muscles tensed, and limping—a common sign of orthopedic pain.

Table 6.11 / Movements Suggesting Pain in Large Animals

Movement	Description	Significance
Restless/ Agitated (Fig. 6.12)	• Pawing with one leg, up and down, circling/stall walking, kicking at walls, kicking at abdomen	• Pain, anxiety, normal behavior
Muscle Fasciculations	• Muscle tremors over part or all of body	• Pain, anxiety, chronic disease process
Thrashing (Fig. 6.13)	• Laying down in stall, rolling and/or kicking limbs wildly	• Pain
Lateral Recumbency	• Laying down lateral with limbs stiff and rarely moving	• Pain, chronic disease process

Figure 6.12 Horse circling in stall, kicking with hind leg at abdomen—a common sign of abdominal pain.

Figure 6.13 Miniature horse rolling onto its back—a common sign of severe abdominal pain (photo courtesy of Christopher Rizzo).

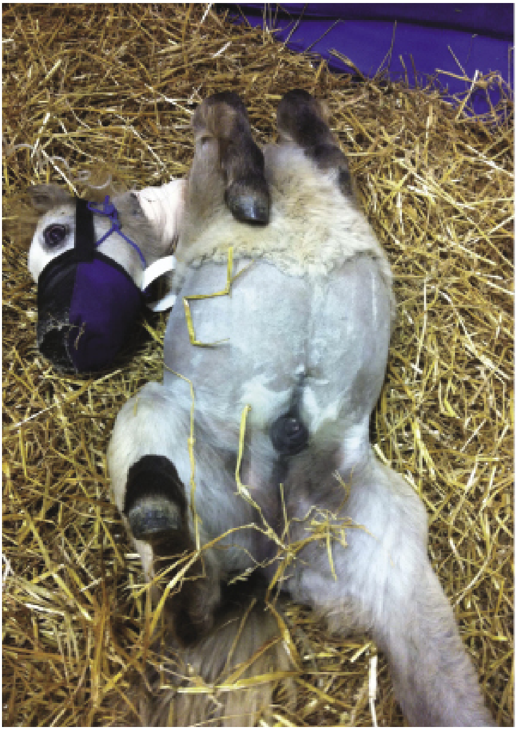


Table 6.12 / Attitudes Suggesting Pain in Large Animals

Attitude	Description	Significance
Avoidance	• Moving away, cowering in a corner, turning hind end	• Pain, anxiety, normal behavior
Hyperesthesia	• Agitation, muscle twitching or tremors, startling when touched, or being oversensitive to light or sound	• Pain, anxiety, chronic disease process
Aggression	• Pinning ears, biting, kicking	• Anxiety, normal behavior

Table 6.13 / Vocalizations Suggesting Pain in Large Animals

Vocalization	Description	Significance
Groaning	• Making low guttural noise, with movement, while lying down	• Pain, anxiety, normal behavior
Squealing or Screaming	• Pigs, goats, and camelids can vocalize and sound as though they are screaming.	• Pain, anxiety, normal behavior
Bellowing or Bleating	• Cattle, sheep, and goat vocalizations	• Pain, anxiety, normal behavior

Table 6.14 / General Appearances Suggesting Pain in Large Animals

General Appearance	Description	Significance
Dull/ Depressed	• Eyes dull, head held low, ears droopy, somnolent	• Pain, chronic disease process, excessive sedation

Bruxism (Grinding Teeth)	• Clenching jaw and rubbing teeth together	• Pain, chronic disease process
"Star Gazing"	• Staring into space	• Chronic disease process, excessive sedation

Table 6.15 / Physiologic Behaviors Suggesting Pain in Large Animals

Physiologic Behavior	Description	Significance
Tachycardia	• Increased heart rate	• Pain, anxiety, chronic disease process
Tachypnea	• Increased respiratory rate	• Pain, anxiety, chronic disease process
Febrile	• Increased temperature	• Pain, anxiety, chronic disease process
Hypertension	• Increased blood pressure, usually able to be visualized in horses and cattle with a bounding jugular thrill	• Pain, anxiety, chronic disease process

Table 6.16 / Appetite/Elimination Behaviors Suggesting Pain in Large Animals

Appetite/ Elimination Behaviors	Description	Significance

Appetite (Decreased, Inappetance)	• Picking at food or absolutely no interest in food	• Pain, chronic disease process, excessive sedation
Fecal production	• Decreased, difficulty posturing	• Pain, chronic disease process. Excessive sedation can cause GI motility to decrease, which will decrease fecal production.
Urination	• Posturing with little or no urine production	• Pain, chronic disease process

Table 6.17 / Levels of Pain Associated with Common Procedures, Injuries, or Illnesses

Mild to Moderate	Moderate	Moderate to Severe	Excruciating
Laryngeal Surgery: • Tie Back • Tie Forward Abdominal Exploratory Surgery: • LCV • SCV • RDA Arthroscopy Laceration Repair Abscess Lancing Castration	• Thoracocentesis • Hernia Repair • Cystotomy • Enucleation • Soft tissue injury • Corneal ulcer • Foreign body removal • Osteoarthritis • Navicular disease • Sepsis	• Sinus mass removal • Tooth removal • Dew claw removal • Claw amputation • Urethrotomy • Fracture repair • Hoof abscess • Hoof wall resection, partial or complete • Ovarectomy • C-section • Arthrodesis • Traumatic injury • Tendon injuries • Pleural pneumonia • Mastitis • Diarrhea associated with disease process • Colic • Colitis, ileus, or enterocolitis	• Amputation • Laminitis • Cellulitis • Meningitis • Burns

Table 6.18 / Parameters to Monitor in the Patient Receiving Pain Management

Body System	Visual Assessment	Physical Assessment	Normal Values
Body Temperature • Increases or decreases depending on which type of sedation is given	• Monitor patient for sweating, muscle fasciculations, increased respiratory rate with nostril flare, or open-mouth breathing.	• Monitor body temperature by taking temperature regularly (~q 3 hr). • Take appropriate action by notifying veterinarian if temperature is greater than or less than set parameters.	• *Horses:* 99–101.5°F • *Cattle:* 100.5–102.5°F • *Sheep:* 101.5–103.8°F • *Goats:* 101.5–103.5°F • *Swine:* 100–102°F • *Camelids:* 99.5–101.5°F
Cardiovascular • Increases or decreases depending on level of pain and type of sedation • In general, sedation my cause an initial period of tachycardia followed by bradycardia.	• Monitor patient for agitation with visible jugular pulse (particularly in horses and cattle).	• Monitor HR by using a stethoscope and auscultating the heart. • Physically palpate pulses at the facial artery and transverse facial artery.	• *Horses:* 30–40 bpm • *Cattle:* 40–80 bpm • *Sheep:* 60–120 bpm • *Goats:* 70–110 bpm • *Swine:* 60–90 bpm • *Camelids:* 60–90 bpm
Respiratory • Respiratory depression can occur with sedation. • Tachypnea may occur if dose of sedation is low and does not alleviate pain.	• Monitor patient for increased or decreased respiratory rate (RR) and respiratory effort (RE). Visual indicators could be nostril flare or open-mouth breathing.	• Monitor RR and RE. Use stethoscope and listen to lung fields.	*Horses:* 10–16 rpm *Cattle:* 12–36 rpm *Sheep:* 12–72 rpm *Goats:* 15–40 rpm *Swine:* 20–40 rpm *Camelids:* 10–30 rpm

Wound Care and Management

Wound management is the assessment, treatment, and care of traumatic injury. There are several different types of wounds. Open wounds are injuries where the skin is torn or punctured. Closed wounds are injuries that are under the skin. Wounds can be caused by injury, trauma, chronic health conditions, or surgery. Appropriate assessment and treatment of wounds is extremely important to reduce the risk of uncontrolled bleeding, infection, and other serious complications.

The first step in wound care is to control hemorrhage, if present. Assess the cause of the wound and determine the type of wound you are treating. The location of a wound is also important. For instance a wound involving the joint can influence how the wound will be treated.

Wounds can be acute or chronic. Acute wounds are typically injuries caused by trauma or accidents, such as a fall or burn. Chronic wounds include ulcers, sores, and other wounds due to a chronic condition, such as botulism.

Table 6.19 / Phases of Wound Healing

Inflammatory Phase (**Fig. 6.14**)	Proliferative Phase (**Fig. 6.15**)	Remodeling Phase (**Fig. 6.16**)

Immediate to 2–5 days
Hemostasis
1. Vasoconstriction
2. Platelet formation
3. Clot formation
 	
Inflammation
1. Vasodilatation
2. Phagocytosis
	• 2 days to 3 weeks
	• Granulation
	  • Fibroblasts lay a bed of collagen.
	  • Fills wound and produces collagen
	• Contraction
		• 3 weeks to 2 years
		• New collagen formation, increasing tensile strength

	• Wound edges pulled together • Epithelialization begins • Repair phase	

Figure 6.14 A front limb laceration in the inflammatory phase of wound healing (photo courtesy of Christopher Rizzo).

Figure 6.15 A front limb laceration in the proliferative phase of wound healing (photo courtesy of Christopher Rizzo).

Figure 6.16 A front limb laceration in the remodeling phase of wound healing (photo courtesy of Christopher Rizzo).

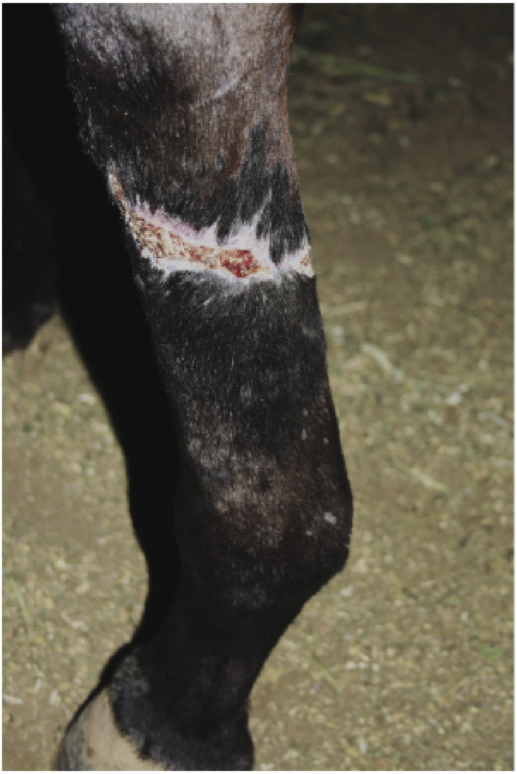


Table 6.20 / Types of Wounds

Types	Definition
Open Wounds	
Incision	• Wound with sharp, clean edges and minimal trauma to the tissue • Created by a sharp object like a scalpel
Avulsion	• An injury where a section of tissue is torn off from its attachment, usually caused by extreme force trauma
Laceration	• A contaminated wound with ragged edges • May have significant loss of tissue

Penetration	• An injury caused by an object such as a stick or fencing entering one area of the body and coming out another
Puncture	• Contaminated, deep, narrow wounds caused by a nail or needle
Closed Wounds	
Contusion	• Subcutaneous tissue damage with little or no damage to the skin (bruise)
Hematoma	• Damage to a blood vessel that in turn causes blood to collect under the skin
Crush Injury	• Great or extreme force or pressure applied to an area of the body over a long period of time

Table 6.21 / Methods of Wound Closure

Method	Description
Primary Closure (Fig. 6.17)	• Suturing of skin within 6–8 hours of injury • Used in clean, minimally contaminated wounds • Used with facial or upper body wounds • Used in flap wounds with clean edges and good blood supply
Delayed Primary Closure	• Suturing of skin 1–3 days post injury • Performed before granulation tissue forms • Allows for infection to be controlled • Allows for swelling to be reduced • Used in moderate to severely contaminated wounds
Secondary Closure	• Suturing of skin 3–5 days post injury • Wounds closed surgically after healthy bed of granulation tissue has formed • Used in chronic wounds with compromised blood supply
Second Intention Healing	• Wound is not closed surgically. • Wound healing by granulation and contraction of tissue • Used for wounds over highly moveable areas (limbs, pectorals and gluteals)

Skin grafting	• Extrication and transfer of a segment of skin from one site to another (generally the hip) • Used to reduce skin deficits in large wounds, where wound contraction and epithelialization is not enough to heal the wound

Figure 6.17 Primary closure of a front limb laceration (photo courtesy of Christopher Rizzo).

Table 6.22 / Treatment of Wounds

Assessment	Description
Control the Hemorrhage	Apply direct pressure to stop or control bleeding.

<table>
<tr><td>Examine the Wound</td><td>Assess wound to determine type of wound.</td></tr>
<tr><td>Examine the Wound Location</td><td>Assess wound location.

Face:
Are the eyes, nares, or mouth involved?
Are the nerves, veins, or arteries involved?
Neck:
Is the carotid artery or jugular vein involved?
Is the nuchal ligament involved?
Is the spine involved?
Chest and Thorax:
Could there be damage to the thoracic cavity?
Are the lungs or ribs involved?
Abdomen:
Could the peritoneal cavity be involved?
Limbs:
Are the joints involved?
Are the tendons sheaths involved?
</td></tr>
<tr><td>Degree of Contamination</td><td>
Assess the degree of contamination to the wound
Clean wound
Clean contaminated wound
Contaminated wound
Dirty infected wound
How long a wound has been exposed and untreated will also determine the contamination level of the wound.
</td></tr>
<tr><td>Flush the Wound (Fig. 6.18)</td><td>Open exposed wounds should be flushed with sterile saline (if available) to decrease contamination.</td></tr>
<tr><td>Bandage the Wound (Fig. 6.19)</td><td>Until the veterinarian is able to assess and treat the wound, a clean dry bandage should be applied to protect the wound from further contamination.</td></tr>
</table>

Figure 6.18 Proper cleaning (flushing) of a laceration (photo courtesy of Christopher Rizzo).

Figure 6.19 Proper placement of a full limb bandage to keep the laceration clean (photo courtesy of Christopher Rizzo).

Table 6.23 / Clinical Wound Care

Equipment Set-Up	• Clippers • Water soluble lube • Chlorhexidine scrub/Iodine scrub • Warm sterile saline • Carbocaine (local anesthetic) • Sedation (xylazine, acepromazine, butorphanol, detomadine) • Sterile 4 × 4s • Gloves (sterile and nonsterile) • Instruments (hemostats, scalpel, scissors, forceps) • Suture material

Preparing the Wound for Treatment	• Clean out all obvious debris (piece by piece) • Apply water-soluble lube to the wound. • Clip area surrounding the wound • Scrub area surrounding the wound, using care not to get soap into the wound. • Remove lubricant from the wound.
Cleaning the Wound (Fig. 6.20)	• Lavage the wound with warm sterile saline. Try not to get soap into the wound. • Pour sterile saline directly from 1 L bottle or use a sterile 60 cc catheter tip syringe. • Lavage wound until all debris and soap is flushed away.
Debridement	• Performed by veterinarian
Wound Closure **(Performed by Veterinarian)**	• Primary closure. • Delayed primary closure (1–3 days post injury) • Secondary closure (3–5 days post injury) • Second intention healing (grossly contaminated wounds, wounds over areas of the body with high movement and where sutures would not remain intact)

Figure 6.20 Cleaning gross debris and serous discharge from the primary closure site of a laceration (photo courtesy of Christopher Rizzo).

Table 6.24 / Wound Bandaging

Bandage Layer	Purpose	Material
Primary or Contact Layer (Fig. 6.21)	• Direct contact with the wound • Protects the wound from infection • Promotes healing	N/A
Adherent Primary Layer	• Promotes debridement of the wound • *Dry to dry:* Closely woven or widely open gauze material is used so that tissue will adhere to the bandage and	• *Gauze pads:* Generally sterile 4 × 4s

	debridement of the wound occurs when the bandage is changed. • *Wet to dry:* Gauze is soaked with sterile saline and applied to the wound. It is applied when a scab has formed to rehydrate the wound and remove debris. Wet dressings are discontinued once healthy granulation tissue develops.	

Nonadherent Primary Layer	• Nonstick material is indicated when a healthy granulation bed has developed.
	  • *Occlusive:* Used when discharge is present during repair phase
	  • *Semiocclusive:* Prevents tissue dehydration, allows fluid absorption
		• Telfa™ pads, polyurethane foam sponges
		• *Occlusive:* Hydrogels, hydrocolloid, or silicone
		• *Semiocclusive:* Petrolatum infused gauze, Telfa, polyurethane film

Secondary Layer	• Further protects the wound from contamination • Additional layer to absorb discharge • Holds wound dressing in place	• Cast padding • Roll or pound cotton • Combine bandage
Tertiary Layer	• Secures primary and secondary layer	• Brown or white gauze
Protective or Outer Layer (Fig. 6.22)	• Secures entire bandage from contamination and helps prevent bandage from slipping	• Vetwrap™ • Coflex® • Elastikon®

Figure 6.21 The inner layers of a bandage that is being removed (photo courtesy of Christopher Rizzo).

Figure 6.22 Protective outer layer of the bandage (photo courtesy of Christopher Rizzo).

Fluid Therapy and Administration

Fluid Therapy is an essential part of large animal medicine. Fluid administration is used to restore electrolyte imbalances, to maintain hydration status, and to provide nutritional support; it can ultimately save an animal's life.

The veterinarian is responsible for prescribing the appropriate fluids. Veterinary technicians can assist the veterinarian in making the appropriate choice by properly assessing hydration and perfusion.

Veterinary technicians need to have a well-developed understanding of fluid therapy and fluid requirements and of what is available to ensure that proper fluid balance is maintained in each patient.

Table 6.25 / Hydration Assessment

Assessment of Hydration	Method	Hydration Significance

Physical Examination	• Assess dehydration status
	  • *Skin tenting/Skin turgor test:* Tests skin elasticity after being picked up. The amount of time it takes for skin to return to normal is a quick assessment of hydration. Test several areas along the neck, cranial to the scapula
	  • *MM:* Assess for color and moistness of gums and, in female animals, the vulva.
	  • *Eyes:* Degree of eye sinkage into the orbital sinus (enophthalmus)
	• Assess perfusion status
	  • *CRT:* The amount of time required for mucosa (oral or vaginal) once blanched to return to normal pink color. Press on gums for a second and count the amount of time the blanched area takes to return to normal
		• Mild dehydration (5–7%)
		  • *Clinical signs:* Slight decrease in skin elasticity, tacky mucous membranes, prolonged JRT
		• Moderate dehydration (8–10%)
		  • *Clinical signs:* Decreased skin elasticity, tacky-to-dry mucous membranes, prolonged CRT (>2 sec), prolonged JRT
		• Severe dehydration (10–12%)
		  • *Clinical signs:* Depression, sunken eyes (enophthalmus), pale and dry MM, weak pulse quality, increased HR (>50 bpm), as well as all clinical signs present in mild and moderate dehydration. Limbs and body

	pink color. (Normal is <2 seconds.) • *JRT (jugular refill time):* Occlude jugular vein and observe how long it takes for blood to fill. (Normal is ~3–5 seconds.) (This is easily assessed in equine, bovine, ovine, and caprine.)	temperature are cool. • Above 12% dehydrated • The patient is in shock, and death is imminent.

Physical Examination	• Heart rate and pulse: Mandibular artery, transverse facial artery, coccygeal artery, dorsal metatarsal artery
	• Assess HR and pulse rate (rate and rhythm):
	  • Normal equine HR: 28–44 bpm
	  • Normal bovine HR: 40–80 bpm
	  • Normal ovine HR: 70–90 bpm
	  • Normal caprine HR: 70–90 bpm
	  • Normal porcine HR: 60–90 bpm
	  • Normal camelid HR: 99–101.5 bpm	

Laboratory Assessment	• Packed cell volume: Blood
	  • Normal equine: 32–48%
	  • Normal bovine: 24–46%
	  • Normal ovine: 27–45%
		• Increased HCT = dehydration
		• Increased TP = dehydration. (TP can be decreased in cases of a protein-losing disease such as diarrhea.)
		• Normal USG:

	• Normal caprine: 22–38% • Normal porcine: 36–43% • Normal camelid: 29–39% • Total protein: Serum • Normal equine: 6–8.5 g/dl • Normal bovine: 6–8 g/dl • Normal ovine: 6–7.5 g/dl • Normal caprine: 6–7.75 g/dl • Normal porcine: 6–8 g/dl • Normal camelid: 6–8 g/dl • *Urine specific gravity:* Evaluates kidney function more than hydration. Only reflects dehydration if kidneys are healthy. • *Electrolyte assessment:* See laboratory section for normal values.	• Equine: 1.025–1.060 • Bovine: 1.030–1.045 • Ovine: 1.015–1.045 • Caprine: 1.015–1.045 • Porcine: 1.010–1.050 • Camelid: 1.015–1.045
Medical History	• Review of patient's history and conversation with owner	Previous Hx of heart or kidney issues can influence fluid therapy.

Table 6.26 / Calculating Fluid Requirements*

Purpose	Basis of Rehydration Formula	Rate
Rehydration (Replacement of Fluids)	• *Replacement calculation:* Only use for the dehydrated animal.	• Animal's body weight in kilograms × % dehydrated = RF in liters • RF in liters × 1000 = RF in milliliters

	• Maintenance calculation volume of fluids necessary to supply the body's cells with the water necessary to maintain life and remove toxins. Fluids can be lost via urination, manure, sweat, or respiration. • Ongoing fluid losses	• *Example:* 500 kg × .07 = 35; 35 × 1000 = 35,000 • 50–60 ml/kg/d or 2 ml/kg/hr (large animal) • 1 L/25 kg body weight over several hours (large animal) • 80–120 ml/kg/d (foals or calves) • Calculate the amount of fluids lost from diarrhea. Gastric reflux and urine output are measurable losses. • *Example:* A horse is losing 10 L of reflux every 4 hours. How many 4-hour intervals in 24 hours? • 24 hours divided by 4 = 6 • 10 L reflux × 6 = 60 L/d • 60 L/d × 1000 ml/L = 60,000 ml/d
Anesthetic Protocol	• Maintenance rate for general anesthesia/elective surgery • Ongoing loss or dehydration due to illness such as colic	• 10 ml/kg/hr • 25–30 L in addition to the 10 ml/kg/hr
Postoperative Protocol	• Maintenance rate for postoperative cases	• 1–2 L/hr for 12–24 hr

	with normal hydration status	
Neonatal Protocol	• Maintenance rate for hydration status with the addition of meeting caloric needs of the neonatal patient	• *Holliday-Segar formula:* • 1–10 kg of weight = 100 ml/kg/d • 11–20 kg of weight = 1000 ml + 50 ml for each kg >10 kg/d • >20 kg of weight = 1500 ml + 25 ml for each kg >20 kg/d
Shock Protocol	• Shock rate for life-threatening situations only • Maximum amount of fluids that can be administered to a patient in one hour	• 60–90 ml/kg/hr

***Note: Veterinarians will need to prescribe the actual amounts, types, and rates of fluids to be administered.**

Table 6.27 / Routes of Fluid Administration

Fluid Administration Routes	Appropriate Use	Materials Required	Possible Complications	Notes
Oral	• Mild dehydration	• Drinking buckets • NGT (Fig. 6.23) • OGT (Fig. 6.24)	• Pharyngeal and esophageal irritation as well as nosebleed from NGT	• Not an option if there is an absence of GI motility, if patient is refluxing, or when animal is in shock
Intravenous • Jugular • Lateral Thoracic • Cephalic • Auricular (swine)	• Moderate-to-severe dehydration	• IVC in place • *IVF administration*: Set IVF pump	• Hematoma • Thrombosis • Phlebitis • Septicemia	• *Monitor:* IV fluids are going at the proper rate (minimum of q 2 hr) • IV catheter is in place and no heat, swelling, or discharge is present at insertion site • IVF do not become disconnected (minimum q1-2 hr). • Urination and fecal output • PCV and TS • Flush IVC with heparinized saline q 6 hr.
Subcutaneous	• Supplementation	• Large bore needle 14–16 g 1–1/2 inch	• Skin slouching, irritation	• Used for supplementation administration such as calcium. • Can administer only ~500 ml (cattle) • Not practical for fluid replacement in large animals because the volume of fluids needed for replacement far exceeds the SQ space.
Intraosseous (Proximal Tibia, Head of Femur)	• Moderate-to-severe dehydration (when IV access is not possible)	• #11 blade 12 g, 2.3 cm infusion needle, Sur-Fast® infusion needle or 16–18 g spinal needle • 2% injectable lidocaine • Heparinized saline • Sterile scrub and preparation materials • Sterile gloves • Suture material	• Extravasations into subcutaneous tissues • Incomplete insertion of needle • Overpenetration through the opposite cortex	• Not practical in adult large animal patients • Primarily used in neonatal patients where vascular access is not achievable
Intraperitoneal	• Mild-to-moderate dehydration • Plasma administration	• Large bore needle 14–18 g (filter administration set for blood products)	• Peritonitis	• Not practical in adult large animal patients • Typically used to administer plasma in neonatal patients or in camelids

Figure 6.23 Equine nasogastric tube and 450-ml dose syringe.

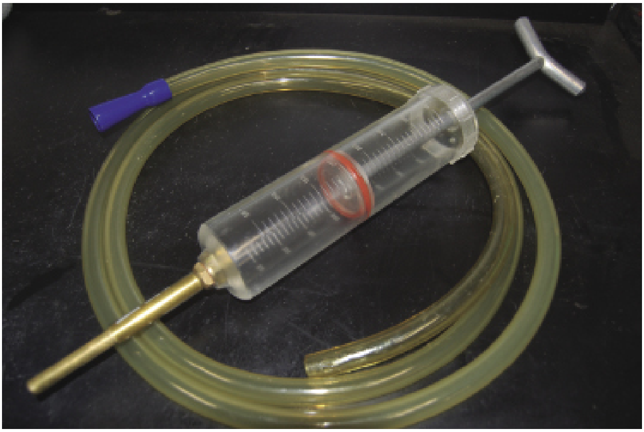


Figure 6.24 Bovine/Ruminant orogastric tube and speculum.

Table 6.28 / Monitoring Fluid Administration

Assessment	Technique	Significance
Cardiac Function	• Stethoscope	• Listen to the heart for changes in rate and rhythm
Respiratory Function	• Stethoscope	• Listen to lungs for increased respiratory noise, wheezes, stridor, or wetness.
PCV/TP	• Blood withdrawal	• Quick and easy way to assess hydration status in animals receiving rapid IVFs
Urine Output	• Collect urine	• Monitor urine concentrations via USG and volume of urine output.
Electrolyte Status	• Blood withdrawal	• Assess electrolyte imbalances
Central Venous Pressures	• 18- to 24-inch catheter inserted into the right atrium • Saline-primed extension set	• CVP decreases when blood pressure is low and increases when blood pressure is high. • CVPs can be used to assess cardiac function and hydration.

	attached to CVP catheter and to a manometer with a 3-way valve • Saline-filled syringe attached to one of the valves • Fill manometer with saline from syringe. • Manometer baseline (0 cm) should be positioned at shoulder so it is over the right atrium. • Turn 3-way valve off to syringe so the manometer is open to the patient. • The fluid column in the manometer will fall to level of CVP.	
Equipment	• Monitor IVF sets and the connections. • Check IVC for placement, position, and patency. • Monitor IVF bags.	• If IVC is positional or kinked, fluid rates may need adjusting to allow for proper IVF rate.
Temperature	• Thermometer	• Monitor for hypothermia.
Volume Overload Signs	• Auscultate heart and lungs.	• Because of their size, it is difficult to fluid overload an

	• Monitor for nasal discharge, pitting edema, increased RR, RE, and lung sounds.	adult large animal (horse or cow), unless they have compromised renal or cardiac function.

Table 6.29 / Fluid Additives

Fluid	Usage	Route	Monitoring	Disadvantages
Normosol—R/Plasmalyte (Crystalloid) (Fig. 6.25)	• Isotonic • Provides balanced electrolyte ratio • Restores decrease in circulatory volume in patients with mild-to-moderate blood loss	• IV	• Urine output and concentration • USG • Pulmonary function • PCV and TS	• May sting if administered SQ
Lactated Ringer's Solution (Crystalloid)	• Isotonic • Provides balanced electrolyte ratio	• IV, SQ	• Urine output and concentration • USG • Pulmonary function • PCV and TS	• Contains lactate and calcium and can precipitate with fluid additives such as DMSO and sodium bicarbonate and certain antibiotics
Sodium Chloride 0.9%/ Normal Saline (Crystalloid) (Fig. 6.26)	• Isotonic • Indicated in fluid and electrolyte losses, particularly when plasma potassium levels are increased due to underlying disease • Increases plasma volume • Corrects hyponatremia	• IV, SQ	• Sodium concentrations • Potassium concentrations • Pulmonary function	• Contraindicated in cases involving cardiac disease, hypertension, or metabolic acidosis
Dextrose 5% (Crystalloid) (Fig. 6.27)	• Hypertonic/Isotonic • Indicated for parenteral replenishment of fluids with primary water loss when patient is unable to take in oral fluids • Caloric booster • Good start for neonatal patients if they are not nursing	• IV	• Monitor blood glucose closely • Monitor urine for glucose • Monitor patient for edema	• Diuresis if patient becomes hyperglycemic which worsens dehydration
Hypertonic Saline 7.2% (Crystalloid)	• Hypertonic • Used to improve cardiac output in cases of shock	• IV	• Short-term benefit and should be followed up by other fluids • Potassium and sodium concentrations	• Hemolysis • Thrombosis • Re-hemorrhage • Increase in sodium with decrease in potassium
Hetastarch (Colloid)	• One-time treatment to correct hypovolemia • Synthetic plasma volume replacer	• IV	• Monitor for allergic reaction	• Potential for allergic reaction and coagulopathy
Plasma (Colloid)	• Isotonic • Failure of passive transfer (neonates) • Hypoproteinemia, endotoxemia, DIC, clotting issues	• IV	• Monitor TPR and patient closely and for plasma reaction	• Allergic reaction (Example: hives, edema of the muzzle, anaphylaxis)
Whole Blood (Fig. 6.28)	• Acute hemorrhage, severe anemia, red maple toxicosis	• IV	• Monitor TPR and patient closely for signs of whole blood transfusion reaction.	• Allergic reaction (Fig. 6.29)
Lidocaine 8 mg/ml	• Management of ventricular arrhythmias • Provides visceral pain management and promotes GI motility in patients with ileus	• IV	• Monitor for potential side affects. • Monitor heart rate and respiratory rate.	• Adverse reactions can occur.
Additive	**Usage**	**Route**	**Monitoring**	**Disadvantages**
Sodium Bicarbonate	• Correction of metabolic acidosis	• IV	• Blood gas • May be incompatible with other solutions	• Use with caution in patients with CHF. • Do not use in patients who are refluxing.
Potassium Chloride	• Treatment of hypokalemia • Dilute before administering.	• IV	• IVF rate closely • Monitor HR for arrhythmia, bradycardia	• Fatal arrhythmias
Calcium Gluconate 23%	• Treatment of hypocalcemia, (typically diluted) • Treatment of milk fever or down cow syndrome (administered full strength)	• IV, SQ	• Blood sampling for hypocalcemia • Heart rate for arrhythmias	• Fatal arrhythmias
Dextrose 50%	• Treatment of hypoglycemia • Short-term nutrient replenisher • Caloric booster	• IV	• Blood glucose	• Hyperglycemia which can cause diuresis and worsen dehydration
CMPK (Calcium, Magnesium, Phosphorous, Potassium: Premixed Fluid Additive for Treatment of Milk Fever)	• Treatment of milk fever in cattle	• IV, SQ	• Monitor electrolytes	• Fatal arrhythmia
DMSO	• Primarily used in treatment of neurologic disease in large animal • Can be used to treat inflammatory conditions, laminitis, arthritis, and intestinal ischemia • Typically diluted if used parenterally	• IV		• Industrial solvent with quick absorption through the skin. Wear gloves when handling.

Figure 6.25 Five-liter bags of a common large animal intravenous fluid, Plasmalyte (photo courtesy of Christopher Rizzo).

Figure 6.26 A bag of 0.9% NaCl (sodium chloride) with fluid additives of potassium chloride (KCl) and dextrose.

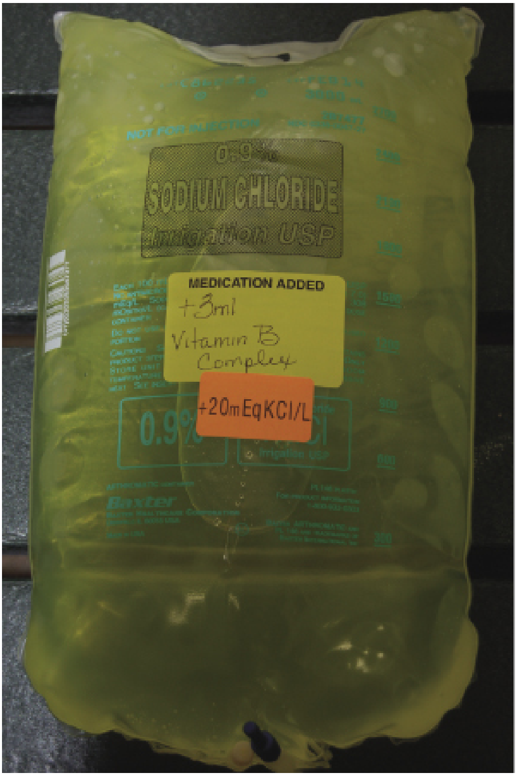


Figure 6.27 A bag of 5% dextrose with additional dextrose added to the bag.

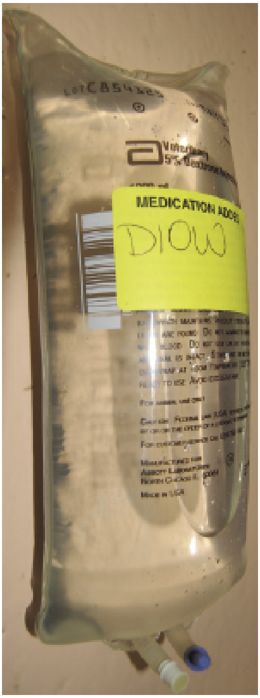


Figure 6.28 Bags of freshly harvested whole blood for a whole blood transfusion (photo courtesy of Christopher Rizzo).

Figure 6.29 A horse having an adverse reaction to blood or plasma transfusion (photo courtesy of Christopher Rizzo).

Basic Clinical Techniques

Basic clinical techniques are sets of skills that all veterinary technicians need to develop and master. These skills include but are not limited to intravenous, intramuscular, subcutaneous, intradermal, and oral medication administration, as well as intravenous blood withdrawal. Veterinarians rely on veterinary technicians to perform a wide array of tasks in the veterinary hospital. However, most often, veterinary technicians are expected to perform medication administration and blood sampling. Possessing good, clean technical skills is vital for all veterinary technicians.

Table 6.30 / Common Medication Administration Techniques

Route	Species	Location	Tools	Indications/Contraindications	Technique
Oral	• Equine • Bovine • Ovine • Caprine • Porcine • Camelid	• Mouth or NGT (using the nose to access the GI tract)	• 3- to 12-cc slip tip syringe • 60 cc-dose syringe • 450 ml-dose syringe • Nasogastric tube • Orogastric tube • Balling gun • Drenching gun • Pill forceps • Syringe size dependent upon the dose of medication needing to be administered and the size of the animal	• Enteral administration used to give therapeutic doses of medications that are supplied in pill, capsule, tablet, liquid, or paste form	• Technique to be described in Skills Box 6.8 • Pills and tablets may need to be crushed if an enteric coating is present. • Capsules will need to be opened to access medication. • Pills, tablets, and capsules will need to be dissolved in enough water to make them into a paste consistency. If dissolved medications are too watery, they can cause the animal to lose the prescribed dose or aspiration could occur.
Intravenous (IV) (Fig. 6.30)	• Equine • Bovine • Ovine • Caprine • Porcine • Camelid	• Jugular vein • Auricular vein (swine)	• 1- to 60-cc luer lock syringe • 18- to 25-g needle • Syringe size will be dose dependent. • Needle size will depend on the size or age of the animal.	• **AS A GENERAL RULE NO WHITE MEDICATIONS (with the exception of Propofol and TPN) SHOULD BE ADMINISTERED INTRAVENOUSLY.** • Parenteral administration is used to give therapeutic doses of medications that are supplied in injectable form, intravenously. • When administering medications direct stick (via needle and syringe), it is important to know your jugular groove anatomy and to avoid injecting the carotid artery. • If you should insert the needle into the carotid artery, do not inject any medication. Remove the needle and hold off for a minimum of 5 minutes, until hemostasis occurs. • Use caution when administering medications direct stick intravenously and ensure you are still in the vein. Certain drugs can be very irritating if accidently administered perivascularly. • Use caution when administering multiple different medications intravenously when an IV catheter is in place because certain medications react poorly together and precipitate in the intravenous catheter.	• Technique to be described in Skills Box 6.9 • Always insert needle to the hub and aspirate (pull back on plunger of syringe) to ensure you are in the vessel. • Use a one-handed technique, and stabilize your syringe to prevent too much needle movement while inserted in the vessel. • Some injectable medications are supplied in powder form and need to be reconstituted. Read all directions to assure that the proper dose of medication is prepared.
Intramuscular (IM) (See Fig. 2.4.)	• Equine • Bovine • Ovine • Caprine • Porcine • Camelid	• Neck (splenius, trapezius, brachiocephalicus ,or serratus cervicus) • Hamstrings or hind end (semimembranosus, semitendinosus) • Pectoral • Gluteal • Epaxial (sheep and goats)	• 1- to 60-cc luer lock syringe • 18–25 g, 1-inch needle • Size of syringe and needle are dependent on type and dose of medication, as well as age and size of animal.	• Parenteral administration of therapeutic medication, the most common vaccination that is supplied in injectable form, intramuscularly. • Use caution when administering IM injections, especially if the animal requires multiple doses for multiple days. Rotate IM sites to avoid muscle soreness, swelling, or abscess. • Pectorals should only be used for very small and infrequent IM doses as they tend to swell and become sore more quickly. • Gluteal muscles should be avoided because there is no ventral drainage if they should abscess. • Neck should be avoided in camelids.	• Technique to be described in Skills Box 6.10 • Insert needle to the hub; use one-handed technique; and stabilize the syringe. • Always aspirate before administering medication. You do not want to see blood in the hub of your needle when administering IM injections. • IM injections in cattle and small ruminants are almost always administered in the neck only. • Swine IM injections are typically administered 70 mm (~3 inches) caudal to the base of the ear. • Camelid IM injections are typically administered in the semitendinosus muscles.
Subcutaneous (SC or SQ) (See Fig. 2.5.)	• Equine • Bovine • Ovine • Caprine • Porcine • Camelid	• Neck (just cranial to the scapula) • Caudal to the elbow • *Swine:* Inside the thigh • Behind the shoulder	• 1- to 10-cc luer lock syringe • 18–25 g, 1-inch needle • Size of needle and syringe are dependent on size and age of animal.	• Parenteral administration of therapeutic medication and some vaccinations that are supplied in injectable form, subcutaneously. • SQ injections will be absorbed slowly by the body. • Try to limit SQ injections to smaller doses unless absolutely necessary. • SQ vaccinations can sometimes cause "knots" or swellings at injection sites.	• Lift skin at desired location, make a tent, and access the SQ space. • Insert needle (retrograde or antegrade). Aspirate to ensure there is no blood in the hub of the needle. Administer medication. • There may be a small raised bleb where medication was administered. This is normal and should disperse after a few hours. Check injection sites for signs of abscess.
Intradermal (ID)	• Equine • Bovine • Ovine • Caprine • Porcine • Camelid	• Intradermal injections are administered just under the epidermal layer of skin into the dermal layer, commonly to "deaden" or "block" an area for specific procedures. • Intradermal injections can be administered anywhere on the body where a potentially painful or uncomfortable procedure will occur.	• 1- to 60-cc luer lock syringe • 18–25 g, 1-inch needle • Size of needle and syringe depends on how much medication will be administered intradermally and the location of the injection.	• Commonly used in large animal medicine to "block" or temporarily "deaden" the skin so unpleasant or painful procedures can be performed • Intradermal injections are also used for allergy testing.	• Insert needle at a shallow angle (less than 45°) through the epidermis and into the dermis. • Aspirate to ensure there is no blood in the hub of the needle. • Inject medication (typically Lidocaine or Carbocaine) to deaden the area.

Figure 6.30 Proper technique for performing intravenous medication administration.

Table 6.31 / Intravenous Blood Withdrawal Techniques. (See Skills Box 6.11.)

Species	Location	Indications	Contraindications	Technique

Equine (Adult and Foal)	• Jugular vein
	• Transverse facial vein
	• Lateral thoracic vein
	• Cephalic vein
	• Saphenous vein
		• Jugular vein is most often used for venipuncture in adults or foals when larger amounts of blood are needed to fill blood tubes.
		• Transverse facial vein is used commonly in adult equine for smaller blood samples, such as a PCV and TS, but up to 10 ml can be withdrawn from this vessel safely if the horse tolerates it.
		• Cephalic vein can be used in foals for blood sampling.
		• Saphenous vein is commonly used in foals for blood sampling.
		• Proper restraint is important whenever performing venipuncture.
			• Cephalic vein should be used with extreme caution in adult equine.
			• Lateral thoracic vein is in an extremely sensitive area on the horse and should be used only as a last resort (example: jugular vein thrombosis, unsafe to use cephalic or transverse facial) and be saved for IV catheter placement.
			• Saphenous vein should never be used in adult equine for safety reasons.
			• Vacutainer use is not practical when using the cephalic or saphenous veins because there is a risk of collapsing the vessel.
				Tools:
				• Needle and syringe
				  • Commonly use a 20 g, 1-inch needle.
				  • Syringe size is dependent upon how much blood is needed for sampling.
				• Vacutainer system
				  • 20–22 g, 1-inch Vacutainer needle
				  • Plastic Vacutainer needle holder
				• Blood tubes

Bovine (Adult and Calf)	• Jugular vein
	• Coccygeal vein
	• Mammary vein (milk vein)
	• Cephalic vein
	• Saphenous vein
		• Coccygeal and jugular veins are most commonly used in the bovine species for both larger and smaller blood samples.
		• The mammary vein can be used for blood samples but is more commonly used by farmers for oxytocin administration in dairy cattle.
		• Cephalic and saphenous veins can be used in calves for blood sampling.
		• Proper restraint is important whenever performing venipuncture.
			• Cephalic and saphenous veins are not practical to use in adult bovine patients.
			• It is easier to accidentally introduce the needle into the carotid or the coccygeal artery in cattle. Use caution.
			• Vacutainer use is not practical when using the cephalic or saphenous veins because there is a risk of collapsing the vessel.
				Tools:
				• Needle and syringe
				  • Commonly use a 20 g, 1-inch needle.
				  • Syringe size is dependent upon how much blood needed for sampling.
				• Vacutainer system
				  • 20–22 g, 1-inch Vacutainer needle
				  • Plastic Vacutainer needle holder
				• Blood tubes

Ovine (Adult and Lamb)	• Jugular vein
	• Cephalic vein
	• Saphenous vein
		• Jugular vein is the most common vessel used for blood sampling.
		• Cephalic and saphenous can be used for smaller blood samples.
		• Cephalic and saphenous veins are used more commonly in lambs.
		• Proper restraint is important whenever performing venipuncture.
			• Saphenous vein is not practical to use in adult sheep.	Tools:
				• Needle and syringe
				  • Commonly use a 20 g, 1-inch needle.
				  • Syringe size is dependent upon how much blood is needed for sampling.
				• Vacutainer system
				  • 20–22 g, 1-inch Vacutainer needle
				  • Plastic Vacutainer needle holder
				• Blood tubes

Caprine (Adult and Kid)	• Jugular vein
	• Cephalic vein
	• Saphenous vein
		• Jugular vein is the most common vessel used for blood sampling.
		• Cephalic and saphenous veins can be used for smaller blood samples.
		• Cephalic and saphenous veins are used more commonly in kids and smaller goat breeds.
		• Proper restraint is important whenever performing venipuncture.
			• Saphenous vein is not practical to use in adult goat.	Tools:
				• Needle and syringe
				  • Commonly use a 20 g, 1-inch needle.
				  • Syringe size is dependent upon how much blood needed for sampling.
				• Vacutainer system
				  • 20–22 g, 1-inch Vacutainer needle
				  • Plastic Vacutainer needle holder
				• Blood tubes

Porcine (Adult and Piglet)	• External jugular vein
	• Cranial vena cava
	• Brachiocephalic vein
	• Auricular vein
	• Orbital sinus
		• Auricular vein (ear vein) is most commonly used for small blood samples.
		• Orbital sinus can be used for blood samples up to 10 ml.
		• Proper restraint is important whenever performing venipuncture.
			• Jugular vein is safer to access with a needle, but it is a smaller vessel.
			• Aspiration of blood should be slow in order to avoid collapsing the vessel.
			• Vacutainer system use is not practical for the auricular vein or orbital sinus.
				Tools:
				• Needle and syringe
				  • Commonly use a 20 g, 1-inch needle.
				  • Syringe size is dependent upon how much blood needed for sampling.
				• Vacutainer system
				  • 20–22 g, 1-inch Vacutainer needle
				  • Plastic Vacutainer needle holder
				• Blood tubes

Camelid (Adult and Cria)	• Jugular vein
	• Cephalic vein
	• Saphenous vein
		• Jugular vein is most commonly used for blood sampling in camelids.
		• Cephalic and saphenous veins can be used in crias but are not practical to use in adult camelids.
			• Either jugular vein can be used, but the preferred site is the right jugular vein because the esophagus runs along the left.
			• Cephalic and saphenous veins are small and collapse easily. Use care when aspirating for blood sampling.
				Tools:
				• Needle and syringe
				  • Commonly use a 20 g, 1-inch needle.
				  • Syringe size is dependent upon how much blood needed for sampling.
				• Vacutainer system
				  • 20–22 g, 1-inch Vacutainer needle
				  • Plastic Vacutainer needle holder
				• Blood tubes

Skills Box 6.1 / Nasogastric Intubation

- Rest the hand over the muzzle without occluding the airway. Lift the nares with the thumb to ensure you are not entering the false nostril.
- The tube is placed at the ventral nasal meatus.
- Push on the tube with your thumb medially and ventrally (Fig. 6.31).
- The horse's neck is flexed, and the tube is gently pushed through the nostril to the pharynx.
- Once at the pharynx, you will encourage the horse to swallow by gently bumping against the pharynx and turning the tube.
- Pharynx = soft, bouncy.
- Ethmoid turbinates = hard.

- Push the tube with the animal's swallow allowing the tube to enter the esophagus.
- You should feel minimal resistance when you enter the esophagus. If you enter the trachea, the tube will slide very easily and quickly with no resistance.
- Blowing into the tube inflates the esophagus and makes it easier to pass the tube. This also creates an air bubble which can be seen. This is one of several ways to ensure the tube is not in the trachea.
- To assure that the tube is in the esophagus and not in the trachea, feel for the tube and watch it pass down the esophagus on the **left** side of the neck. When the stomach is entered, the smell of gases is obvious.
- You should also suck back on the tube with the dose syringe, or some people use their mouth, to obtain negative pressure (Fig. 6.32).
- If the tube is in the trachea or the lungs, there will not be negative pressure.
- If you suspect the tube is in the trachea, pull the tube out steadily with the tube kinked until you pass back over the pharynx.
- It is imperative to be sure that the tube is in the esophagus before fluids are pumped in.
- **Pumping fluids into the lungs can be fatal!**
- When pulling the NGT, blow into the tube to clear any possible fluid or debris.
- Kink the tube to ensure that, if there is left over fluid or debris at end of tube, it remains in tube.
- Pull the tube with a steady, smooth motion and try to stabilize the tube by holding your thumb on it to ensure you do not hit the ethmoid turbinates and cause a nosebleed. Hitting the ethmoid turbinates and causing a nosebleed would have the potential to become a serious issue, although it usually looks worse than it actually is.

Figure 6.31 Proper technique for nasogastric intubation in horses.

Figure 6.32 Proper technique for checking to ensure proper placement of nasogastric tube in horses.

Skills Box 6.2 / Standing Wrap

- *Horses:*
  - Used for protection of lower legs or to prevent "stocking up" (accumulation of fluid in the distal limbs of horses, often seen when horses are confined to a stall due to illness or injury)
- *Supplies needed:*
  - Fleece, quilt, or cotton padding, 10–16 inches wide
  - Stable bandage with Velcro® or fleece wrap
  - White tape if wrap does not have Velcro
- *How to set a standing wrap:*
  - Ensure proper size quilt to cover metacarpus/metatarsus.
  - Start the wrap on the medial aspect of the limb and unroll in a cranial-to-caudal direction.
  - Avoid wrinkles. Tighten the wrap using the front of the limb, and do not make the wrap too tight or pull on tendons running along back of leg.
  - *Securing layer (stable wrap with Velcro or fleece wrap)*: Start in the middle of the padding layer. Wrap from the medial aspect of the leg and unroll in a cranial-to-caudal direction.
  - Stabilize the wrap with the hand while setting the wrap. Again, tighten along the front of the leg, and do not pull the wrap tight along tendons.
  - To end the wrap, secure with Velcro or white tape. Check to make sure 1 inch of padding is visible at the top and bottom of the wrap. This prevents the outer wrap from rubbing along the skin and potentially causing sores (Fig. 6.33).

Figure 6.33 Proper placement of standing/support wraps in horses.

Skills Box 6.3 / Distal Limb Bandage

- Typically used on limbs
- *Supplies needed:*
  - Adherent (sterile 4 × 4s) or nonadherent pad (Telfa)
  - Brown gauze, white gauze (Kling®), elastic adhesive tape
  - Cast padding, combine, or pound/roll cotton
  - Brown gauze or white gauze (Kling)
  - 4- to 6-inch adhesive elastic tape (Vetwrap, Coflex)
  - Elastikon
- *How to apply a bandage over a wound on the distal limb:*
  - Place adherent or nonadherent pad over the clean wound.
  - Loosely wrap pad with gauze or elastic adhesive tape in order to secure the pad over the wound.
  - Wrap the limb with cast padding, combine, or roll cotton. Start this layer on the medial aspect of limb and unroll in cranial to caudal direction.
  - Secure padding, combine or roll cotton with gauze.
  - Apply a finishing layer of 4- to 6-inch elastic adhesive tape.
  - The bandage can be secured further by wrapping the top and bottom with Elastikon (Fig. 6.34).

Figure 6.34 Proper placement of a hind limb/distal limb bandage.

Skills Box 6.4 / Full Limb Bandage

- Generally used for injuries to the carpus or the radius of the forelimb or tarsus to gaskin on the hind limb.
- Applied in 2 steps, commonly referred to as a stack wrap or double-decker bandage.
- *Supplies needed:*
  - Adherent (sterile 4 × 4s) or nonadherent pad (Telfa)
  - Brown gauze, white gauze (Kling), elastic adhesive tape
  - Cast padding, combine, or pound/roll cotton
  - Brown gauze or white gauze (Kling)
  - 4- to 6-inch adhesive elastic tape (Vetwrap, Coflex)
  - Elastikon
- *How to place a full limb bandage:*
  - Apply distal limb bandage using the same procedure as in Skills Box 6.3.
  - Apply upper limb bandage using the same procedure as distal limb bandage except this will overlap the distal limb bandage (Fig. 6.35).

Figure 6.35 Proper placement of a full limb bandage on a horse (photo courtesy of Christopher Rizzo).

Skills Box 6.5 / Robert Jones Bandage (Full Limb or Half Limb)

- Heavily padded limb bandage, commonly used to transport an animal with a severe fracture or tendon injury. This bandage provides limb support, controls swelling, and protects soft tissue from further injury.
- *Supplies needed:*
    - Nonsterile or sterile 4 × 4s to cover/protect the wound
    - Brown gauze, white gauze (Kling), elastic adhesive tape to secure the wound cover
    - 5 or more rolls of pound/roll cotton
    - 5 or more rolls of brown gauze or white gauze
    - 4 or more rolls of elastic adhesive tape (Vetwrap or Coflex)
    - 4 or more rolls of Elastikon
- *How to place a Robert Jones Bandage:*
    - Half limb Robert Jones Bandage is placed using the same initial steps as placing a distal limb bandage (see Skills Box 6.3), except you will then apply several layers alternating between cotton and gauze until bandage is large and thick.
    - Full limb Robert Jones Bandage is placed using the same technique as full limb bandage (Skills Box 6.4) except you will apply several

layers alternating between cotton and gauze until the bandage is large and thick.
- Can be applied with or without a splint
- To determine whether there are enough layers, flick your finger along the bandage ("thump"). Bandages should sound like you are thumping on a watermelon.

Skills Box 6.6 / Splints

- Splints are used in conjunction with bandages for added immobilization. Often used to support severe tendon injuries or to help correct flexural deformities. Can be applied to the flexor or extensor surface of the limb.
- There are several different types of splints. Most commonly in large animals (equine and bovine) splints are made from PVC pipe cut in half. Equines have a specialized splint for immobilization known as a Kimsey splint.
- *Supplies needed:*
    - Bandage materials necessary to complete a distal or full limb bandage (Skills Box 6.3 and Skills Box 6.4)
    - PVC pipe measured and cut to fit the animal's limb
    - 1–2 rolls of duct tape
- *How to place a splint (Fig. 6.36):*
    - Bandage the limb as described for distal or full limb bandage (Skills Box 6.3 and Skills Box 6.4).
    - Apply the splint to the medial, lateral, cranial, or caudal aspect of the limb (wherever support is deemed necessary by the veterinarian).
    - Duct tape the splint to the bandage.
- Monitor the splint for rotation or any movement that could negatively impact limb healing.
- Monitor the patient for comfort. Is the splint rubbing and causing sores? Monitor how the patient is ambulating. Is movement easy? Is the animal dragging the limb? Is the animal bearing weight?

Figure 6.36 Proper splint placement on a hind limb of the horse (photo courtesy of Christopher Rizzo).

Skills Box 6.7 / Abdominal Bandages

- Abdominal and thoracic bandages are used to cover wounds, protect incisions, keep hernias reduced, and help keep drains clean and in place.
- *Supplies needed:*
  - XS, small, medium, large, or extra large elastic with Velcro belly band
  - 2–4 rolls of Elastikon (abdominal or thoracic)
  - Package of sterile 4 × 4s (abdominal or thoracic)
  - Army/Navy bandage, field bandage, or combine (abdominal bandage)
- *How to place an abdominal bandage (Fig. 6.37):*
  - Use a size-appropriate elastic with Velcro belly band.

- Add an Army/Navy, combine, or field bandage to the center of the belly band.
- Place sterile 4 × 4s in center of combine.
- The belly band will take two people to place it. (One person holds the Velcro end, while the other person holds the non-Velcro end.) Pass the belly band under the animal between the front and back legs.
- Pull both sides of the belly band, ensuring that 4 × 4s on the field bandage cover the desired area. Place the non-Velcro side down first and secure the belly band with Velcro. You need to pull the belly band very tight to ensure that it will remain in place.
- The belly band can be secured with some Elastikon on the front and back. Make sure that some of the Elastikon sticks to the hair.

Figure 6.37 Proper placement of an abdominal/thoracic bandage on the horse.

Skills Box 6.8 / Oral Medication Administration

Supplies needed:

- Equine
  - 3- to 12-cc slip tip syringe (foals and juveniles)
  - 60-cc dose syringe (adult)
  - 450-ml dose syringe (adult)
  - Nasogastric tube
- *Bovine, ovine, caprine, and camelid:*

        - 3- to 12-cc slip tip syringe
        - 60-cc dose syringe
        - Balling gun
        - Drenching gun
        - Pill forceps
        - Oro-gastric tube
        - Oral speculum
    - *Porcine:*
        - 3- to 12-cc slip tip syringe
        - Balling gun
        - Drenching gun
        - Pill forceps
        - Oral speculum

Technique:

- *Equine:*
    - Place one arm under the horse's chin and rest your hand on the horse's nose.
    - Have the medication in the dose syringe and in the other hand.
    - Gently place the tip of the dose syringe into the interdental space.
    - Gently move the dose syringe farther back into the mouth using care not to damage oral tissues.
    - Press the dose syringe plunger and slowly administer the medication.
        - The medication should be paste-like as opposed to watery.
    - Hold the horse's head up to ensure that swallowing of the medication occurs.
        - Some horses are head shy and mouth shy. With these cases, moving slowly and patiently, try sticking fingers into the side of the mouth, only holding the side of the halter. Distraction such as blindfolding or using a handful of grain can help achieve the goal.
        - Some horses may require more restraint like a twitch or gum chain.
- *Bovine, ovine, caprine, and camelid:*
    - Proper restraint is necessary. Halter and tying the bovine head is highly recommended.
    - For sheep, goats, and camelids, manual restraint may be all that is necessary.
    - With an arm over the head, place fingers into mouth.
    - Hold the head securely and insert the syringe, balling gun, drenching gun, or pill forceps into the mouth.
        - Balling gun and pill forceps need to be inserted all the way to the back of the mouth for delivery of medication.

    - Squeeze the plunger or handle to dispense medication. Open the pilling forceps to release the pill, tablet, or capsule.
- *Porcine:*
    - Oral medications are typically crushed and dispensed into food with the expectation that the pig will eat the medication within the food.
    - Because of their sharp teeth and tusks, it is necessary to have an oral speculum and proper restraint to achieve medication administration.

Skills Box 6.9 / Intravenous Administration (Jugular Vein) for All Large Animal Species

Supplies needed:

- 1- to 60-cc luer lock Syringe
- 18–22 g, 1-inch needle. In adult bovine/equine, you would use 1½-inch needle.

Technique:

- Properly restrain the animal
- Occlude the vessel, by pressing against the jugular groove. This will distend the vessel and allow you to visualize it.
- Using a one-handed technique, hold the syringe at ~45° and insert the needle (with the syringe attached) into the vessel (see Fig. 2.3).
    - Use a gentle technique. Hold needle close to the animal. There is no need to harpoon the animal even if they are large/farm animals.
    - For more fractious animals, it may be necessary to insert the needle antegrade (toward the heart) because then you are going with the animal. This technique will help you avoid the need to reinject the vessel.
- Aspirate to ensure a flashback of blood is obtained and to make certain you are in the jugular vein and not the carotid artery.
    - If you miss the vessel or do not get a flashback immediately, do not pull the needle out of the vessel; instead pull the needle approximately half way out and gently redirect your angle.
    - ALWAYS ASPIRATE BEFORE INJECTING ANY MEDICATION. NEVER ADMINISTER ANY MEDICATION IF YOU SUSPECT YOU COULD BE IN THE CAROTID ARTERY.
- Inject the medication. Approximately half way through injection, it is advisable to aspirate again to ensure you are still in the vessel and not administering medications perivascularly.
    - Perivascular administration can be extremely irritating to the tissue around the jugular vein, which can lead to skin sloughing or permanent scarring.

- Once IV medication administration has been completed, pull the needle out of the skin and hold off the injection site promoting hemostasis.
- An alternative method is to insert the needle without the syringe attached and then attach the syringe once you know the needle is in the jugular vein.
- The cephalic, saphenous and auricular veins can be used, but these vessels are smaller and more difficult to access. Small doses of medication can be administered into these vessels.

Skills Box 6.10 / Intramuscular Administration (Neck) for All Large Animal Species. (See Fig. 2.4.)

Supplies needed:

- 1- to 60-cc luer lock syringe
- 18–22 g, 1–1½ inch needle
- Alcohol wipes to clean away gross debris before injection
- This is the basic technique for IM injection in the neck. For hamstring injections, proper safety methods are vital for personal safety. Stand close, next to the animal's hind leg. Your back should be to the animal's head. Rest the arm closest to the animal over the rump; then insert the needle quickly, but gently. The animal may react unfavorably, so the safest way to administer in horses—and rarely, but sometimes, in cows—is to attach the syringe after the needle has been inserted.

Technique:

There are two methods for intramuscular injection

- First, place the needle; then attach the syringe and aspirate.
    - Use this commonly used, very-safe method to perform IM injections, especially when administering large doses. Blood will be seen immediately in the needle hub if it has been injected into the muscle and not the vessel. If this happens, remove needle and reinject.
    - If an animal is fractious or throws its head repeatedly, the needle is less likely to come out of the neck if the syringe has not been attached yet.
    - Certain medications can cause serious—and sometimes fatal—reactions when introduced into the bloodstream.
    - If animals are fractious, it can sometimes be difficult to attach the syringe to the needle.
- The needle and syringe should be put together before medication administration.
    - This method is acceptable for smaller doses.

    - Remember that you must aspirate the plunger and check to ensure you have no blood in the hub.
    - If the animal throws its head, the needle and syringe could fall out.
- Hold the needle or needle and syringe like you would hold a dart.
    - Just because you hold it similar to a dart does not mean that you will throw the needle or "dart" the animal with the needle.
- Rest the wrist of the injecting hand against the animal. Then gently insert needle at a 90° angle all the way to the hub. Ensure there is no blood in the hub of the needle.
- Stabilize the needle and attach the syringe if it has not already been attached.
    - If the syringe is attached prior to injection, do not place the thumb over the end of the plunger, to prevent accidental injection of medication prior to checking for the presence of blood.
- Stabilize the syringe, for example, by wrapping all four fingers around the syringe, aspirating the plunger with the thumb, and then injecting medication with the thumb.
    - There is no one technique that is the absolute correct way to administer IM medications, but stabilizing the needle and syringe is essential for good, clean technique and for avoiding muscle swelling and tissue damage.
- Remove the needle and hold off at the injection site to promote hemostasis.

Skills Box 6.11 / Intravenous Blood Withdrawal for All Large Animal Species

Supplies needed:

- 1- to 30-cc luer lock syringe
- 18–22 g, 1-inch needle
- Vacutainer holder
- 20–22 g, 1-inch Vacutainer needles
- Blood tubes
- Alcohol wipe to remove gross debris from the skin

Technique:

- Needle and syringe (See Fig. 2.3.)
    - *Jugular vein:*
        - Basic technique is the same as the IV medication administration described in Skills Box 6.9.

- The needle can be inserted with or without the syringe attached.
- Draw back on the plunger until the desired amount of blood is obtained.
- Transfer the blood to the proper blood tubes for sampling or place the blood in micro hematocrit tubes for PCV and TS values.

- *Cephalic and saphenous vein:*
    - The vessel needs to be occluded for visualization.
    - Insert the needle toward the body of the animal (toward the flow of blood).
    - Draw back on the plunger slowly. (These vessels are smaller and can collapse more easily than the jugular vein.)
    - Collect the desired amount of blood and transfer to blood tubes or micro hematocrit tubes.
- *Transverse facial vein:*
    - This is a blind stick that is commonly used in horses for small blood samples. Most adult horses are surprisingly tolerant of this method.
    - This vessel is located ~45° dorsal to the medial canthus of the eye just under the facial crest.
    - The needle is inserted at a 90°angle directly under the facial crest. Expect to hit bone with the needle. Pull the needle out slowly and draw back on plunger until blood begins to flow into the syringe.
    - Pull the needle out and hold off to promote clotting and to prevent hematoma formation.
- *Coccygeal vein (see Fig.2.6):*
    - This is also a blind stick commonly used in cattle for blood samples
    - The tail is restrained with one hand pushing it firmly straight up toward the back. (This is known as a “tail jack.”)
    - Insert 20 g, 1-inch needle using a 45–90°angle and directly on the midline of the tail at the proximal (closest to the cow) third of the tail.
    - Remember that the tail has vertebrae and that bony arches (hemal processes) run through it and protect the coccygeal artery and vein. Therefore, insertion of the needle needs to be between the vertebrae.
    - Insert the needle while drawing back on the plunger. You may hit the bone. If this occurs, retract the needle while still aspirating. Once you find the vessel, withdrawal desired amount of blood.
    - Remove the needle and apply pressure to the insertion site to promote hemostasis and to prevent hematoma formation.

- *Auricular vein:*
    - For small blood samples most commonly used in swine, use the ear vein, which runs along the lateral border of the ear and can be accessed on the dorsal or outside of the ear.
    - Proper restraint is necessary.
    - To stabilize the ear, place a roll of Vetwrap, Elastikon, or gauze in its entirety in the ventral or inside of the pinna.
    - To distend the vessel, use a tape tourniquet.
    - Insert 20–25 g, 1-inch needle at a slight 45°angle with the needle directed toward the head
    - Aspirate on syringe slowly, and obtain your blood sample
    - Withdrawal needle and hold off to promote hemostasis and prevent hematoma formation
    - This vessel is small and if you aspirate too quickly you will collapse the vessel

- Vacutainer system (See Fig. 2.1.)
    - The Vacutainer system is a plastic holder with a wide end that a blood tube can fit into and a narrow end that the needles will be screwed into.
    - The needle is a double-ended needle—one to puncture the vessel and one to puncture the blood tube—to allow blood to flow into the blood tube.
    - Venipuncture with the Vacutainer system requires the same one-handed technique that is used with a needle and syringe.
    - The advantage of the Vacutainer system is that you have to stick the animal with a needle only once in order to collect several blood samples.
    - Attach the Vacutainer needle to the holder. Keep the blood tubes in your hand or in a pocket until after you insert the needle into the vessel.
    - Insert needle all the way to the hub into the vessel using same technique as if you are using needle and syringe
    - Stabilize the Vacutainer system, and hold it steady while inserting the blood tube. Do not pull the blood tube until it is filled to the required amount needed. You will know when the blood tube is full because the blood will initially stream into the tube and gradually start dripping or stop; this is when you can remove tube and place another (see Fig. 2.2).
    - When all tubes have been filled, it is important to pull the last tube before pulling the vacutainer needle to break the seal created and avoid causing a hematoma.
    - Once you remove the needle, hold off at the insertion site to promote hemostasis and to prevent hematoma formation.

Chapter 7

Clinical Pathology

Sarah Ouellette

Chemistry Strip Examination
Sediment Examination
Sediment Examination: Cellular Structures
Sediment Examination: Bacteria
Sediment Examination: Blood Cells
Sediment Examination: Casts
Sediment Examination: Crystals

Key Terms and Phrases

Agglutination
Aggregation
Anemia
Anisocytosis
Anisokarosis
Anticoagulant
Axonemes
Axostyle
Basophilic
Brownian movement
Buffy coat
Carbohydrate
Cellularity
Cestode
Chromatin
Colorimetric
Cornified
Crenation
Dermatophyte
Encephalopathy
Enzyme
Epithelial
Extracellular
Extrinsic
Femtoliters
Fibrinogen
Genal combs
Globulin alpha
Globulin beta
Globulin gamma
Glucogenesis
Glycoaminoglycans
Glycogenolysis
Granularity
Hemolyzed
Hemostasis
Heparinized
Hepatoid
Hydatid cyst
Hypercellular
Hyperplasia
Hypersthenuric
Hypocellular
Hypochromic
Hypoplasia
Hyposthenuric
Inanimate
Intermediate host
Intracellular
Intrinsic
Lipemic
Lyophilized
Lysed
Lysosomes
Macrocytosis
Macromesenchymal
Metabolism
Microfilariae
Mitotic figures
Mordant
Mucoprotein
Nematode
Normocellular
Normochromic
Nucleoli
Oncosphere
Oncotic
Oocysts
Operculum
Paratenic host
Percutaneous
Plasma
Pleomorphism
Poikilocytosis
Polychromatophilic
Polycythemia
Postparandial
Prepatient period
Preprandial
Proglottid
Pronotial
Protozoa
Pyknotic
Rickettsiae
Rodenticide
Rouleaux
Serum
Sporangium
Sporulated
Thrombosis
Trematodes
Trophozoite
Urolithiasis
Vacuoles
Vacutainer

Abbreviations

AchRs: Serum antibody against nicotinic
ACT: Activated clotting time
ACTH: Adrenocorticotropic hormone
ADH: Antidiuretic hormone
AIHA: Autoimmune hemolytic anemia
ALKP: Alkaline phosphatase
ALP: Alkaline phosphatase
ALT: Alanine aminotransferase
APTT: Activated partial thromboplastin time
AST: Aspirate aminotransferase
AT: Adrenocortical tumors
BA: Blood agar
BMBT: Buccal mucosal bleeding time
BTT: Light blue top tube
BUN: Blood urea nitrogen
CBC: Complete blood count
Cl: Chloride
CNS: Central nervous system
CO_2: Carbon dioxide
DIC: Disseminated intravascular coagulation
dL: Ceciliter
DM: Diabetes mellitus
EDTA: Ethylenediaminetetraacetic acid
F: Fahrenheit
FDP: Fibrin degradation product
fL: Femtoliter
FNA: Fine needle aspirate
FNB: Fine needle biopsy
FSP: Fibrin split product
g/dl: Grams per deciliter
GGT: Gamma glutamyltranspeptidase
GIT: Gastrointestinal tract
GRNTT: Green top tube
GTT: Gray top tube
HAC: Hyperadrenocorticism
HCO_3: Bicarbonate
Hct: Hematocrit
HGB: Hemoglobin
HPF: High power field
IFA: Immunofluorescence
IgE: Immunoglobulin gamma E
IM: Intramuscular
IMHA: Immune mediated hemolytic anemia
IV: Intravenous
K: Potassium
kg: Kilogram
KPO4: Potassium phosphate
L: Leader
LPF: Lo power field
LTT: Lavender top tube
MC: MacConkey agar
MCH: Mean corpuscular hemoglobin
MCHC: Mean corpuscular hemoglobin concentration
MCV: Mean corpuscular volume
mEq: Milliequivalent
mg: Milligram
Na: Sodium
N/A: Not applicable
ng: Nanogram
NMB: New methylene blue
nRBC: Nucleated RBC
NSAIDs: Nonsteroidal antiinflammatory drugs
PAP: Immunoperoxidase test
PCR: Polymerase chain reaction
PCV: Packed cell volume
PDH: Pituitary dependent hyperadrenocorticism
pg: Picigram
pH: Potential of hydrogen
PIVKA: Protein induced by vitamin K antagonism
pmol: Picomole
PT: Prothrombin time
PTH: Parathyroid hormone
RBC: Red blood cell
RTT: Red top tube
SAP: Alkaline phosphatase
SGOT: Serum glutamic oxaloacetic transaminase
SGPT: Serum glutamic pyruvic transaminase
SST: Serum separator tube
SUN: Serum urea nitrogen (aka BUN [blood urea nitrogen])
T3: Triiodothyronine
T4: Tetraiodothyronine
TLI: Trypsin-like immunoreactivity
TP: Total protein
TRH: Thyroid releasing hormone
TSH: Thyroid stimulating hormone
TT: Thrombin time
TWBC: Total white blood cell count
U: Unit
µg: Microgram
µm: Micrometer
µmol: Micromole
USG: Urine specific gravity
UTI: Urinary tract infection
VWF: Von Willebrand Factor
WBC: White blood cell

Introduction

Laboratory skills are some of the most important skills to have in the veterinary profession. Simple tests may yield a diagnosis when clinical signs alone cannot. Many hospitals prefer to send out samples to reference laboratories; however, knowledge of proper collection and handling of samples—as well the understanding of proper procedure protocols—will allow for optimum interpretation of the tests. Laboratory skills are essential diagnostic tools that aid in planning courses of treatment for animals. The main goal in laboratory medicine is to consistently generate reliable laboratory results to aid in a diagnosis. For achievement of the most-accurate test results, extreme care should be taken when performing laboratory tests.

This chapter covers all aspects of laboratory medicine including collection, handling, storage, and transport of specimens, as well as procedures and normal ranges. This chapter will give you the information you need to understand and perform laboratory medicine.

Slight variations may occur among some protocols and ranges depending on the reference laboratory and specific tests performed.

Blood Chemistry Tests

Blood chemistry tests are extremely useful diagnostic tools in veterinary medicine. They are used to evaluate various blood substances—substrates, enzymes, and hormone levels—to help portray certain body and organ functions. The most critical part of performing blood chemistry tests is the collection and the handling of each sample. For example, allowing a blood sample to sit at room temperature for an extended period of time may elevate some blood chemistries and decrease others, which could lead to a possible misdiagnosis and treatment. Extreme care should be taken and proper protocols should be followed during the collection, handling, and storage of samples in order to ensure the most accurate results.

Blood Collection, Handling, Storage, and Transport Tips

Collection

- Most biochemistry tests can be performed on either serum or heparinized plasma.
- Potassium is best measured on heparin plasma separated immediately after collection.
- Glucose measurement requires fluoride/oxalate plasma.
- Lipemic and hemolyzed samples can falsely alter values on some serum chemistries.
- If feasible, enough blood should be collected to run the test three times. This allows for human error, machine error, and dilution, if needed.
- Venipuncture site and technique significantly contribute to the quality of the sample.
- Ideally, a Vacutainer system should be used to decrease hemolysis and ensure the correct blood-to-anticoagulant ratio.

Handling

- Fill the anticoagulant tubes first to minimize clot formation.
- Gently mix the tubes by inverting them 6–10 times. Do not shake the tubes vigorously because this leads to hemolysis.
- Blood smears should be made immediately, if possible, using fresh blood.
- Allow blood to clot in an upright position to prevent cells from sticking to the rubber stopper and hemolyzing during centrifugation.
- Serum should be removed from the rest of the sample and run within 30 to 40 minutes of collection. This minimizes artifacts caused by hemolysis and leakage of intracellular fluid components, such as potassium, out of the cells.
- Each tube should be clearly labeled with the patient's full name, date, and any special instructions about the sample (e.g., time-specific samples, samples with possible zoonotic diseases, and samples from a chemotherapy or radioactive patient.

- For serum samples, invert the tube to activate clotting. Stand it upright for 20 minutes and then centrifuge for 10–15 minutes to ensure proper separation.

Storage

- If the sample cannot be evaluated 4–6 hours from the time of collection, the plasma or serum should be poured off and refrigerated.
- A blood smear should be dried completely and stored at room temperature to avoid the formation of condensation inside the slide container, which can lead to cellular abnormalities on the slide.
- Samples that need to be frozen should be placed immediately in an ice bath, centrifuged, transferred into a plastic tube, and then frozen.

Transportation

- To avoid hemolysis, ice packs should not come into contact with tubes. Wrapping paper towels or newspaper around the ice packs and the tubes inhibits condensation formation and subsequent hemolysis.

Table 7.1 / Blood Collection Tubes

Tube	Contents	Uses	General Information
Gray Top Tube (GTT)	• Potassium oxalate and sodium fluoride	• Glucose determination	• Prevents RBCs from metabolizing glucose by inhibiting enzymes in the glycolytic pathway to more accurately measure blood glucose concentrations than a serum separator tube (SST) or red top tube (RTT)
Green Top Tube (GRNTT)	• Lithium heparin	• Lead determination • Electrolyte analysis	• Binds with lead • Not appropriate for cell morphology
Lavender Top Tube (LTT)	• Ethylenediaminetetraacetic acid (EDTA)	• Hematology smears • Platelet counts	• Tube must be filled to ensure proper dilution of blood with anticoagulant. • Too much anticoagulant may lead to RBC alterations.
Light Blue Top Tube (BTT)	• Buffered sodium citrate	• Coagulation assay	• Measures clotting time • Must be a perfect venipuncture stick to avoid activation of coagulation pathways • Tube must be filled to ensure proper dilution of blood with anticoagulant.
Serum Separator Tube (SST), Red/Gray, Tiger Top	• Clot activator polymer gel	• Blood chemistries	• Serum is not able to mix with clotted blood once centrifuged. • The clotting activator can interfere with some lab tests (e.g. phenobarbital levels).
Red Top Tube (RTT)	• Plain • No anticoagulant	• Blood chemistries • Serology • Blood banking	• Serum and clotted blood can resuspend if the tube is tilted. • Serum should be separated to a separate plain tube after centrifugation. • Glucose is metabolized at approximately 10% per hour when left in contact with cells.

Table 7.2 / Blood Chemistries

Chemistry	Definition	Normal Range	Associated Conditions	Handling and Special Considerations
Alanine Aminotransferase (ALT,SGPT)	*Source* • Major: Hepatocytes • Minor: Cardiac muscle, skeletal muscle, pancreas *Role* • Amino acid metabolism *Notes* • Liver specific • There is a correlation between ALT levels and hepatic cell damage, but not liver function. • ↑ ALT is often seen 2–3 days after hepatic insult and resolves by 14 days.	*Equine* • 2.7–21.0 g/dl *Cattle* • 6.9–35.0 g/dl *Sheep* • 15–44 g/dl *Goat* • 15–52 g/dl *Swine* • 22–47 g/dl *Llama* • N/A	• ↑ Muscle injury	*Handling* • Hemolysis and lipemia increase values. *Storage* • Room temperature or refrigerated for 24 hours • 2 days at 68°F • 1 week at 32–39°F • Do not freeze sample. *Notes* • Corticosteroids and anticonvulsants, +/- increase values
Albumin	*Source* • Hepatocytes *Role* • Maintain osmotic pressure by retaining vascular fluid • Protein transport and binding	*Equine* • 2.8–4.8 g/dl *Cattle* • 2.1–3.6 g/dl *Sheep* • 2.4–3.0 g/dl *Goat* • 3.0–3.4 g/dl *Swine* • 1.9–2.4 g/dl Llama • 3.0–5.0 g/dl	• ↑ Dehydration • ↓ Brucellosis, chronic liver disease, glomerular disease, hyperglobinemia, hypertension, malnutrition/malabsorption	*Handling* • Extreme hemolysis and lipemia; ↑ value *Storage* • Keep samples covered to prevent dehydration; ↑ value. • 1 week at 68°F • 1 month at 32–39°F
Alkaline Phosphatase (ALKP, ALP, SAP)	*Source* • Major: Liver (adult animals), bone (young animals) • Minor: Kidneys, intestines *Role* • Assist in various chemical reactions	*Equine* • 143–395 U/L *Cattle* • 35–350 U/L *Sheep* • 238–440 U/L *Goat* • 123–392 U/L *Swine* • 9–20 U/L *Llama* • 10–100 U/L		*Handling* • Do not use EDTA or oxalate coagulants *Storage* • At room temperature greater than 24 hours, ↑ value • 8 days at 32–39°F
Amylase	*Source* • Major: Pancreas • Minor: Liver and small intestines *Role* • Breakdown of starches and glycogen in sugars	*Equine* • 9–34 U/L *Cattle* • N/A *Sheep* • N/A *Goat* • N/A *Swine* • N/A *Llama* • N/A		*Handling* • Hemolysis ↑ value • Lipemia ↓ value • Do not use EDTA *Storage* • 7 days at 68°F • 1 month at 32–39°F
Aspartate Aminotransferase (AST, SGOT)	*Source* • Major: Hepatocytes • Minor: Cardiac and skeletal muscles, kidneys, pancreas, and erythrocytes *Role* • Amino acid metabolism	*Equine* • 101–290 U/L *Cattle* • 60–150 U/L *Sheep* • 87–256 U/L *Goat* • 41–62 U/L *Swine* • N/A *Llama* • 10–280 U/L	• ↑ Liver and/or muscle damage • May also increase in horses with high exercise	*Handling* • Hemolysis and lipemia ↑ value *Storage* • 2 days at 68°F • 2 weeks at 32–39°F
Bicarbonate (Venous TCO_2)	*Source* • All cells *Role* • Aids in transport of CO_2 from tissues to the lungs • Acid-base balance by acting as a buffer	*Equine* • 23–32 mmol/L *Cattle* • 20–30 mmol/L *Sheep* • 21–28 mmol/L *Goat* • 23–30 mmol/L *Swine* • 18–27 mmol/L *Llama* • N/A		*Handling* • Chill in ice water to prevent alteration of acid-base composition. *Storage* • Do not freeze, as it results in hemolysis.

Chemistry	Definition	Normal Range	Associated Conditions	Handling and Special Considerations
Total Bilirubin	*Source* • Derived from catabolism of hemoglobin *Role* • N/A	*Equine* • 0.5–1.8 mg/dl *Cattle* • 0–1.9 mg/dl *Sheep* • 0.14–0.32 mg/dl *Goat* • 0–0.9 mg/dl *Swine* • 0–0.2 mg/dl *Llama* • 0.1–0.3 mg/dl	• ↑ In animals with liver disease, bile duct obstruction, jaundice, or hemolytic anemia • ↑ Finding may be normal in horses if animal was fasted for more than 24 hours.	*Handling* • Lipemia ↑ value *Storage* • Not stable when stored in the light at 68°F • 2 weeks at 32–39°F in the dark
Calcium	*Source* • Bones *Role* • Nerve transmission, clotting cascades, muscle contraction, cardiac function, milk production, enzyme activities, blood coagulation	*Equine* • 11.2–13.6 mg/dl *Cattle* • 8.0–10.5 mg/dl *Sheep* • 11.5–12.8 mg/dl *Goat* • 8.6–10.4 mg/dl *Swine* • 11–11.3 mg/dl *Llama* • 8.8–10.4 mg/dl	• ↑ Calcium kidney stones, mineral deposits in soft tissues, chronic renal failure • ↓ Milk fever, renal disease, bone disease	*Handling* • Lipemia ↑ value • Hemolysis and contact with cork stoppers; ↓ value • Citrate, oxalate or EDTA ↓ value *Storage* • 10 days at 68° F or 32–39°F
Chloride	*Source* • Extracellular fluid *Role* • Acid-base balance • Maintenance of water distribution • Maintain osmotic pressure	*Equine* • 95–107 mEq/L *Cattle* • 95–110 mEq/L *Sheep* • 95–103 mEq/L *Goat* • 105–120 mEq/L *Swine* • 100–105 mEq/L *Llama* • 100–118 mEq/L		*Handling* • Hemolysis and lipemia ↓ value *Storage* • Stable if separated from blood cells
Cholesterol	*Source* • Major: Hepatocytes • Minor: Adrenal cortex, ovaries, testes, and intestinal epithelium *Role* • Steroid hormone production	*Equine* • 46–177 mg/dl *Cattle* • 39–177 mg/dl *Sheep* • 40–58 mg/dl *Goat* • 80–130 mg/dl *Swine* • 117–119 mg/dl *Llama* • 22–176 mg/dl		*Handling* • Hemolysis, fluoride, and oxalate ↑ value (depending on testing method) *Storage* • Very stable at 68°F if separated from blood cells
Creatinine	*Source* • Skeletal muscle *Role* • N/A	*Equine* • 0.9–2.0 mg/dl *Cattle* • 1.0–2.7 mg/dl *Sheep* • 1.0–2.7 mg/dl *Goat* • 0.9–1.8 mg/dl *Swine* • 1.0–2.7 mg/dl *Llama* • 2.0–8.0 mg/dl		*Handling* • N/A *Storage* • 1 week at 86.0–98.6°F
Fibrinogen	*Source* • Hepatocytes *Role* • Clot formation	*Equine* • 0.2–0.4 g/dl *Cattle* • 0.2–0.6 g/dl *Sheep* • 6.5–7.5 g/dl *Goat* • 6.5–7.5 g/dl *Swine* • 7.0–8.0 g/dl *Llama* • 100–500 g/dl	• ↑ Inflammatory disease	*Handling* • Heparin ↓ value *Storage* • Several days at 68°F • Several weeks at 32–39°F

Chemistry	Definition	Normal Range	Associated Conditions	Handling and Special Considerations
Gamma Glutamyltranspeptidase (GGT)	*Source* • Major: Hepatocytes • Minor: Kidneys, pancreas, intestines, and muscle cells *Role* • Enzyme function unknown	*Equine* • 4–13 U/L *Cattle* • 0–31 U/L *Sheep* • 25–59 U/L *Goat* • 24–39 U/L *Swine* • 0–25 U/L *Llama* • 3–30 U/L	• ↑ Hepatocellular and cholestatic liver disease, hepatocyte necrosis, cholestasis	*Handling* • N/A *Storage* • 2 days at 68°F • 1 week at 32–39°F
Globulins	*Source* • α-Globulins: Hepatocytes • β-Globulins: Hepatocytes • γ-Globulins: Plasma cells *Role* • α-β-Globulins: Transport ad bind proteins • γ-Globulins: Antibodies	*Equine* • α: 0.7–1.3 g/dl • β: 0.4–1.2 g/dl • γ: 0.9–1.5 g/dl *Cattle* • α: 0.7–1.2 g/dl • β: 0.6–1.2 g/dl • γ: 1.6–3.2 g/dl *Sheep* • α: 0.3–0.6 g/dl • β: 1.1–2.6 g/dl • γ: 0.9–3.3 g/dl *Goat* • α: 0.5–0.7 g/dl • β: 0.7–1.2 g/dl • γ: 0.9–3.0 g/dl *Swine* • α: 0.3–0.4 g/dl • β: 0.1–0.3 g/dl • γ: 2.2–2.5 g/dl *Llama* • N/A	• α and β: Chronic liver failure in horses • γ: Chronic antigenic stimulation	*Handling* • N/A *Storage* • See laboratory reference guide
Glucose	*Source* • Dietary intake and gluconeogenesis or glycogenolysis by the liver *Role* • Cellular energy	*Equine* • 75–115 mg/dl *Cattle* • 35–55 mg/dl *Sheep* • 42–76 mg/dl *Goat* • 60–100 mg/dl *Swine* • 65–95 mg/dl *Llama* • 80–145 mg/dl	• ↓ Fatty liver in cattle	*Handling* • GTT at 6–10 mg/ml of blood as a glucose preservative • Delayed sample submission without centrifugation decreases levels. *Storage* • Separate from blood cells immediately (less then 30 minutes). • 8 hours at 68°F • 72 hours at 32–39°F
Iron	*Source* • Within red blood cells *Role* • Helps in blood hemoglobin production, muscle oxygenation, enzyme activity	*Equine* • 73–140 μg/dl *Cattle* • 57–162 μg/dl *Sheep* • 166–222 μg/dl *Goat* • N/A *Swine* • 65–95 μg/dl *Llama* • N/A	• ↑ Toxicity in piglets	
Lactic Dehydrogenase (LDH)	*Source* • Liver: Cytoplasmic enzyme	*Equine* • 162–412 U/L *Cattle* • 697–1,445 U/L *Sheep* • 238–440 U/L *Goat* • 123–392 U/L *Swine* • N/A *Llama* • 50–300 U/L	• ↑ Hepatocyte damage, muscle damage, hemolysis	*Handling* • Variation of the assay's temperature can alter the activity of this enzyme.

Chemistry	Definition	Normal Range	Associated Conditions	Handling and Special Considerations
Lipase	*Source* • Pancreas and gastric mucosa *Role* • Breakdown of the long-chain fatty acids of lipids	*Equine* • 40–78 U/L *Cattle* • N/A *Sheep* • N/A *Goat* • N/A *Swine* • N/A *Llama* • N/A	• Acute pancreatitis, pancreatic cancer, decreased renal activity/ excretion	*Handling* • Lipemia ↑ value • Do not use calcium-binding anticoagulants. *Storage* • 1 week at 68°F • 3 weeks at 32–39°F
Lipids/ Triglycerides	*Source* • Diet; intestinal absorption *Role* • Fat metabolism • Stimulus of intestinal lymph flow	*Equine* • 5–55 mg/dl *Cattle* • N/A *Sheep* • N/A *Goat* • N/A *Swine* • N/A *Llama* • N/A		*Handling* • Lipemia ↑ value *Storage* • N/A
Magnesium	*Source* • Bones *Role* • Activator of enzyme systems • Muscle contraction • Involved in production and decomposition of acetylcholine • Cellular energy metabolism *Notes* • Cattle and sheep show more severe clinical signs of deficiencies.	*Equine* • 2.2–2.8 mg/dl *Cattle* • 1.2–3.5 mg/dl *Sheep* • 2.2–2.8 mg/dl *Goat* • 2.8–3.6 mg/dl *Swine* • 1.9–3.9 mg/dl *Llama* • 1.5–3.0 mg/dl	• ↓ Milk fever, grass tetany, fever, hypersalivation	*Handling* • Hemolysis and metal containers; ↑ value • Only heparin anticoagulants should be used. *Storage* • Samples are very stable.

Chemistry	Definition	Normal Range	Associated Conditions	Handling and Special Considerations
pH	*Role* • Acid/base balance	*Equine* • 7.32–7.55 mmol/L *Cattle* • 7.35–7.50 mmol/L *Sheep* • 7.32–7.50 mmol/L *Goat* • N/A *Swine* • N/A *Llama* • N/A		
Phosphorus	*Source* • Bones *Role* • Energy storage • Carbohydrate and protein metabolism • pH balance • Milk secretion • Building muscle • Bone development	*Equine* • 3.1–5.6 mg/dl *Cattle* • 4.0–7.0 mg/dl *Sheep* • 5.0–7.3 mg/dl *Goat* • 4.2–9.8 mg/dl *Swine* • 4.0–11.0 mg/dl *Llama* • 4.5–8.5 mg/dl	• ↑ Renal failure, decreases calcium levels • ↓ Osteomalacia, rickets, tetany	*Handling* • Hemolysis and lipemia ↑ value *Storage* • Separate from blood cells immediately. • 3–4 days at 68°F • 1 week at 32–39°F
Potassium	*Source* • Intracellular fluid *Role* • Muscular function and development • Cardiac function • Carbohydrate metabolism • Nerve impulse transmission • Insulin secretion • pH balance	*Equine* • 3.2–5.2 mEq/L *Cattle* • 3.9–5.8 mEq/L *Sheep* • 3.9–5.4 mEq/L *Swine* • 4.7–7.1 mEq/L *Llama* • 4.0–6.5 mEq/L	• ↑ Not common, usually following severe metabolic acidosis, laboratory error • ↓ Anorexia, increased renal excretion, abomasal stasis, intestinal obstruction, enteritis, irregular gait, stunted growth, weight loss	*Handling* • Hemolysis and refrigeration of a nonseparated sample increase the value. *Storage* • Do not freeze nonseparated samples. • Stability is unknown.

Chemistry	Definition	Normal Range	Associated Conditions	Handling and Special Considerations
Sodium	*Source* • Extracellular fluid *Role* • Maintenance of body fluids and osmotic pressure • pH balance • Muscle contraction • Absorption of carbohydrates	*Equine* • 134–143 mEq/L *Cattle* • 132–152 mEq/L *Sheep* • 139–152 mEq/L *Goat* • 135–154 mEq/L *Swine* • 140–150 mEq/L *Llama* • 140–155 mEq/L	• ↑ Staggering, blindness, neurologic disorders, hypertension • ↓ Acute diarrhea, enterotoxigenic *Escherichia coli*, polyuria/ polydipsia, weight loss, anorexia, stunted growth, decreased milk production	*Handling* • Heparin ↑ value • Hemolysis ↓ value *Storage* • Stability is not known.
Total Protein (TP)	*Source* • Seeg *Role* • Oncotic blood pressure, transport mechanism, and immunity	*Equine* • 6.0–7.7 g/dl *Cattle* • 5.7–8.1 g/dl *Sheep* • 6.0–7.9 g/dl *Goat* • 5.9–7.4 g/dl *Swine* • 7.9–8.9 g/dl *Llama* • N/A		*Handling* • Severe hemolysis and sample dehydration ↑ value *Storage* • Keep sample covered to prevent dehydration. • Stability is not known.
Blood Urea Nitrogen (BUN; SUN)	*Source* • Amino acids via liver processing *Role* • N/A	*Equine* • 10–20 mg/dl *Cattle* • 6–27 mg/dl *Sheep* • 8–20 mg/dl *Goat* • 15–33 mg/dl *Swine* • 8–24 mg/dl *Llama* • N/A	• ↑ Kidney disease, azotemia, uremia	*Handling* • N/A *Storage* • 8 hours at 68°F • 10 days at 32–39°F

Hematology

Although many hospitals prefer to send out samples to reference laboratories for evaluation, the knowledge of how to perform a manual complete blood count (CBC) can be very useful in certain situations, for example, when time is crucial during emergencies, when an automated machine is not functioning properly, or when an automated machine is not at hand. Having rapid results can give the veterinarian insight into the patient's hematologic status or provide information on certain types of anemia, organ functions, and neoplasia.

A CBC consists of red and white blood cell evaluation, hematocrit, total protein, hemoglobin concentration, differential count, platelet estimation, and red blood cell indices. These tests are run using whole blood stored in an anticoagulant tube.

Once a blood smear is made and stained, the differential count and cell morphology are performed in the monolayer of the smear. The feathered edge and the thick portion of the smear should be avoided when performing a differential count and morphology because they have a tendency to cause cell distortion, which can lead to inadequate representation of the different types of cells. The feathered edge however should be evaluated at 10x objective for platelet clumps, mast cells, and microfilaria, all of which tend to be pushed to the edge of the smear during preparation.

The differential count should be performed using the 40X or 100X objective, moving back and fourth throughout the monolayer. The monolayer is the area of the smear where the cells are evenly distributed and show minimal overlap and is the best area to identify leukocytes and red blood cell abnormalities. A distinct pattern should be followed to ensure that the same cells are not counted twice.

Red blood cell inclusions are often confused with platelets and stain precipitate. One way to differentiate between them is to determine their location, whether they lie within the cell or on its surface. To do this, focus up and down through the cell. An inclusion will go in and out of focus with the cell itself, and other abnormalities will not.

Skills Box 7.1 / Complete Blood Count

Procedure	Definition/Uses	Technique	Normal Ranges	Associated Conditions
Packed Cell Volume (PCV), Hematocrit (Hct)	• Percentage of whole blood that is composed of erythrocytes • Measure of red blood cell mass	1. Fill a capillary tube 3/4 full with whole blood; plug one end with clay to create a seal. 2. Centrifuge for 3–5 minutes, and read results as a percentage using a microhematocrit reader. 3. Record the color and transparency of the plasma.	*Equine* • 32–52% *Cattle* • 24–46% *Sheep* • 24–50% *Goat* • 22–38% *Swine* • 32–50% *Llama* • 28–45%	• ↑ Polycythemia, dehydration, excitement or stress, neonates, high globulin levels • ↓ Anemia, bleeding, overhydration, weanlings
Total Protein Concentration* (TP)	• Indicates oxygen transport capacity of the blood	1. Break a spun capillary tube above the buffy coat level. 2. Let plasma drip onto the face of the refractometer.	*Equine* • 6.5–8.5 g/dl *Cattle* • 6.0–7.5 g/dl *Sheep* • 6.0–7.5 g/dl *Goat* • 6.0–7.5 g/dl *Swine* • 6.0–7.0 g/dl Llama • 5.8–7.0 g/dl	• ↑ Dehydration, lipemic samples • ↓ Overhydration
Hemoglobin (HGB) Concentration	• Indicates how well the blood is transporting oxygen • Needed for calculation of mean corpuscular hemoglobin (MCH) and its concentration (MCHC)	1. Follow manufacturer's guidelines for machine use.	*Equine* • 11–19 g/dl *Cattle* • 8–15 g/dl *Sheep* • 8–16 g/dl *Goat* • 8–12 g/dl *Swine* • 10–16 g/dl Llama • 12.5–18.0 g/dl	• ↑ Polycythemia • ↓ Anemia
CBC	• Gives an accurate count of RBCs • Machine counters have been shown to be more accurate than manual counting. • The main use of an RBC count is to calculate indices.		*Equine* • $6.5–12.5 \times 10^6$/mcL *Cattle* • $5–10 \times 10^6$/mcL *Sheep* • $8–16 \times 10^6$/mcL *Goat* • $8–18 \times 10^6$/mcL *Swine* • $5–8 \times 10^6$/mcL Llama • $9.0–19.5 \times 10^6$/mcL	• ↑ Polycythemia, dehydration • ↓ Anemia, overhydration, hemorrhage

Procedure	Definition/Uses	Technique	Normal Ranges	Associated Conditions
Total WBC Count (TWBC)	• Gives an accurate count of total WBCs • Machine counters have been shown to be more accurate then manual counting.	1. Using the 1000X objective, select a starting point within the monolayer where the cells are evenly distributed. 2. A minimum of 100 WBCs should be counted and identified using a cell counter. 3. Each cell is recorded as a percentage.	*Equine* • $5.5–12.5 \times 10^3$/mcL *Cattle* • $4–12 \times 10^3$/mcL *Sheep* • $4–12 \times 10^3$/mcL *Goat* • $4–13 \times 10^3$/mcL *Swine* • $11–22 \times 10^3$/mcL Llama • $7–14 \times 10^3$/mcL	• ↑ Acute local inflammation, toxicity, bacterial infections • ↓ Marrow disease, radiation, drug therapy, certain viruses
Differential	• Indicates the number of specific WBCs found • The TWBC count should roughly equal the differential total.	1. Examine a prepared blood smear using 100X objective. 2. Count up to 100 WBCs: (neutrophils [N], basophils[Ba], monocytes [M], lymphocytes [L],eosinophils [E], and band cells [Band],and classify according to type. 3. Refer to Skills Box 7.2 for calculation of the differential.	*Equine* • N: 30–65% • Ba: 0–2% • M: 0.5–7.0% • L: 25–70% • E: 0–11% • Band: 0–3% *Cattle* • N: 15–45% • Ba: 0–2% • M: 2–7% • L: 45–75% • E: 2–20% • Band: 0–2% *Sheep* • N: 10–50% • Ba: rare • M: 0.6% • L: 40–75% • E: 0.1% • Band: 0–3% *Goat* • N: 30–48% • Ba: Rare • M: 0–4% • L: 50–70% • E: 1–8% • Band: 0–1%	• Variable dependent on type of cell(s)

Procedure	Definition/Uses	Technique	Normal Ranges	Associated Conditions
			Swine • N: 28–47% • Ba: 0–2% • M: 2–30% • L: 39–62% • E: 0.5–11% • Band: 0–2% Llama • N: 50–70% • Ba: 0–2% • M: 0–2% • L: 25–45% • E: 0–2% • Band: 0–5%	
Nucleated RBCs (nRBCs)	• Early release of immature RBCs • The corrected value should be calculated when >5 nRBCs are found and then used to calculate the differential.	1. While performing the differential, keep track of any nRBCs. 2. Calculate a corrected TWBC count: Corrected TWBC count = $\frac{\text{Observed TWBC} \times 100}{100 + \text{nRBC}}$	• N/A	• ↑ Regenerative response to anemia, lead poisoning, splenic disease, marrow neoplasia
Platelet Estimate (Fig. 7.1 and Fig. 7.2, black arrows)	• Indicates ability for adequate clotting	1. Examine a prepared blood smear using 100X objective. Observe in the monolayer, an area in which the RBCs are close, but not touching. 2. Count platelets in 5 different fields and average them. 3. Multiply by 15,000 and 18,000 to obtain a range. 4. When large areas of clumping are seen, assume adequate numbers of platelets.	*Equine* • $1–6 \times 10^5$/mcL *Cattle* • $1–8 \times 10^5$/mcL *Sheep* • $2.5–7.5 \times 10^5$/mcL *Goat* • $3–6 \times 10^5$/mcL *Swine* • $3.25–7.15 \times 10^5$/mcL	• ↓ *Cattle:* DIC, toxicities, bovine viral diarrhea • *Horses:* Marrow hypoplasia, equine infectious anemia, septicemia, epistaxis, immune mediated hemolytic anemia, DIC, erlichiosis • *Pigs:* Swine fever, hog cholera, DIC, endotoxic shock • *Sheep:* Radiation, tick infection (amblyomma)

Procedure	Definition/Uses	Technique	Normal Ranges	Associated Conditions
Reticulocyte Count	• Immature RBCs • Used to evaluate the bone marrow's response to anemia • Perform along with a CBC when severe anemia is present	1. Mix together an equal part of whole blood and NMB; agitate; and let sit for 10 minutes. 2. Prepare a blood smear. 3. Examine under ×100 by counting 1,000 RBCs while separately keeping track of the number of reticulocytes. 4. Divide the reticulocyte number by 1,000 and convert to a percentage. 5. Calculate the correct reticulocyte number. Correct reticulocyte percentage = $\frac{\text{Observed retic\%} \times \text{PCV}}{\text{normal mean PCV for species}}$	*Equine:* 0 % *Cattle:* 0 % *Sheep:* 0 % *Goat:* 0 % *Swine:* 1 %	• ↑ Anemia
RBC Indices Mean Corpuscular Volume (MCV)	• Indicates the size of volume of RBCs • Classifies anemias as normocytic, macrocytic, or microcytic	$\text{MCV(fL)} = \frac{\text{PCV(\%)} \times 10}{\text{RBC count} \times 10^6/\text{mcL}}$	*Equine* • 34–58 fL *Cattle* • 40–60 fL *Sheep* • 23–48 fL *Goat* • 15–30 fL *Swine* • 50–68 fL Llama • 17–28 fL	• ↑ B12 and folic acid deficiency • ↓ Iron deficiency
Mean Corpuscular Hemoglobin (MCH)	• The mean weight of HGB in an RBC • Used as a lab check • ↑ MCH should see a ↑ MCV. • ↓ MCH should see a ↓ MCV.	$\text{MCH(PG)} = \frac{\text{PCV(\%)} \times 10}{\text{RBC count} \times 10^6/\text{mcL}}$	*Equine* • 15.2–18.6 pg *Cattle* • 14.4–18.6 pg *Sheep* • 9–13 pg *Goat* • 5.2–8.0 pg *Swine* • 16.6–22.0 pg Llama • 17–19 pg	• ↑ Hemolysis • ↓ Iron deficiency

Procedure	Definition/Uses	Technique	Normal Ranges	Associated Conditions
Mean Corpuscular Hemoglobin Concentration (MCHC)	• Indicates the average hemoglobin concentration in each RBC • Classifies anemias as hypochromic or normochromic	$\text{MCHC(g/dl)} = \frac{\text{HGB (g/dl)} \times 100}{\text{PCV(\%)}}$	*Equine* • 31–37 g/dl *Cattle* • 30–36 g/dl *Sheep* • 31–38 g/dl *Goat* • 35–42 g/dl *Swine* • 30–34 g/dl Llama • 36–50 g/dl	• ↑ Hemolysis, lipemia, Heinz bodies • ↓ Iron
Fibrinogen	• Coagulation factor		*Equine* • 100–400 g/dl *Cattle* • 300–700 g/dl *Sheep* • 100–500 g/dl *Goat* • 100–400 g/dl *Swine* • 100–500 g/dl Llama • 100–400 g/dl	

*Score the capillary tube with the edge of a microscope slide just above the buffy coat to allow the tube to be broken easily. Using the unbroken end, gently tap a hand on table above the refractometer plate. Be sure not to touch the capillary tube to the refractometer plate to avoid scratching it.

Skills Box 7.2 / Calculating a Differential

- Count up to 100 WBCs, differentiate their types, and record totals as percentages. For example:

45 neutrophils = 45
45 lymphocytes = 45
7 monocytes = 7
3 eosinophils = 3
0 basophils = 0
100 WBCs

- Multiply each WBC type by the previously obtained TWBC count. For example:

TWBC count = 8,650
$8{,}650 \times 0.45 = 3893/\mu l$ neutrophils
$8{,}650 \times 0.45 = 3893/\mu l$ lymphocytes
$8{,}650 \times 0.07 = 606/\mu l$ monocytes
$8{,}650 \times 0.03 = 260/\mu l$ eosinophils
$8{,}652/\mu l$ TWBC

- The TWBC should roughly equal the TWBC count. For example:

TWBC (8,652) = TWBC count (8,650)

Evaluation of a Blood Smear

Once these tests have been performed, the blood smear is examined and evaluated for cell morphology abnormalities, inclusions, and parasites. While viewing the sample in the monolayer of the slide, these abnormalities should be graded as the number per oil immersion field or the terms “occasional” and “rare.”

1. Prepare a blood smear slide with stain or use the prepared slide from the differential.

2. Scan the slide, using low magnification.

- **a.** RBC Rouleaux
- **b.** RBC agglutination
- **c.** Abnormalities in the feathered edge
  - **i.** Mast cells (rarely seen)

ii. Platelet aggregation

3. Examine the slide, using oil immersion magnification.
    a. RBC morphology
        i. Size
        ii. Shape
        iii. Color
        iv. Inclusions
    b. WBC morphology
        i. Toxic changes
        ii. Nuclear degeneration
        iii. Cytoplasmic inclusions
        iv. Alterations
        v. Parasites
    c. Platelet
        i. Distribution
        ii. Size
        iii. Alterations

Red Blood Cell Alterations and Morphology

The normal morphology of large animals is similar to those of small animals. The diameter of a normal RBC ranges between 3.2–6.0 mcm, from largest to smallest: swine (6.0 mcm), equine (5.7 mcm), cattle (5.5 mcm), sheep (4.5 mcm), and goat (3.2 mcm). (See Figure 7.3 for a normal smear.) Sheep and cattle will have a central pallor; however, goats (Fig. 7.4) and llamas will not. The central pallor in swine and equine may or may not be present. Llama and alpaca erythrocytes are large, flat, and oval. When observing a prepared slide for RBC morphology, the cells should be evaluated for alterations in size, shape, color, and inclusions.

Figure 7.1 Equine blood smear of normal red blood cells. Normal platelets are indicated by black arrows.

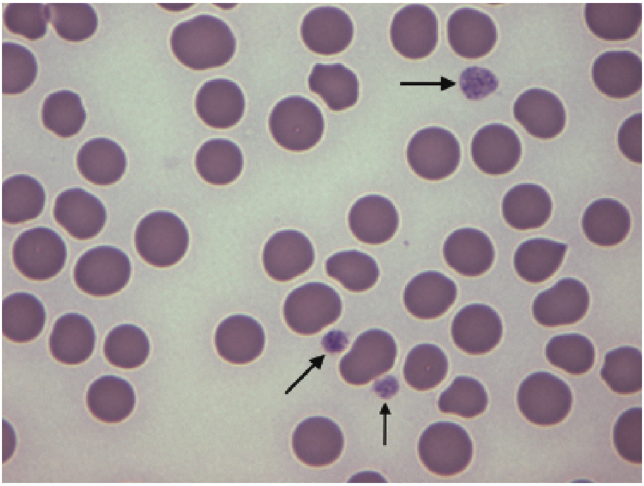


Figure 7.2 Equine basophil and neutrophil. Also note the activated platelets indicated by black arrows.

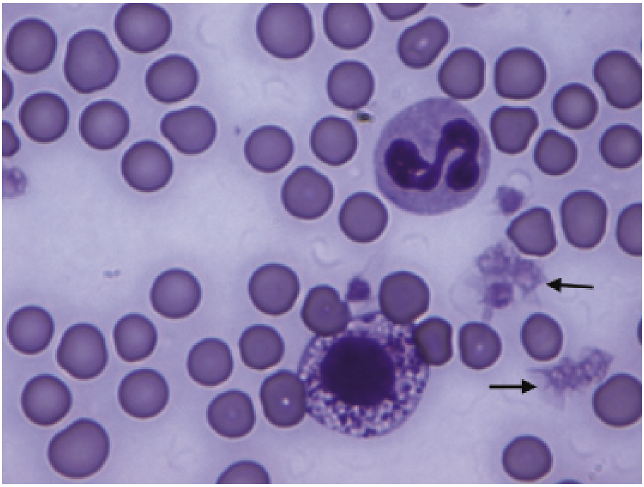


Figure 7.3 Rouleaux formation, which is a normal anomaly in an equine blood smear.

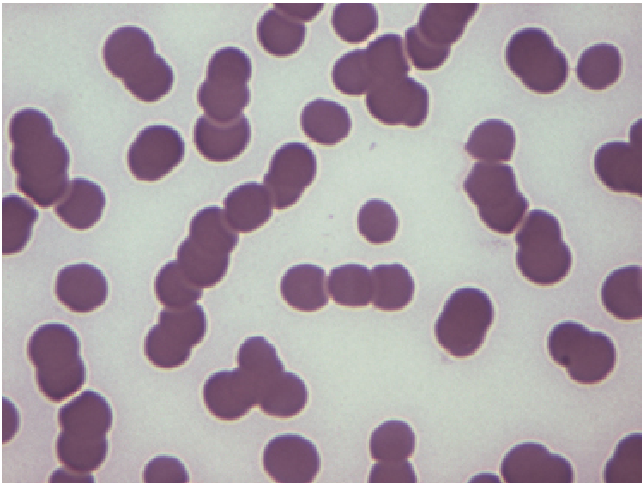


Figure 7.4 Caprine blood smear. Irregular red blood cells, normal for this species. Normal neutrophil.

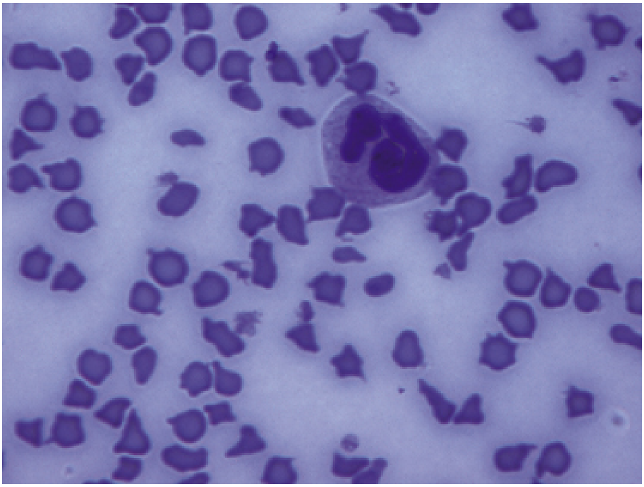


Table 7.3 / Red Blood Cell Alterations and Morphology

Alteration	Definition	Appearance	Associated Conditions
		Arrangement	
Agglutination	• The clumping together of cells due to an antibody antigen reaction	• Clumping of cells	• Transfusion reactions
Rouleaux (Fig. 7.3 and Fig. 7.5)	• ↑ Concentration of plasma proteins (e.g., fibrinogen, immunoglobulins), which results in linear aggregation of erythrocytes	• Stacking of RBC • Takes the shape of coins stacked on each other	• Normal occurrence in horses • Certain inflammatory conditions
		Inclusions	
Basophilic Stippling	• Residual RNA, spontaneous clumping of ribosomes	• Dark purple punctuating dots or wispy material within the red blood cell	• Primary sign of regeneration in anemic ruminants • Occasionally seen with lead toxicity and some bone marrow diseases
Heinz Bodies	• Denatured hemoglobin caused by certain chemicals or oxidant drugs	• Pale round structures that protrude from the edge of the RBC	• May lead to anemia due to false splenic distraction
Howell-Jolly Bodies (Fig. 7.6 and Fig. 7.7)	• Nuclear remnants	• Small, dark purple dots within the RBC	• Regenerative response to anemia, splenic disease, immunosuppressive therapy, bone marrow disease
		Morphology and Color	
Hypochromasia (Fig. 7.8)	• ↓ Hemoglobin concentration	• More prominent area of central pallor along with a pale coloring around the cells periphery	• Iron deficiency due to chronic blood loss
Polychromasia	• Increase in polychromatophilic erythrocytes; immature erythrocytes • When stained with new methylene blue (NMB), they are termed reticulocytes.	• Appear larger than normal RBCs and have a darker color when stained • No central pallor in animals that normally show a central pallor	• Indicates a regenerative response by the bone marrow • Suggests anemia due to blood loss or hemolysis • Significance is species dependent. • Not commonly seen in cattle, goats, and sheep • Never present in horses

Alteration	Definition	Appearance	Associated Conditions
		Morphology and Size	
Microcytosis	• ↓ Cell volume	• RBC smaller than normal	• Regenerative response to anemia • REB maturation defects
Macrocytosis	• Cell volume • Immature RBCs, reticulocytes	• RBC larger then normal • Presence of large, immature RBCs	• Regenerative response to anemia • RBC maturation defects
Anisocytosis	• Variation in cell volume • Result from early cell release or increased RBC division	• Variation in cell size	• Regenerative response to anemia • RBC maturation defects
		Morphology and Shape	
Acanthocytes (Spur Cell; Fig. 7.9)	• Caused by cholesterol concentration changes in the cell membrane	• Irregular, blunt, finger-like projections that vary in width, length, and surface distribution	• Increase in blood cholesterol content or the presence of abnormal plasma lipoprotein composition
Blister Cells (prekeratocytes)	• Fusion of inner cell membranes	• Blister or vacuole on the cell membrane ruptures, leaving a cell resembling a helmet with straps	• Anemia, iron deficiency, hepatic disease
Codocyte Cell (Target Cell)	• Excessive membrane that folds over on top of the cell	• Bull's-eye or target-shaped characteristics	• Little clinical significance
Dacrocytes	• Deformed during maturation process	• Tear shaped	• Smear preparation artifact or occasionally seen in marrow disease
Eccentrocytes	• Fusion of opposing oxidized cell membranes	• Shifting of hemoglobin to one side • Crescent-shaped, clear area outlined by a thin layer of membrane and lack of central pallor	• Reducing pathways in erythrocytes are damaged.
Echinocytes (Crenation)	• Mechanism unknown, possibly calcium or ATP changes in vivo	• Evenly spaced, blunt-to-sharp projections of uniform shape and size • Notched or scalloped cell membrane	• *Artifact:* Excess EDTA pH changes associated with slow-drying blood films
Keratocytes	• Blister cells (vacuolated cells) that enlarge and break open on one side of membrane	• Spiculated cells with 2 or more projections; cells appear to have horns.	• Anemia, iron deficiency, hepatic disease

Alteration	Definition	Appearance	Associated Conditions
		Morphology and Shape	
Nucleated RBCs (Metarubricytes, Normoblasts)	• Early release of RBCs still maintaining their nuclei	• Dark purple nucleus in a normal-sized RBC	• Regenerative anemia, splenic dysfunction, high stress, hyperadrenocorticism, corticosteroid treatment
Poikilocytosis	• Characteristic of ↑ RBC fragility	• Variation in cell shape	• Liver disease, iron deficiency, bone marrow or splenic disease
Schistocytes	• Shearing of the RBC by intravascular trauma	• Irregularly shaped fragments and sharp pointed projections	• Disseminated intravascular coagulation, splenic disease
Spherocytes	• Develop after a piece of cell membrane is pinched off	• Small, dark, round RBCs with little or no central pallor	• Membrane defects, drugs, antibodies, or parasites attach to the cell.
Stomatoctes	• Result from leakage of sodium and potassium from the cell membrane	• Cup shaped	• Membrane defect common in small animals
Torocytes	• Punched-out cell lacking internal color	• Remaining cell has normal color.	• Smear preparation artifact

Figure 7.5 Normal equine eosinophil. Also note the Rouleaux formation of the red blood cells, a normal alteration in horses.

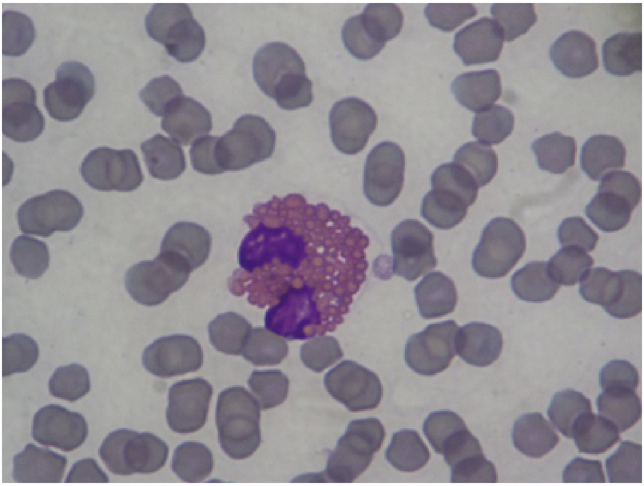


Figure 7.6 Howell-Jolly body seen in an equine blood smear.

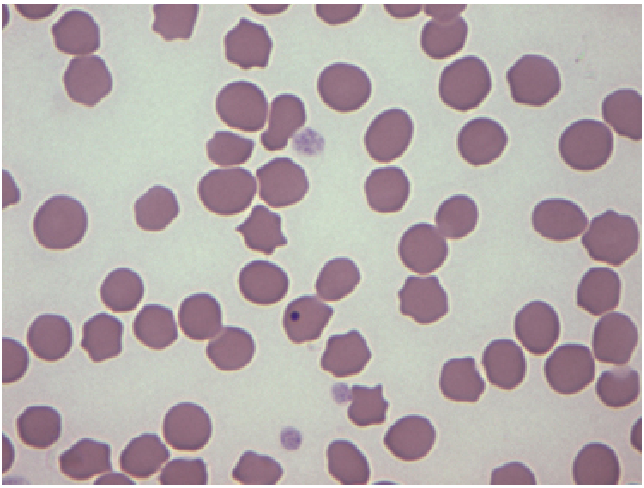


Figure 7.7 Band neutrophil, some mild anisocytosis visible. Howell-Jolly body indicated by black arrow. Equine blood smear.

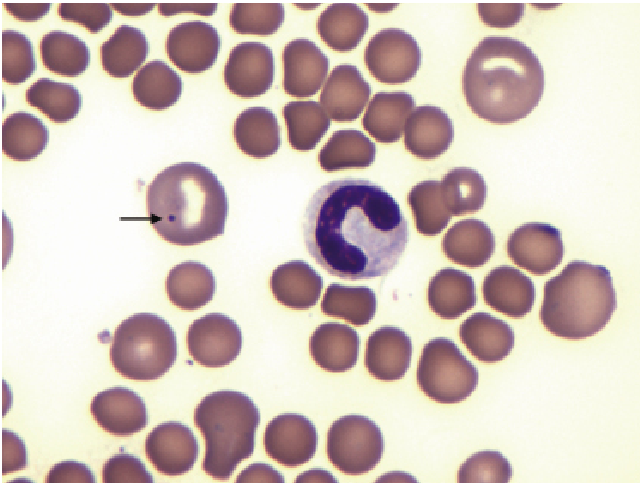


Figure 7.8 Hypochromasia seen in an alpaca blood smear.

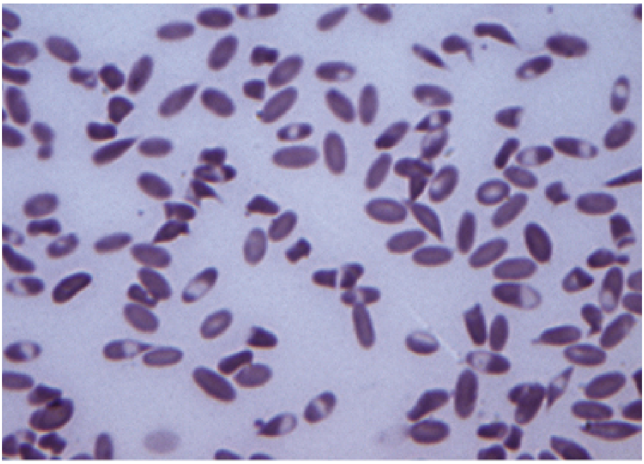


Figure 7.9 Equine blood smear; acanthocyte or spur cell. Irregular, blunt, finger-like projections that vary in width, length, and surface distribution; indicated by black arrow.

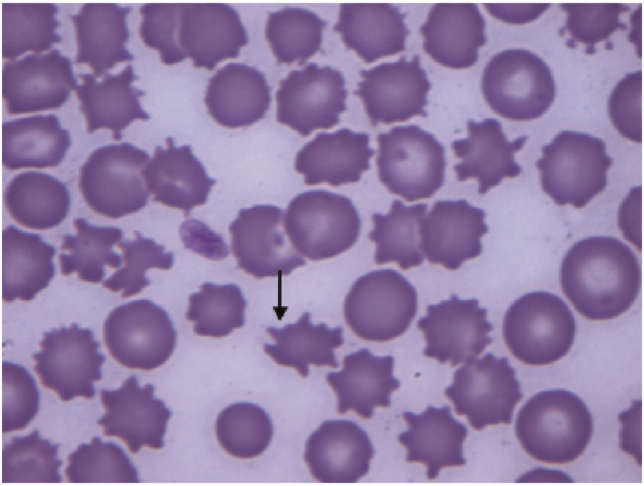
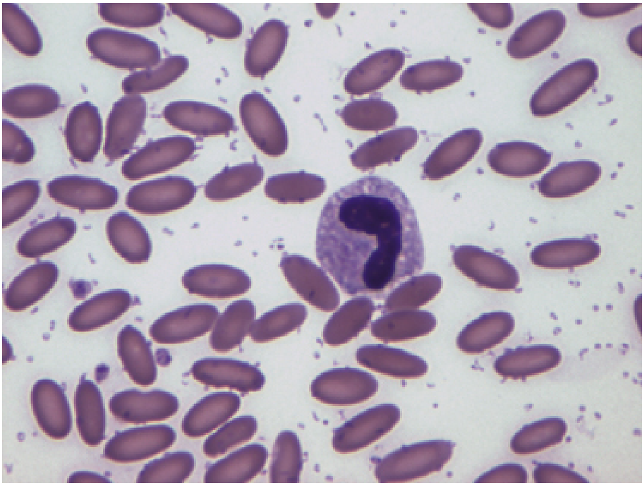


Table 7.4 / Parasites of Red Blood Cells

Alteration	Definition	Microscopic Findings	Clinical Findings
Anaplasma, spp.	• Anaplasmosis (gall sickness) • Tick-transmitted disease of cattle, sheep, and goats	• Intraerythrocytic bacteria • Round, dark-staining inclusions that are generally located near the margin of erythrocytes	• Anemia, fever, weight loss, uncoordinated movements, abortion
Mycoplasma haemolamae formerly genus *Eperythrozoon* (Fig. 7.10)	• Tick-transmitted disease of llamas and alpacas	• Parasitemia • Single or multiple small cocci or rod organisms coating the surface of the RBC • The organisms detach from the red cell surface with storage and are found within the plasma of the sample.	• Mildly to moderately anemic, but the anemia is poorly regenerative
Babesia spp.	• Babesiosis • Tick-transmitted disease of cattle, sheep, goats, and pigs	• Intraerythrocytic protozoan parasite • Small teardrop- or round-shaped intracellular structures, often seen in pairs	• Fever and hemolytic anemia
Theileria spp.	• Equine babesiosis (East Coast fever) • Tick-transmitted disease of horses	• Intraerythrocytic protozoan parasite • Small teardrop- or ring-shaped intracellular structures, often seen in pairs	• High fever, swelling of the lymph nodes, dyspnea, possible death

Figure 7.10 Llama blood smear; *mycoplasma haemolamae*. Single or multiple small cocci or rod organisms coating the surface and surrounding the red blood cells.



White Blood Cell Morphology

White blood cells function as the body's defense against foreign organisms within the tissues. They are typically nonfunctional in the circulatory system. White blood cell morphology is significantly different between each type of white blood cell. Each type plays a role in the diagnosis of various diseases. The frequency that they appear in the body is listed in order below.

Table 7.5 / White Blood Cell Morphology

WBC	Definition	Appearance (Stained)	Associated Conditions
Neutrophils (Polymorphonuclear and Segmented; Fig. 7.2)	• First line of defense against infection • Highly motile and phagocytic • Replace in the body 2.5 times per day	• Lobed nuclei with condensed, dark purple chromatin. (Sheep and horses have more prominent segmentation of nucleus.) • Clear to light pink cytoplasm with diffuse granules. (Ruminants are slightly more pink.)	• ↑ Inflammation, stress • ↓ Severe infections, certain chemical toxicities
Band Cells (Fig. 7.7)	• Immature neutrophils • Left shift is an ↑ in immature neutrophils.	• Nucleus is horseshoe-shaped with smooth parallel sides and large round ends.	• ↑ Regenerative response to inflammation by the bone marrow, neoplasia, inflammation, bacterial infection
Lymphocytes	• Immunity and antibody production • Virus and tumor defense	*Equine:* • Large, round, dark nucleus with small amount of blue cytoplasm *Ruminant:* • Large, varying-in-shape, dark nucleus with abundant cytoplasm • Most predominant cell in cattle	• ↑ Chronic infections, leukemia, high stress, lymphosarcoma, normal finding • ↓ Corticosteroids, immunodeficiency disease, loss of lymph
Monocytes	• Highly phagocytic • Antiviral and antitumor qualities • Become macrophages once in extracellular fluid	• Largest of the WBCs • Light to deep blue-grey cytoplasm with a grainy texture • Nucleus can assume any shape (round, bean shaped, lobular). • Vacuoles often present	• ↑ Corticosteroids, stress, severe infection, or hemorrhage
Eosinophils (Fig. 7.5)	• Responsible for combating parasites and certain infections	• Less segmented nuclei than neutrophils with light blue cytoplasm *Equine:* • Large, round, pink-orange granules filling cytoplasm *Ruminant:* • Small, round-to-oval, red-orange granules that fill the cytoplasm	• ↑ Parasitic infections, allergies, IgE stimulation • ↓ Corticosteroids
Basophils (Fig. 7.2)	• Their function is still unclear. • Rarely seen	• Small, dark purple granules that obscure the lobed nucleus	• ↑ Allergies, chronic IgE stimulation • ↓ Hyperlipidemia

Toxic Changes in Neutrophils

Toxic changes refer to a morphological change within the neutrophils, most often due to bacterial infection, acute inflammatory condition, or bone marrow disease. These conditions cause neutrophils to look "smeared" or distorted. However, toxic changes do not alter the functionality of the cell. The bone marrow is responsible for the release of neutrophils; and when an inflammatory response happens, the marrow releases neutrophils at an accelerated rate. This causes morphology changes within the cell, such as Döhle bodies, cytoplasmic basophilia, and cytoplasmic vacuolization. These results are reported on a scale of 1+, 2+, 3+, and 4+.

Table 7.6 / White Blood Cell Alterations

Alterations	Definition	Appearance	Associated Diseases
Inclusions			
Döhle Bodies (Fig. 7.11)	• Retained rough endoplasmic reticulum • Seen with ↓ time in the marrow for maturation	• Bluish gray, angular cytoplasmic inclusions typically found at the periphery of the cell • Size: 0.5–2.0μm	• Severe toxemia, inflammation, or infection
Morphology			
Cytoplasmic Basophilia	• Persistent ribosome	• Having a degree of solid, patchy, light blue to purple cytoplasm	• Severe toxemia, inflammation, or infection
Cytoplasmic Vacuolation	• Disruption in bone marrow production, resulting in a loss of granule and membrane integrity	• Foamy, bubble-like, nonstaining circles	• Systemic toxicity
Nuclear Hypersegmentation (Fig. 7.12)	• Prolonged circulating life	• More than 6 segmented loops of nucleus	• Aged neutrophils, prolonged storage of blood
Nuclear Hyposegmentation	• Early release of bands and immune neutrophils	• Unsegmented nucleus	• Steroid use, inflammatory response if intense or severe
Pyknosis	• Result of improper anticoagulant • Effect on nucleus	• Condensed, lysed, or damaged nucleus	• Insignificant
Reactive Lymphocyte (Immunocyte)	• Immune-stimulated T and B cells	• Cytoplasm and basophilia and a larger, more-convoluted nucleus	• Antigenic stimulation (ehrlichiosis)
Vacuolated Lymphocyte	• Accumulation of storage products (e.g., proteins, carbohydrates, lipids)	• Cytoplasmic vacuoles	• Prolonged storage of blood
Parasites			
Anaplasma Phagocytophilum Also Known as *Ehrlichia equi* (Fig. 7.13)	• Rickettsia, tick-transmitted disease	• Blue-gray to dark blue coccoid, coccobacillary, or pleomorphic organisms encapsulated and found within the cytoplasm of neutrophils	• Ehrlichiosis

Figure 7.11 Döhle body (indicated by black arrow) seen within a toxin neutrophil in an equine blood smear. Notice the increased cytoplasm, vacuolization, and hypersegmentation of the nucleus.

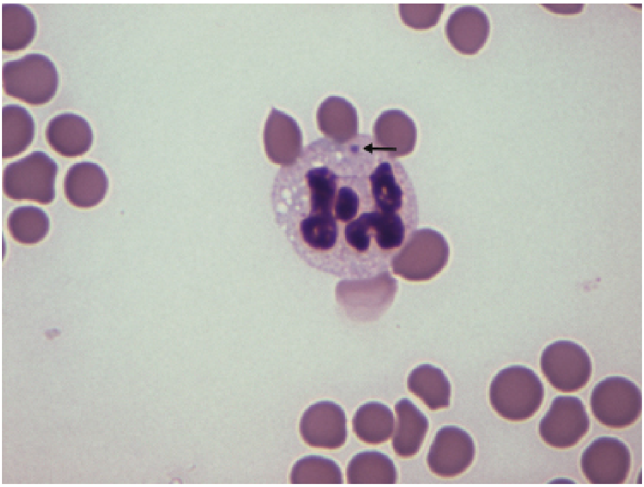


Figure 7.12 Hypersegmentation of an equine neutrophil.

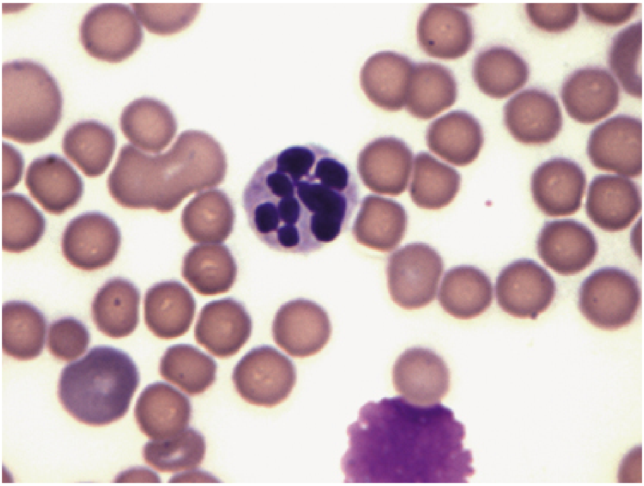


Figure 7.13 Anaplasma phagocytophilum cytoplasmic inclusion within the neutrophil of an equine blood smear, indicated by the black arrow.

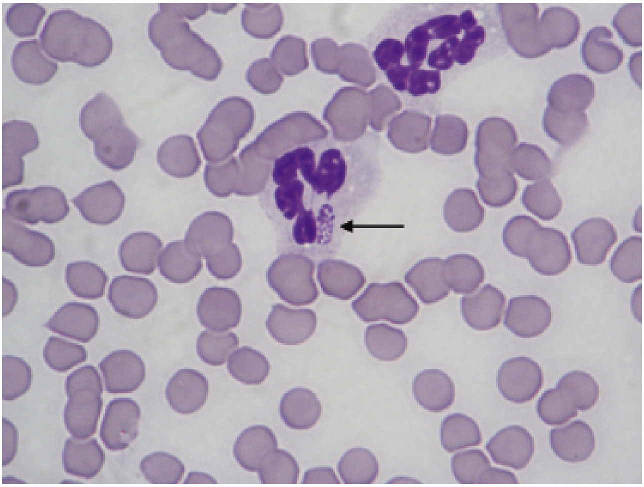


Table 7.7 / White Blood Cell Left Shift

Left Shift	• ↑ Immature neutrophils
Regenerative Left Shift	• Neutrophilia • Mature cells < immature cells

	• Lymphopenia • Monocytosis
Degenerative Left Shift	• Neutropenia or slight neutrophilia • Mature cells < immature cells • Leukopenia
Transitional Left Shift	• Moderate-to-marked neutrophilia • Mature cells < immature cells
Right Shift	• Nuclear hypersegmentation
Stress Leukogram (Corticosteroid Leukogram)	• Mature neutrophilia • Lymphopenia • Eosinopenia • +/− Monocytosis

Platelet Morphology

Platelets absorb and carry plasma factors needed to form fibrin to facilitate hemostasis. Thrombocytes are nonnucleated with pale lavender to pale blue granules (Fig. 7.1 and Fig. 7.2, black arrows). They are often seen in clumps along the feathered edge of a prepared slide. They are observed and counted using the 100× objective. (See Figure 7.1 for normal platelets.)

Table 7.8 / Platelet Alterations

Alteration	Definition	Appearance	Associated Conditions
Megathrombocytes (Megaplatelets, Giant Platelets, Shift Platelets)	• Immature release of platelets from bone marrow	• Platelets appear larger than RBCs. *Horse* • Hard to visualize due to weak staining and poor granulation *Goat* • About the same size as erythrocytes, often clumped	• Bone marrow disorders, myeloproliferative disorders • Normal in some species • Common finding in horse's normal alteration

Coagulation Tests

Hemostasis is defined as the normal arrest of bleeding. Normal hemostasis is dependent upon the complex interaction of plasma coagulation, fibrin proteins, platelets, and blood vasculature.

Coagulation abnormalities are most commonly seen as excessive bleeding or hemorrhage. Coagulation tests are performed in patients exhibiting signs of questionable clotting abilities. These tests or a combination of tests can aid in the diagnosis of a hereditary condition or current coagulopathy.

The coagulation process is the sequence of events that divides into three pathways: intrinsic, extrinsic, and common. Each pathway consists of several coagulation factors that contribute to the entire hemostasis process. A deficiency in one or any combination of the factors can alter the entire process, leading to coagulopathy.

Blood drawn for coagulation tests must be collected and handled following very specific guidelines in order to obtain proper results.

Here are some tips to remember:

1. Venipuncture should be atraumatic using the largest vein possible.

2. Drawn blood should come into contact with the tube additive as soon as possible.

3. The following tubes will give invalid results and should not be used: LTT, GRNTT, SST.

4. Spun samples that are hemolyzed or have visible clots should be redrawn.

5. Place samples on ice if they cannot be processed immediately.

Table 7.9 / Coagulation Screening

Coagulation Factor	ACT	APPT	PIVKA	PT	TT
			Extrinsic Pathway		
III				X	
VII			X	X	
			Intrinsic Pathway		
VIII	X				
XI	X				
XII	X				
			Common Pathway		
I (Fibrinogen)	X	X		X	X
II (Prothrombin)	X	X	X	X	
V	X	X		X	
X	X	X	X	X	

Skills Box 7.3 / Coagulation Tests

Test	Definition	Procedure	Normal Ranges
Activated Clotting Time (ACT)	• Tests intrinsic clotting mechanism • Less sensitive than APTT • Clot formation may be inhibited by administration of salicylates, NSAIDs, anticoagulants, antibiotics, and barbiturates	1. Warm the syringe and tube containing diatomaceous earth to 98°F (37°C). 2. Index 2 ml of freshly drawn whole blood into the tube. Invert 5 times to mix. 3. Begin the clock with the injection of the blood into the tube, and incubate in a warm bath for 1 minute. 4. Observe at 5-second intervals for the first sign of clotting. 5. Place the tube back in incubation between each 5-second check.	*Equine* • 163 seconds +/– 18 seconds *Cattle* • 145 seconds +/– 18 seconds
Buccal Mucosal Bleeding Time (BMBT)	• Evaluates platelet dysfunction • Making a standard wound and noting the time to the cession of bleeding • Some NSAIDs, analgesics, and sedatives may alter the results.	1. Make a puncture at a site with no hair. 2. Begin timing when blood appears. 3. Remove the blood with filter paper at 30-second intervals. 4. Stop timing when there is no more blood. **Note:** Do not touch the skin with the filter paper	
Platelet Estimation	• Estimation of platelet number	1. Examine a prepared blood smear, using 100× objective, observing where the red blood cells are close but not touching each other. 2. Examine at least 10 fields, and find the average expressed as per high power field.	*Equine* • 100,000–600,000 platelets/μL *Cattle* • 200,000–800,000 platelets/μL *Conversion* • Estimated platelet count/μL = average count in 10 fields × 15,000
Clot Retraction Test	• Evaluation of platelet number and function, as well as intrinsic and extrinsic pathways	1. Draw a tube sample into a plain, sterile tube and incubate at 37°C. 2. Examine the tube at 60 minutes when a clot should be evident. 3. Examine the tube at 4 hours to find a retracted clot. 4. Examine the tube at 24 hours to find a distinct compact clot.	*60 minutes* • Clot evident *Four hours* • Clot retracted *24 hours* • Clot clearly compact
Activated Partial Thromboplastin Time (APTT)	• Test of intrinsic clotting mechanism in common coagulation pathways • Measure the time in seconds for fibrin clot formation. • Preservation is critical to the accuracy of this test.	1. Draw a fresh sample and fill BTT. 2. Invert sample 6–10 times to activate the anticoagulant. 3. Refrigerate if testing is less than 24 hours or centrifuge sample, pipette off plasma, and freeze in plastic tube.	*Equine* • 25–45 seconds
Test	**Definition**	**Procedure**	**Normal Ranges**
Fibrin Split Product (FSP) or Fibrin Degradation Product (FDP)	• Measures the presence of products that result from the action of plasmin on fibrin and fibrinogen • Proper dilution is crucial to the accuracy of this test. • Aids in the diagnosis of DIC	1. Draw a fresh sample and fill in an FDP tube with at least 2 ml. 2. Gently invert the sample 6–10 times. 3. Clot permission should occur shortly after the blood draw.	• Most animals have levels of less than 10 mg/ml.
Fibrinogen	• N/A	1. Draw a fresh blood sample to fill an LTT. 2. Gently invert the sample 6–10 times to activate the anticoagulant.	*Equine and goat* • 0.1–0.4 g/dl *Sheep and swine* • 0.1–0.5 g/dl
Prothrombin Time (PT)	• Test of extrinsic clotting mechanism and common coagulation pathways • Measures the time in seconds for fibrin clot formation • Proper dilution is crucial to the accuracy of this test. • Used for vitamin K antagonist poisons	1. Draw a fresh blood sample to fill a BTT. 2. Gently invert sample 6–10 times to activate the anticoagulant. 3. Refrigerate if testing is less than 24 hours or centrifuge the sample, pipette off the plasma, and freeze in a plastic tube.	*Equine* • 9.5–11.5 seconds
Thrombin Time (TT)	• Tests abnormalities of the conversion of fibrinogen to fibrin • Measures the amount of time for fibrin clot permission in citrate plasma after the addition of thrombin • Normal values with rodenticide poisonings	1. Draw a fresh blood sample to fill a BTT. 2. Gently invert the sample 6–10 times to activate the anticoagulant. 3. Refrigerate if testing is less than 24 hours or centrifuge the sample, pipette off the plasma, and freeze in a plastic tube.	• N/A
Von Willebrand Factor (VWF) Assay	• Measurement of the VWF antigen • Proper dilution is crucial to the accuracy of this test. • Do not test during pregnancy, estrous, or lactation.	1. Draw sample before beginning therapy in (e.g., plasma, cryoprecipitate) or wait 48 hours post therapy. 2. Draw a fresh blood sample using a Vacutainer® needle into a 2 ml BTT or use a syringe containing citrate (1 part citrate to 9 parts blood). 3. Do not use a dry syringe and then transfer blood into a BTT. 4. Centrifuge blood and gently pipette off plasma into a plastic container. 5. Within 30 minutes, the sample should be centrifuged, transferred into a plastic tube, and frozen.	• Variable is dependent on bleeding time and VWF antigen percentage.

Microbiology

Most often, microbial samples are sent to reference laboratories for analysis and identification, because they have the proper equipment and techniques needed to accurately identify a pathogen as a specific species. However, in-house microbiology can be a valuable asset and can provide quick results with minimal investment. It is important to understand and know how to perform the preliminary evaluation and the interpretation of bacterial growth. Skills Box 7.4 goes over the handling and collection techniques needed to obtain a proper sample.

Skills Box 7.4 / Collection Techniques

Site	**Collection**
Abortion	• Entire fetus or multiple specimens from a range of body parts should be attained as soon as possible after the animal has died. Collect the placenta and serum from the dam.
Access/ Wound	• *Unruptured:* Sterile syringe with wide bore needle • *Ruptured:* Swab the edge of the wound and take scrapings from the inside wall of the abscess.
Anaerobic Bacteria	• Sterile syringe attached to a fine-gauge needle • Expel all air out of the syringe before obtaining the sample.
Blood	• Collect 5–10 ml of blood from at least 2 different sites and immediately place it in separate blood culture tubes. • Collect multiple samples throughout the day.
Bone and Joint	• Joint aspirate, marrow aspirate, or bone
Ear	• Swab both ear canals and the middle ear, if needed.
Eye	• Corneal scrapings, swab of the conjunctival sac, or swab of lacrimal secretions
Fecal	• Collect 1 g freshly voided or rectal examination–obtained feces. • Clean the anus before collection to avoid contamination with rectal skin microflora.
Genital	• Swab of vulvar mucosa

Leptospirosis	• 20 ml of midstream urine
Milk	• 5–10 ml placed into sterile tube
Urine	• 5 ml urine via a catheter or voided

Microbiology Collection, Handling, Storage, and Transport Tips

Collection

- Collect the sample as aseptically as possible.
- Collect an adequate amount of the sample to allow for complete examination.
- Obtain sample before starting antibiotic therapy to yield the most accurate results.

Handling

- The sample should be handled using aseptic techniques to avoid contamination.
- Maintain a clean environment in which laboratory tests are run.
- If possible, several separate samples should be taken to avoid cross-contamination.
- Wood-shafted and cotton-tipped swabs should not be used with samples suspected of *Chlamydia* spp.
- The sample should be clearly marked with the patient's name, origin of the sample, date, and whether it was refrigerated, zoonotic suspect, radioactive, or chemotherapeutics.

Storage

- Swab samples need to be placed in a transport media if they are not immediately inoculated.

- Swabs may also be placed in a sterile plain red top blood collection tube for brief transport.
- Agar plates must be stored inverted to prevent condensation buildup on the surface of the agar.

Skills Box 7.5 / Handling and Storage Techniques

Test	Type of Sample	Storage Container
Acid-Fast	• Tissue	• Sterile red top tube
	• Slides	• Slide holder
Anaerobic Bacteria	• Tissue	• Sterile red top tube
	• Slides	• Slide holder
	• Fluid	• Sterile culturette swab
Bone and Joint	• Fluid	• Blood culture medium
	• Marrow aspirate	• Sterile red top tube
	• Bone	• Sterile red top tube
Blood	• Whole blood (5–10 ml)	• Blood culture medium
Chlamydia	• Tissue	• *Chlamydia* transport media
Culture and Sensitivity (Bacteria)	• Swab	• Sterile culturette swab or transwab
	• Fluid	• Sterile red top tube
	• Tissue	• Enteric transport media • Red top tube
Fecal Culture	• Feces	• Culturette swab

		• Enteric transport media • Red top tube • Clean, dry container
Fungal Culture	• Hair, scrapings, or swab	• Top tube
	• Fluid	• Culturette swab • Transwab • Screw-cap tube
Gram Stain	• Slides	• Slide holder
	• Swab	• Culturette swab • Transwab
	• Fluid or tissue	• Sterile red top tube
Identification Only	• Swab	• Culturette swab • Transwab
	• Fluid	• Sterile red top tube
	• Tissue	• Enteric transport medium • Sterile red top tube
	• Plate with growth	• Culture plate
Milk	• Fluid	• Sterile red top tube frozen
Mycoplasma	• Fluid and tissue	• Mycoplasma transport media • Sterile culturette swab
Sensitivity Only	• Plate with growth	• Culture plate

Urine	• Fluid	• Culture needs to be set up within 2 hours to avoid overgrowth of insignificant bacteria or refrigerated for no longer than 18–24 hours.

Transport

- Tape the lids of inoculated tubes and plates closed before shipment.
- Freeze the tissue to be submitted for fungal culture and mark with "Caution" because of its zoonotic potential.
- Empty the water that has accumulated on the lid to avoid contaminating the agar plate and to avoid mixing in the colonies of bacteria.
- Make sure all samples are labeled correctly with the type of specimen or culture, as well as any zoonotic potential.

Table 7.10 / Commonly Used Culture Media

Medium	Preparation	Definition/Uses	Interpretations
Blood Agar	• Trypticase soy agar • 5% sheep's blood	• Enriched media that supports the growth of most bacterial pathogens • Differential media portrayed by different types of hemolysis	• Observe for growth, rate, morphology, and hemolytic patterns • *Gamma:* No hemolysis, no color change • *Alpha:* Incomplete hemolysis of RBCs; green ring around the bacterial growth • *Beta:* Complete hemolysis; clear ring around the bacterial growth • *Delta:* Double zone hemolysis
MacConkey Agar	• Crystal violet • Bile acids • pH indicator	• Selective medium that contains crystal violet which suppresses growth of gram-positive bacteria • Differential media portrayed by color of colonies	• Pink to purple colonies indicate lactose fermentors. • Colorless to light yellow colonies indicate nonlactose fermentors.
Urea Broth	• Trypticase soy broth	• Incubation of swabbed cultures	• Turbidity, sediment, presence of a mat within the tube indicate growth.
Sabouraud Dextrose Agar	• N/A	• Isolation of fungi	• N/A
Culturette	• N/A	• Transport media	• Used to collect a sample and keep it viable until it can be analyzed by a laboratory

Note: Numerous types of culture media are available; however, most veterinary clinics only use a few. The more extensive cultures are sent to reference laboratories for growth and interpretation.

Skills Box 7.6 / Culture Media Inoculation and Incubation

General Points for Proper Aseptic Technique:

- Keep culture plates closed unless inoculating or transferring specimens.
- Do not set down the tube cap of medium to avoid contamination.
- When flaming the inoculation loop or wire, place the end closest to the handle in the hottest portion of the flame and then move toward the loop to prevent splattering.

- When transferring sample to the agar, use gentle touch to avoid tearing the surface of the plate.
- Cool the inoculating loop or needle on the side of the tube medium or agar plate to ensure adequate inoculation of the sample.

Plate Inoculation:

1. Mentally divide the agar plate into four quadrants.

2. Flame and cool the inoculation loop.

3. Dip the loop into the specimen to be cultured.

4. Streak the specimen in the first quadrant.

5. Repeat steps 2–4 while slightly overlapping the previous quadrant and then moving around to each additional quadrant. Be sure to overlap the previous quadrant's streak only 1–2 times to prevent excessive colony growth in the remaining quadrants. If streaked properly, the fourth quadrant is expected to grow isolated colonies.

6. After each quadrant streak, be sure to reflame and cool the inoculation loop to help avoid contamination.

Slant Inoculation:

1. Flame and cool the inoculation wire.

2. Dip the wire into the specimen to be cultured.

3. Types of slant inoculations:

> **a.** *Slant only:* Using the side of the wire, gently streak the slant of agar in a zigzag pattern. Be careful not to apply too much pressure and tear the agar.
>
> **b.** *Stab only:* Stab the wire through the agar stopping just below the bottom. Withdraw the needle along the same path to avoid tearing of the agar.
>
> **c.** *Stab and streak:* Stab the wire through the media, stopping just below the bottom of the tube. Remove the wire and gently streak the slant of agar in a zigzag pattern.

4. Remove the wire and reflame.

Broth Inoculation:

1. Flame and cool the inoculation loop or wire.

2. Dip the wire into the specimen to be cultured.

3. Insert the loop or wire into the broth just below the surface and touch the side of the tube.

4. Remove the loop or wire and reflame.

Incubation of Cultures:

- Maintain incubator temperature at 98.6°F and humidity at 70%.

- Agar plates should be stored upside down to prevent the accumulation of condensation on the plate cover.
- All cultures should be incubated for 24 hours and then checked for growth. If there is no growth or not adequate growth, the sample may be incubated for an additional 24 hours.
- When incubating culture tubes, the caps should be loosened.

Skills Box 7.7 / Evaluation of Culture Growth

1. Identify the source of the sample

2. Visual signs of growth:

a. *Broth media:* Turbidity, sediment, matt

b. *Agar plate:* Colony formation, swarming growth

3. Changes to the media

a. Hemolytic pattern

b. Color changes

c. Odor

4. Microscopic evaluation

a. Simple stain

b. Gram stain

c. Acid-fast stain

d. Negative stain

5. Common identification tests

a. *Catalase test:* Differentiates between catalase-positive staphylococci and catalase-negative streptococci. An isolated sample is taken and mixed with hydrogen peroxide. The formation of bubbles indicates a positive result.

b. *Oxidase test:* Differentiates between species of enterococci. A positive test result is indicated by a purple color change on the reagent paper.

c. *Indole test:* Differentiates between indole-positive *Escherichia coli, proteus,* and indole-negative streptococcus and *salmonella typhimurium* bacteria. A positive test result is indicated by a red color on the surface of the test tube.

Skills Box 7.8 / Staining Solutions and Procedures

- The very first step in identification of a pathogen is to make a smear of the sample and stain the slide to analyze the microbe microscopically.
- Smears should be performed on a clean, dry slide.
- First place a drop of distilled water on the center of the microscope slide.

- A small sample of the specimen should be taken with an inoculation tool and mixed with the drop of distilled water on the slide.
- The sample should be mixed thoroughly and spread out to make a thin layer on the slide.
- The slide should then be allowed to air dry.
- Heat fix the slide by quickly passing it over a flame source 2–3 times. This ensures adhesion of the sample to the slide.
- The slide should then be submerged in the staining solution and agitated to allow adequate coverage of the entire sample.

Skills Box 7.9 / Staining Procedures and Interpretations

Staining Technique	Uses	Preparation	Procedure	Interpretation
Differential Stains				
Diff-Quick (Modified Wright's Stain)	• General cytology and demonstration of the bacteria	• *Fixative:* Methanol, triarylmethane dye • *Eosinophilic:* Xanthene dye • *Basophilic:* Thiazine dye mixture	1. Dip the prepared slide 5 times slowly in methanol fixative. 2. Repeat above with eosinophilic stain and basophilic stain. 3. Rinse with water. 4. Air dry.	• Clear differentiation of cellular morphology • Staining ranges from pale pinks to dark purple
Giemsa Stain	• Detection of spirochetes and Rickettsia	• *Fixative:* Methanol • Giemsa powder • Glycerol	1. Fix the prepared slide in absolute methanol for 3–5 minutes and air dry. 2. Place the slide in diluted stain for 0–30 minutes. 3. Rinse with water and air dry.	• Purplish blue stained bacteria
Gram Stain	• Distinguish between gram-positive and gram-negative act. Based on their cell wall characteristics	• *Primary stain:* Crystal violet • *Mordat:* Grams iodine • *Decolorizer:* Alcohol • *Counterstained:* Dilute caramel fusion or saffronin	1. Flood the prepared slide with crystal violet for 30–60 seconds. 2. Rinse with water for 5 seconds. 3. Flood the slide with iodine for 30–60 seconds. 4. Rinse with water for 5 seconds. 5. Decolorize for about 10 seconds until the purple color is gone. 6. Rinse with water for 5 seconds. 7. Flood the slide with dilute caramel fusion for 30–60 seconds. 8. Rinse with water for 5 seconds. 9. Let air dry.	• Purple stained bacteria are gram positive. • Red to pink stained bacteria are gram negative.
Lactophenol Cotton Blue	• Detection of fungi	• N/A	• Same as simple stain	• Visualization of hyphae, septae, and structure of spores
Ziehl/Neelsen or Acid-Fast Stain	• Section of mycobacterium species and the cardia	• N/A	1. Flood the prepared slide with caramel fusion. 2. Heat over flame until it steams; then let it sit for 5 minutes. 3. Rinse with water. 4. Decolorize with acid alcohol until red color is gone. 5. Rinse with water. 6. Counterstain with methyl and blue for 2 minutes. 7. Rinse with water and dry over low heat.	• Acid-fast bacteria stain red • Non–acid-fast bacteria stain blue
Staining Technique	**Uses**	**Preparation**	**Procedure**	**Interpretation**
Modified Ziehl/ Neelsen Stain with Brilliant Green	• Detection of mycobacterium species in the cardia		1. Flood the prepared slide with caramel fusion for 3 minutes; then heat. 2. Rinse with water. 3. Decolorize with acid alcohol for 3 minutes. 4. Rinse with water. 5. Counterstain with brilliant green for 3 minutes. 6. Rinse and dry.	• Acid fast bacteria stain red • Non–acid-fast bacteria stain green
Modified Ziehl/ Neelsen Stain with Methylene Blue	• Detection of brucella, and chlamydia		1. Flood the prepared slide with dilute caramel fusion for 10 minutes. 2. Rinse with water. 3. Decolorize with a Sikh acid 20–30 seconds. 4. Rinse with water. 5. Counterstain with methyl and blue for 2 minutes. 6. Rinse and dry.	• Brucella, stained bright red, and in clumps
Simple Stains				
Negative Staining	• Detection of capsules and difficult stain bacteria	• A negatively charged chromogen stain • India ink • Nigrosin	1. Prepare an air-dried slide. 2. Apply 1–2 drops of stain on prepared slide. 3. Apply coverslips and examine as a wet mount.	• Capsules appear clear, unstained, and surrounded by dark particles.
Simple Stain	• Demonstration of bacteria and general morphology and shape arrangement	• A positively charge chromogen stain • Carbol fusion • Crystal violet • Menthylin blue • New methylin blue • Saffronin	*Technique One* 1. Place one drop on the coverslip and apply to Ferd slide. 2. Place the paper towel over the coverslip and apply gentle pressure to absorb excess stain. *Technique Two* 1. Place one drop of the stain next to the coverslip of an underprepared slide and allow the stain to seep under the coverslip. 2. Place the paper towel over the coverslip and apply gentle pressure to absorb excess stain.	• Visualization of cell shape and arrangement • Heinz bodies, urine sediment, and oily preparations

Table 7.11 / Staining Problems

Problem	Solutions
Excessive Staining	• Decrease the staining time. • Rinse adequately between stains and after staining. • Prepare a thinner sample on the slide. • Allow slide to dry before applying cover slip.
Weak Staining	• Increasing in time • Change stains. • Stain slides sooner after air drying. • Keep the caps tightly place on the stain containers to prevent of evaporation.
Uneven Staining	• Use only clean and dry slides. • Do not touch the sample area of the slides before after preparation. • Placed slides and anal for drying to prevent liquid from drying onto the slide. • Inadequate mixing of stains • keep the caps tightly placed on the stain containers to prevent evaporation.
Slide Precipitate	• Rinse adequately between stains and after staining. • Use clean slides. • Do not allow stains to dry on slide while staining. • Change or filter stains periodically and regularly. • Keep the caps tightly placed on the stain containers to prevent contamination and evaporation.

Note: To avoid staining problems, use fresh, clean stains and slides. Do not touch the surface of the slide, and stain slides immediately after air dried.

Table 7.12 / Bacterial Identification

Organism	Affected Species	Associated Conditions	Microscopic	Colony Characteristics on Blood Agar Plate
Actinobacillus equuli	• Horses	• Abortion, septicemia, nephritis, endocarditis	• Gram-negative, non-motile coccobacilli	• Small-to-medium nonhemolytic gray colonies
Actinobacillus lignieressii	• Cattle • Horses • Sheep • Pigs	• Tongue abscess; "woody tongue"	• Gram-negative, non-motile coccobacilli	• Small-to-medium nonhemolytic gray colonies
*Actinobacillus pleuropneumoniae (*Previously Known as *Haemophilus pleuropneumoniae)*	• Pigs	• Pneumonia, pulmonary abscess, anorexia, weakness, abortion	• Gram-negative coccobacilli	• Small-to-medium, round, translucent colonies
Actinobacillus suis	• Foals • Pigs	• Arthritis, pneumonia, pericarditis in adult pigs • Septicemia in foals and piglets	• Gram-negative coccobacilli	• Small-to-medium, round, translucent colonies
Actinomyces bovis	• Cattle	• Deep skin abscesses, "lumpy jaw," lung abscess	• Gram-positive, non–acid-fast filamentous rods	• Slow growing, small, gray-white, convex, rough, nodular colonies • Beta hemolytic
Actinomyces pyogenes	• Cattle • Sheep • Goats • Pigs	• Multi-organ infections, mastitis, arthritis, endocarditis, pneumonia, abortion, septicemia, umbilical infections	• Gram-positive, non-acid-fast, filamentous rods	• Slow-growing, small, gray-white, convex, rough, nodular colonies • Beta hemolytic
Actinomyces suis	• Pigs	• Mastitis, suppurative infections	• Gram-positive, non-acid-fast filamentous rods	• Slow growing, small, gray-white, convex rough, nodular colonies beta hemolytic
Bacillus anthracis	• Cattle • Horses • Sheep • Goats	• *Anthrax:* Fever, staggering, dyspnea, collapse, sudden death	• Facultative anaerobic, non-motile, encapsulated, endospores forming gram-positive rods	• White to gray, flat or slightly convex, with irregular edges and a ground-glass appearance
Borrelia burgdorferi	• N/A	• Tick-transmitted disease • Lyme disease	• Spirochete • Refer to reference laboratory for identification.	• Refer to reference laboratory for identification.
Organism	Affected Species	Associated Conditions	Microscopic	Colony Characteristics on Blood Agar Plate
Bordetella broncheseptica	• Pigs	• Wry nose sinusitis	• Gram-negative, slow-growing coccobacillus	• Small, circular-to-pinpoint colonies • Variable hemolysis
Brucella abortus	• Cattle	• Infertility, abortion, metritis, retained placenta • *Bulls:* Orchitis, epididymitis, infertility	• Small, gram-negative, red coccobacillus	• Round, smooth, glistening, translucent
Burkholderia pseudomallei	• Cattle • Horses • Sheep • Goats • Pigs	• Melioidosis • Signs can vary widely within a species. • Abcesses, mastitis, lameness, osteomyelitis, CNS disease	• Motile, gram-negative, facultative anaerobic bacilli	• Small, smooth, white, nonhemolytic colonies
Campylobacter fetus	• Cattle • Goats • Sheep • Pigs	• Abortion, diarrhea	• Gram-negative, microaerophilic, slender, curved, motile bacterium with a polar flagellum	• Small-to-medium, yellow-colored mucoid colonies
Chlamydophila (Chlamydia) psittaci	• Calves • Foals • Goats • Piglets • Llamas	• Abortions, pneumonia, polyarthritis, encephalomyelitis, and conjunctivitis	• Gram-negative, coccoid microorganisms	• Refer to reference laboratory for identification.
Clostridium botulinum	• Cattle • Horses	• Rapidly fatal motor paralysis • *Botulism:* "Shaker foal syndrome"	• Motile, anaerobic, endospore-forming, gram-positive rod	• Round, irregular, transparent, double zone of hemolysis
Clostridium chauvoei	• Cattle • Sheep • Llamas	• "Black leg" • Acute lameness, sudden death, edematous and crepitant swellings	• Obligate anaerobic, endospore-forming, gram-positive rod	• Variable round, irregular, colonies, usually hemolytic
Clostridium difficile	• Cattle • Piglets	• Hemorrhagic enteritis	• Motile, obligate anaerobic, endospore-forming, gram-positive rod	• Glossy gray circular colonies, rough edges, nonhemolytic
Clostridium tetani	• Horses • Goats • Llamas	• *Tetanus:* "Lock-jaw"	• Motile, strictly anaerobic, endospore-forming, gram-positive rod • Terminal, spherical spores	• Fine swarming growth may be difficult to see. • May appear beta hemolytic

Organism	Affected Species	Associated Conditions	Microscopic	Colony Characteristics on Blood Agar Plate
Corynebacterium spp.	• Cattle • Horses	• Skin abscesses, nonsuppurative arthritis, endocarditis, pyogenic infections, abortion, secondary infections, abscess, meningitis, pyelonephritis, UTI	• Non-motile, non–spore-forming, gram-positive rod	• Small-to-pinpoint, slow-growing, opaque, dry-looking colonies • Hemolytic
Coxiella burnetii	• Cattle • Sheep • Goats	• *Q-fever:* Infertility and sporadic abortion with a necrotizing placentitis in ruminants	• Gram-negative coccobacillus	• Refer to reference laboratory for identification.
Dermatophilus congolensis	• Horses	• *Dermatophilosis:* Rain scald or rain rot	• Double chains of cocci with a "railroad-track appearance"	• Sticky, small, grey-yellow colonies • Beta hemolytic
Ersipelothrix rhusiopathiae	• Pigs • Sheep *Uncommon in:* • Cattle • Goats	• Arthritis, chronic endocarditis, sudden death	• Gram-positive rod	• Smooth or rough, pinpoint-to-small, translucent, nonhemolytic colonies
Escherichia coli	• Calves • Lambs • Goats	• Meningitis • Septicemia and septic shock • Neonatal diarrhea	• Gram-negative, facultative, anaerobic rods	• Medium-sized, gray, mucoid alpha-hemolytic colonies
	• Pigs	• *Edema disease:* "Gut edema" or "bowel edema" • Enterotoxemia	• Facultative anaerobes • Gram-negative rods	• Medium-sized, gray, mucoid, beta-hemolytic colonies
Eubacterium suis	• Pigs	• Cystitis, pyelonephritis	• Anaerobic, non–spore-forming, non-motile bacteria containing straight or curved gram-positive rods	• White, flat, granular, with a raised center with irregular edges
Fusobacterium spp.	• Horses • Sheep • Goats • Pigs	• *Necrotic:* Necrotic stomatitis of calves, necrotic rhinitis of pigs, "foot rot" of cattle, foot abscess of sheep, postparturient necrosis of the vagina and uterus, focal necrosis of the liver of cattle and sheep, pyoderma of horses	• Filamentous, anaerobic, gram-negative, non-spore-forming bacteria	• Refer to reference laboratory for identification.
Haemophilus parasuis	• Pigs	• Glässer's disease (porcine polyserositis, infectious polyarthritis)	• Small, pleomorphic, fastidious, gram-negative rod	• Refer to reference laboratory for identification.

Organism	Affected Species	Associated Conditions	Microscopic	Colony Characteristics on Blood Agar Plate
Histophilus somni (Formerly *Haemophilus somnus)*	• Cattle • Calves	• Septicemia, bronchopneumonia, CNS disease, depression, myocarditis	• Gram-negative, non-motile, non–spore-forming, nonencapsulated, pleomorphic coccobacillus	• Refer to reference laboratory for identification.
Leptospira bratislava	• Horses • Sheep • Pigs	• *Leptospirosis:* Uveitis, abortions, stillbirth	• *Spirochetes:* 6–12 microns long and 0.1 micron in diameter • Usually are hooked on both ends	• Refer to reference laboratory for identification.
Leptospira hardjo	• Cattle	• Calves may have fever, anorexia, dyspnea from pulmonary congestion, icterus, hemoglobinuria, and hemolytic anemia. • Cattle show deceased milk production, abortion, and stillbirths.	• *Spirochetes:* 6–12 microns long and 0.1 micron in diameter • Usually are hooked on both ends	• Refer to reference laboratory for identification.
Listeria monocytogenes	• Cattle • Sheep • Goats *Occasionally:* • Pigs	• *Circling disease:* Circling, facial paralysis, septicemia, abortion, still births, encephalitis, conjunctivitis, uveitis	• Small, motile, gram-positive, non–spore-forming, extremely resistant coccobacillus	• Pinpoint-to-small, semi-transparent colonies • Hemolytic
Mycobacterium bovis	• Cattle	• *Tuberculosis:* Infects the tonsils and intestinal mucosa	• Gram-positive, acid-fast bacilli	• Refer to reference laboratory for identification.
Mycobacterium paratuberculosis	• Cattle • Sheep • Goats	• Johne's disease • Enteritis • Paratuberculosis	• Non-motile, slow-growing, acid-fast, non–spore-forming, gram-positive rod	• Refer to reference laboratory for identification.
Mycoplasma bovis	• Cattle • Pigs • Llamas	• Infectious bovine rhinotracheitis, • Pneumonia, mastitis, arthritis, pink eye	• Fastidious bacteria, lack a cell wall, not easily stained or observed	• Large colony variant • Refer to reference laboratory for identification.
Pasteurella haemolytica	• Cattle • Sheep • Goats	• "Shipping fever" • Meningitis bronchopneumonia, dyspnea, pleuritis	• Non-motile, gram-negative rods	• Gray, mucoid, round colonies • Nonhemolytic
Pasteurella trehalosi	• Sheep	• Meningitis	• Aerobic to facultative anaerobic, non-motile, small, gram-negative rods	• Gray mucoid, round colonies • Nonhemolytic

Organism	Affected Species	Associated Conditions	Microscopic	Colony Characteristics on Blood Agar Plate
Pasteurella multocida	• Cattle *Occasionally:* • Horses • Sheep • Goats	• *Pasteurellosis:* Hemorrhagic septicemia • Atrophic rhinitis • Pneumonia	• Gram-negative, non-motile rods	• Medium-sized, mucoid colonies • Nonhemolytic
Proteus spp.	• Cattle • Horses • Sheep • Goats	• Septic wounds • Urinary tract infections	• Strait facultative anaerobe, motile, gram-negative rod	• Swarming growth
Pseudomonas mallei	• Horses	• *Glanders:* Upper respiratory nodules	• Gram-negative rod	• Irregular, grayish colonies • Variable hemolysis • May have a metallic sheen
Rhodococcus equi	• Horses	• Pneumonia	• Gram-positive, rod-coccus cycle, non-motile, obligate aerobes	• Small-to-medium, nonhemolytic, gray-to-white, mucoid colonies
Salmonella spp.	• Cattle • Horses	• Diarrhea, cholangitis	• Gram-negative, motile, facultative, anaerobic non–spore-forming rods	• Medium-sized, nonhemolytic
Staphylococcus spp.	• Cattle • Horses • Sheep • Goats	• Dermatitis, pyodermas, wound infections	• Gram-positive cocci	• Smooth, glistening, white-to-yellow colored colonies • Hemolysis variable dependent on species
Streptococcus equi	• Horses	• *Strangles:* Fever, mucopurulent nasal discharge, depression, and submandibular lymphadenopathy	• Non-motile, gram-positive, capsulated, Lancefield group C coccus	• Semi-transparent, mucoid colonies • Small, beta hemolytic zone
Staphylococcus hyicus	• Pigs	• *Greasy pig:* Generalized dermatitis • Listlessness or depression and anorexia	• Gram-positive, non-motile cocci that occur in pairs, tetrads, or clusters	• Medium-sized, white colonies
Streptococcus dysgalactiae	• Cattle • Horses • Pigs	• Upper respiratory infections, strangles, lymph node abscesses, meningitis	• Gram-positive, facultative, anaerobic cocci occurring in pairs or chains	• Small, glistening colonies • Beta hemolytic
Streptococcus suis	• Pigs	• Meningitis, septicemia, endocarditis, arthritis, or pneumonia	• Gram-positive, facultative, anaerobic cocci arranged in chains	• Small, glistening colonies • Alpha hemolytic

Table 7.13 / Fungi Identification

Organism	Associated Conditions/Clinical Signs	Microscopic Evaluation	Culture Characteristics
Aspergillus spp.	• *Aspergillosis:* Pulmonary infections, abortion, mastitis, pneumonia	• Short thick, septate hyphae • Condidia are usually absent due to handling during slide preparation, but they appear as large, intact, cotton-ball structures.	• Green, yellow, or brown granular colonies with a white edge
Blastomyces dermatitidis	• *Equine:* Weight loss, coughing, anorexia, lymphadenopathy, dyspnea, ocular disease, lameness, skin lesions, and fever	• Thick-walled, round-to-ovoid yeast that often has daughter cells budding from a broad base. They may be empty or contain basophilic nuclear material and have single, broad-based buds.	• White-to-brownish, cobweb-looking appearance
Candida albicans	• Opportunistic • Porcine "candidiasis" affects the oral, esophageal, and gastric mucosa, with diarrhea and emaciation as a result. • Infections involve mucus membranes.	• Oval shape and visible nuclei on vegetative cells • Pseudohyphae constrictions between cells • Observe budding yeasts on wet mounts.	• Small, greenish colonies
Coccidioides immitis	• Respiratory disease of cattle, sheep, pigs	• Barrel-shaped arthoconidia are separated by thinner waved disjunctor cells	• White and wooly colonies may develop a variety of colors with older samples.
Cryptococcus neoformans	• Respiratory disease seen in cattle, horses, sheep, and goats • Mastitis, pneumonia, meningitis	• Spherical, encapsulated, non-fermenting, aerobic yeast that is variable in size	• Mucoid colonies • Shiny, cream colored
Geotrichum candidum	• Ubiquitous fungus of soil, decaying organic matter, and contaminated food. • Causes mastitis in cattle and caseous nodules in the lymph nodes of pigs	• Multinucleated giant cells, as ovoid yeast-like cells with short, jointed chains of round yeast cells forming pseudohyphae	• Rapidly expanding • White, flat
Malassezia pachydermatis	• External otitis • Seborrheic and hypersensitivity reactions associated with dermatitis	• Oval, bottle-shaped, monopolar budding yeast	• Cream color, convex, soft, with entire or lobed margins
Microsporum spp.	• *Ringworm in horses:* Bull's-eye lesions on skin; hair loss	• Rarely produces macroconidia or microconidia, terminal cells	• Grey to tan with light orange colonies
Sporothrix schenckii	• Sporotrichosis has been reported in horses, cows, goats, and pigs.	• Organism presents as few-to-numerous, cigar-shaped, single cells within macrophages. The fungal cells are pleomorphic, and small buds may be present and give the appearance of a ping-pong paddle. • In cultures, a true mycelium is produced with fine, branching, septate hyphae bearing pear-shaped conidia on slender conidiophores.	• Smooth and wrinkled, gray, tough
Trichophyton equinum	• Ringworm in horses	• Spherical to pear-shaped microconidia that may form laterally along the hyphae	• White to buff in color and flat, but some may develop folds
Trichophyton mentagrophytes	• Ringworm in horses	• Spherical to pear-shaped microconidia may be found singularly or in clusters along hyphae. • Antler-like hyphae may also be seen.	• *Variable appearance:* Round in shape; may be cream to brown, colorless, yellow, or red
Trichophyton verrucosum	• Ringworm in cattle	• Smooth, club-shaped conidia with thin walls located at the ends on hyphae	• Granular colonies, white to tan, and may form rings

Urinalysis

Urinalysis is used to diagnose urinary track inflammation, renal lobular dysfunction, and glomerular disease. It is also used for evaluation of pH, ketones, glucose, infections, metabolic disorders, and drug residues. In addition, urinalysis aids in the diagnosis of nonrenal diseases such as liver disease, muscle disease, diabetes, and hemolysis. This test is often used in conjunction with other tests to help yield a diagnosis.

In large animal medicine, many urinary disorders are difficult to diagnose and manage due to the lack of expensive equipment, such as an endoscope or an ultrasound machine. Collection is dependent on the sex and species. Cystocentesis is not performed in large animals; these samples are collected either by free catch or catheterization. Catheterization is not performed in bovine species or llamas and requires sedation in male horses. Excessive aspiration pressure during catheterization can alter the cellular contents and cause small hemorrhages, which can yield an improper representation in the urine sediment, leading to a possible misdiagnosis. Therefore, free catch and voided samples are most effective in cattle, sheep, and goats.

Table 7.14 / Gross Urine Examination

Physical Property	Observation	Definition	Associated Conditions
Color	• Yellow	• Any shade of yellow is normal.	• N/A
	• Red or red brown	• Indicates hematuria	• UTI, cystitis, trauma, neoplasia, urolithiasis
	• Brown	• Contains myoglobin	• Muscle-cell lysis
	• Yellow brown or yellow green	• Contains bile pigments	• Liver disease
	• White	• Contains leukocytes	• UTI, cystitis, crystallurea
Foam	• Small amount	• Normal when shaken	• N/A
	• Large amount	• Contains protein	• Kidney disease, fever, excessive exercise
	• Green	• Contains bile pigments	• Liver disease
Odor	• Ammonia	• Breakdown of urease	• UTI, cystitis
	• Sweet or fruity	• Contains ketones and/or glucose	• Diabetes mellitus
Specific Gravity (USG)	*Normal Ranges* • *Equine:* 1.025–1.060 • *Cattle:* 1.030–1.045 • *Sheep:* 1.015–1.045 • *Goat:* 1.015–1.045 • *Swine:* 1.010–1.050 • *Llama:* N/A	• Normal • Measure the density of urine compared to that of water.	• N/A
	• High	• Hypersthenuric	• Decreased water intake or excretion • Cold urine yields falsely high USG
	• Low	• Hyposthenuric	• Increased water intake, pyometra, liver disease, kidney disease, diuretics, diabetes insipidus
Transparency	• Clear	• Normal	• N/A
	• Cloudy or flocculent	• Contains cellular components	• UTI; normal in horses
Volume	• Polyuria	• Increased urine production; pale with low specific gravity	• Nephritis, diabetes mellitus, diabetes insipidus, pyometra, liver and kidney diseases
	• Oliguria	• Decreased urine production	• Decreased water intake, fever, shock, heart disease, dehydration
	• Pollakiuria	• Frequent urination	• UTI, urolithiasis, crystallurea
	• Anuria	• Lack of urine output	• Urinary obstruction, bladder rupture

Preparation

Evaluation of the chemistry strip is an essential part of running a urinalysis. It can provide you with information on key elements that may not be detectable on visual or microscopic examination. Like so many diagnostic tests, there is the probability of false negative results. This is why the visual (microscopic) examination should always be performed along with the chemical analysis.

It is important to store chemistry strip bottles at room temperature away from intense light, moisture, and heat. Strips can be immersed in a urine sample for 2–3 seconds to allow saturation of the pads; however, this may cause the reagent to leak from the pads back into the sample. This method also increases the risk of cross contamination between pads, which may affect the results. A pipette may be used to place one drop of urine on each pad to saturate it and then turn the strip on its side to remove the excess urine. Then the results are read at the time indicated by the manufacturer. It is important to read the results at that precise time because the reagents slowly break down over time, which may lead to a more prominent color change. The color change can be subjective and can also be altered by the presence of urine pigments (e.g., bilirubin or hemoglobin). This is why it is preferred to run a chemistry strip on a centrifuged sample. It has been proven that bleach and bleach fumes can affect some chemistries. When running a chemistry strip, place a paper towel down on the surface of the table to prevent contamination.

Table 7.15 / Chemistry Strip Examination

Chemical Property	Observation	Definition	Associated Conditions
Bilirubin	• Bilirubinuria	• Byproduct of the breakdown of hemoglobin • *False negative:* Exposure to light • *Confirmation test:* Ictotest	• Hemolytic anemia, bile duct obstruction, liver disease, fever, starvation
Blood	• Hematuria	• Presence of intact red blood cells. After centrifugation, urine will appear clear with a clump of packed cells at the bottom of the tube.	• UTI, cystitis, renal disease, trauma, genital tract contamination
	• Hemoglobinuria	• The presence of free hemoglobin typically caused by hemolysis • After centrifugation, urine will remain tinted red.	• Hemolytic anemia, burns, incompatible transfusions, leptospirosis, metal toxicity
	• Myoglobinuria	• Present due to muscle death • Urine appears brown.	• Muscle damage
Glucose	• Glycosuria	• Appears if blood glucose exceeds the threshold *Values* • *Equine*: >115 mg/dl • *Cattle:* >55 mg/dl • *Sheep:* >76 mg/dl • *Goat:* >100 mg/dl • *Swine:* >95 mg/dl • *Llamas:* >145 mg/dl • Not detectible in normal animals • *False negatives:* Cold urine	• Liver disease
Ketones	• Ketonuria	• Formed from the breakdown of fatty acids • Not detectable in normal animals • *False negative:* Delayed analysis • *False positive:* Pigmented urine • *Confirmation test:* Acetest	• Liver disease, persistent fever, high-fat diets, starvation, or long-term anorexia
PH	• Normal	• Concentration of H+ ions • *Herbivores:* 7.0–8.5	• N/A
	• Alkaline	• Increased concentration of H+ ions • pH < 8.5 • *False increases:* Delayed analysis	• UTI, metabolic or respiratory alkalosis, distal renal tubular acidosis, urine retention, certain drugs (e. g., bicarbonate, citrate)
	• Acidic	• Decrease concentration of H+ ions • pH > 7.0	• Metabolic or respiratory acidosis, fever, starvation, chloride depletion, certain drugs (e.g., furosemide)
Protein	• Proteinuria	• Measurement of albumin and globulins • Trace amounts are normal • *False positives:* Increased USG, increased pH, pigmented urine, detergent contamination • *Confirmation tests:* Sulfosalicyclic acid test; microalbuminuria test	• Glomerulonephritis, glomerular amyloidosis, multiple myeloma, parturition, estrus, UTI
	• Increased	• Increased urine protein loss	• Chronic interstitial nephritis, glomerulonephritis, and amyloidosis

Skills Box 7.10 / Sediment Examination

Microscopic examination of urine sediment is a very important diagnostic tool and should be included in every routine urinalysis. There are many things that can be detected through sediment examination that cannot be tested any other way.

If possible, collect 5–10 ml of urine; separate it into two plain tubes. One tube is used for sediment examination; and the other should remain available for a culture, if needed. The urine is centrifuged; and the supernatant is poured off, leaving a pellet and a small amount of urine in the bottom of the tube. Mix the pellet and remaining fluid together by gently tapping the tube on a hard surface. Then place one drop on a clean microscope slide, and place a coverslip over the sample.

To properly observe an unstained sample, the condenser on the microscope must be lowered and the light source reduced. This allows you to observe the refractile elements and makes it easier to observe casts.

First, scan the entire slide on low power 10× objective to observe for casts and cell clumps. The larger objects tend to collect around the periphery of the coverslip; therefore, careful analysis should be performed when observing these areas. Casts and crystals are reported as #/LPF (low power field); whereas red and white blood cells, epithelial cells, and other abnormalities are reported as #/HPF (high power field). Bacteria and sperm are examined under high power 100× and reported as rare through 4+ as follows:

Rare: Only a few seen after scanning numerous fields

1+: Greater than 1 per high power field

2+: 1–5 per high power field

3+: 6–20 per high power field

4+: Greater than 20 per high power field

Table 7.16 / Sediment Examination: Cellular Structures

Component	Appearance	Definition	Associated Conditions
Fat (Fig. 7.14)	• Round, highly refractile, varied in size, surrounded by a black ring around the perimeter	• Excessive amounts of fat have been excreted into the urine.	• ↑ Numbers indicate: Animals with fatty diets
Sperm	• Rounded head with long, thin, tapered tail	• Contamination from urogenital tract	• ↑ Numbers indicate: Contamination
Renal Epithelial Cells	• Small, round cells with prominent nuclei	• Epithelial cells originating from the renal tubules • Rare	• ↑ Numbers indicate: Renal disease
Squamous Epithelial Cells (Fig. 7.15 and Fig. 7.16)	• Large flat irregular cells, small nucleus, and large amount of cytoplasm	• Derived from vagina, prepuce, and urethra	• ↑ Numbers indicate: Contamination with no diagnostic significance
Transitional Epithelial Cells	• Round, oval shaped, with small nucleus and grainy cytoplasm	• Derived from the proximal urethra, bladder, ureters, and renal tubules	• ↑ Numbers indicate: Contamination from catheterization, or high numbers may indicate inflammatory disease or transitional cell carcinoma

Figure 7.14 Fat droplets in unstained urine sediment.

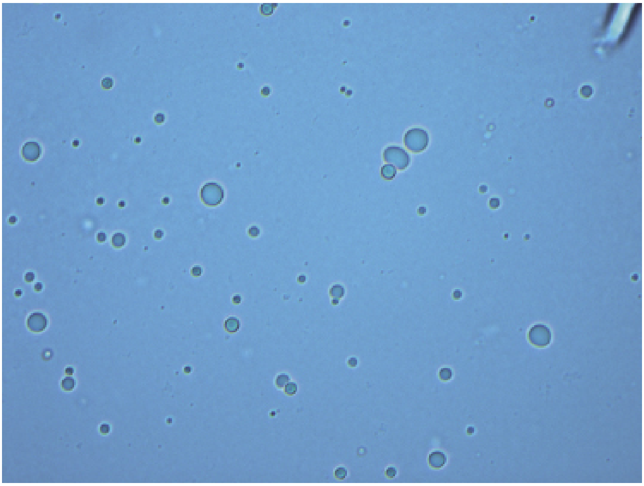


Figure 7.15 Squamous epithelial cells found in unstained urine sediment.

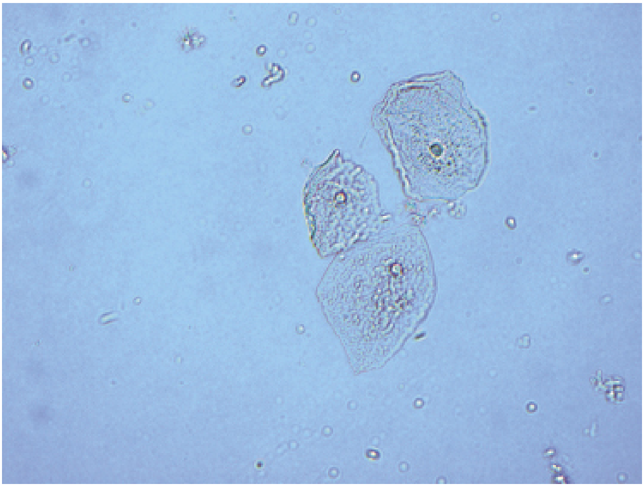
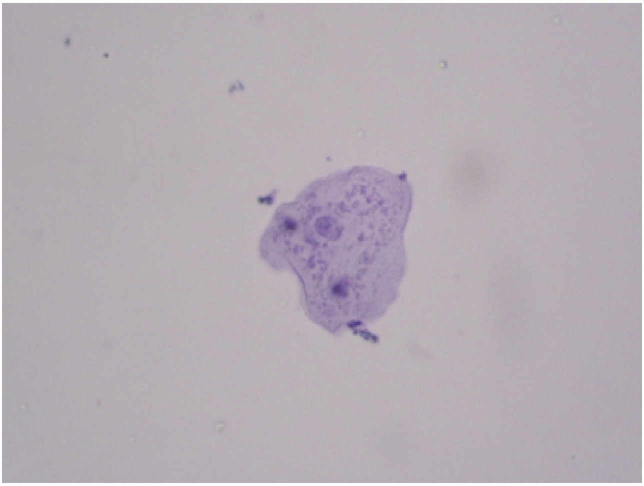


Figure 7.16 Stained squamous epithelial cells in urine sediment.



Bacteria

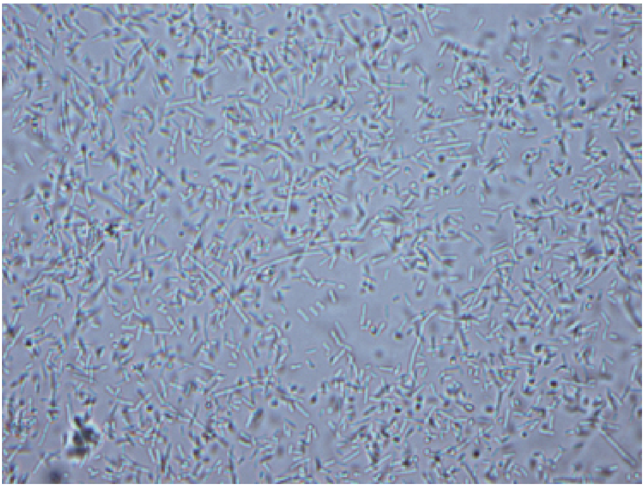
Bacteria are not normally found in properly collected urine samples. Being unable to perform a cystocentesis on many of the larger animals makes it difficult to obtain an assuredly sterile sample. Catheterization is the best method for collection in these animals, but possible contamination is a problem. Any presence of bacteria is a significant note and is correlated to the mode of collection.

There is no way to differentiate between the presence of protein and cocci bacteria in an unstained sediment sample. Both elements are of similar shape, size, and movement. Brownian movement of protein looks similar to the true motility of cocci. Because there is no way to differentiate between the protein and cocci, a stained sediment sample should also be observed to make this differentiation.

Table 7.17 / Sediment Examination: Bacteria

Component	Appearance	Definition	Associated Conditions
Cocci	• Spherical and arranged singularly, in chains, or in pairs • Must be confirmed with gram stain (gram positive)	• Acid pH: *Enterococcus* and *streptococcus* Spp. • Alkaline pH: *Staphylococcus* spp.	• ↑ Numbers indicate: UTI, cystitis, pyelonephritis, metritis, prostatitis, vaginitis
Bacilli (Fig. 7.17)	• Rods arranged singularly, in chains, or in pairs	• Acid pH: *Escherichia coli* • Alkaline pH: *Proteus* Spp.	• ↑ Numbers indicate: UTI, cystitis, pyelonephritis, metritis, prostatitis, vaginitis

Figure 7.17 Bacteria (rods) found in unstained urine sediment.



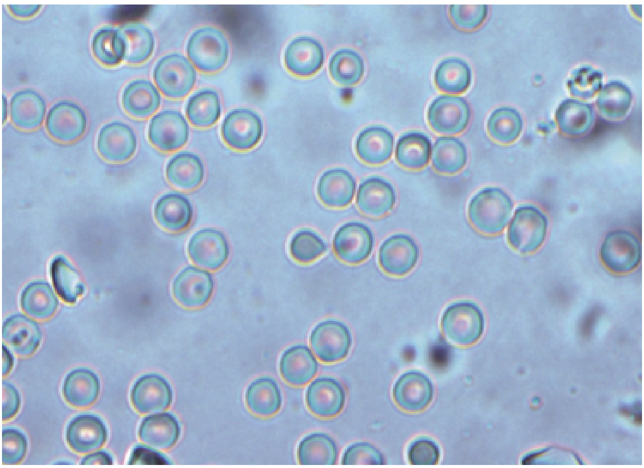
Blood Cells

Blood cells are classified as #/HPF. The presence of red blood cells can be considered a contamination through mode of collection; and, often, catheterization can lead to some inaccurate results due to the mode of collection. White blood cells are always significant, because they typically appear only with some level of a bacterial infection, unless contamination of infected genitalia takes place.

Table 7.18 / Sediment Examination: Blood Cells

Component	Appearance	Definition	Associated Conditions
Red Blood Cells (Fig. 7.18)	• Small, circular • *Unstained:* Pale yellow, transparent spheres • *Stained:* Varying from light pink to deep purple color	• Numbers increase with catheterized samples due to possible trauma during collection.	• ↑ Numbers indicate: Cystitis, neoplasia, calculi, inflammation, necrosis, trauma, bleeding disorder
White Blood Cells	• Round, varying sizes with grainy texture and visible nuclei	• Should always take a careful look for the presence of bacteria when WBCs are found. • Follow up with culture analysis.	• ↑ Numbers indicate: Nephritis, cystitis, pyelonephritis, urethritis, ureteritis

Figure 7.18 Close-up of red blood cells in unstained urine sediment. Notice the biconcave structure of the cells.



Casts

Casts consist of a mucoprotein matrix formed in the lumen of the distal and collecting tubules of the kidneys. They are cylindrical in shape and have parallel sides and round, tapered, or blunt ends. Many factors can affect the delicate morphology of casts, including high-speed centrifugation, refrigeration, extreme pH, and time. (Delayed analysis causes casts to degrade.) The presence of an increased number of casts indicates some form of renal tubular disease. The number of casts does not indicate the severity of the disease, so further diagnostics are needed to determine severity.

Table 7.19 / Sediment Examination: Casts

Component	Appearance	Definition	Associated Conditions
Epithelial Casts	• Nearly transparent, clear, visible renal epithelial cells	• Originate from loop of Henle, distal tubule and collecting tubules • Never seen in normal urine	• ↑ Numbers indicate: Nephrotoxicity, acute renal disease, ischemia, pyelonephritis
Fatty Casts	• Appear as granular cast with fat droplets	• Fat droplets within the cytoplasm of epithelial cells incorporated into a cast	• ↑ Numbers indicate: Diabetes mellitus and renal disease
Granular Casts (Fig. 7.19 and Fig. 7.20)	• Coarse or finely granular	• Composed of mucoprotein, protein, and debris; degenerating cells within renal tubules	• ↑ Numbers indicate: Acute renal disease
Hyaline Casts (Fig. 7.21)	• Semi-transparent with parallel sides and rounded ends	• Mucoprotein cast without incorporated cellular structures	• Occasionally seen • ↑ Numbers indicate: Fever, mild renal disease, general anesthesia, strenuous exercise, renal proteinuria (glomerular disease), tubular damage
RBC/WBC Casts	• Cylindrical casts with cells imbedded in protein matrix • May appear more granular as cells degenerate	• Cylindrical, formed from aggregation of cells • Never observed in normal urine	• Rarely seen • ↑ Numbers indicate: Intrarenal bleeding, infection, trauma, glomerulonephritis, renal tubule inflammation, toxicity, pyelonephritis
Waxy Casts	• Colorless, well defined with parallel sides, blunted ends, and visible cracks	• Final stage of cast degeneration	• ↑ Numbers indicate: Chronic renal disease

Figure 7.19 Granular cast found in unstained urine sediment.

Figure 7.20 Granular cast found in unstained urine sediment.

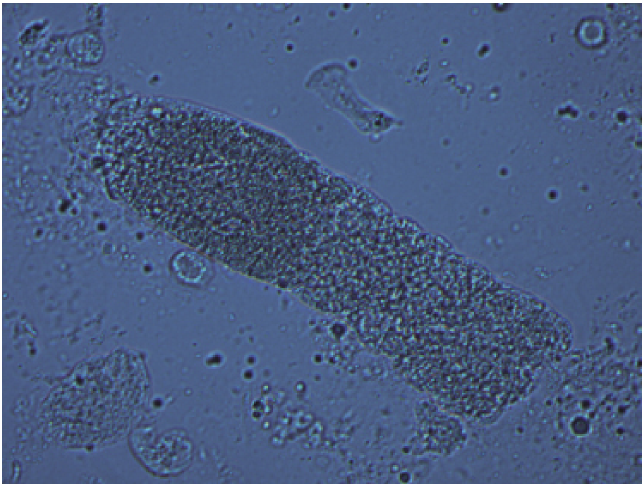
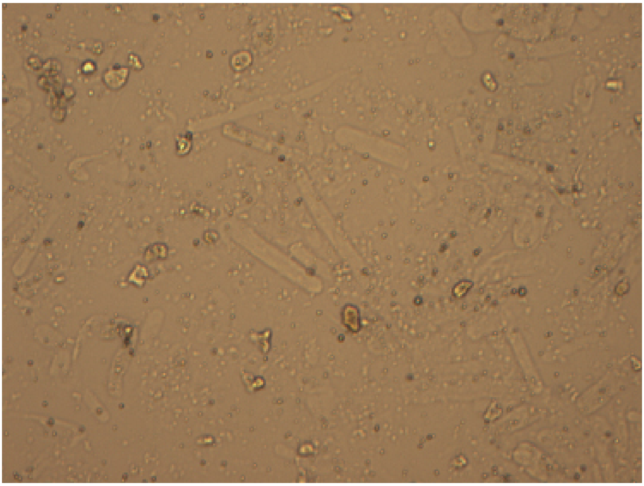


Figure 7.21 Hyaline cast found in unstained urine sediment.



Crystals

The presence of crystals in the urine may or may not be a medical condition. Crystals may form because of sample handling or storage, accumulation of normal urine components, pH concentration, temperature, and solubility.

Urinary stones or uroliths are less common in horses than in small ruminants, but are commonly found in cattle, sheep, and goats. The disease is seen most frequently in adults. Most equine uroliths are composed of calcium carbonate, but struvite uroliths are also occasionally seen. Most uroliths are located in the bladder and cause dysuria, pollakiuria, and hematuria. Although uroliths can be found anywhere within the urinary tract, stones in the urethra are responsible for most clinical problems. Uroliths occur in either sex, but obstruction is seen primarily in males because of anatomic structure. Ruminant urolithiasis is considered primarily a nutritional disease. Ruminants fed high-grain diets with low calcium-to-phosphorus ratio are at increased risk of developing struvite uroliths. The mineral composition of water, along with dietary mineral imbalances, probably contributes to initiating urolith formation. Increased potassium and phosphorus consumption, decreased vitamin A intake, or high silicate intake can lead to crystal and stone formation.

Crystals can be reported as occasional, moderate, or many or by using a 4+ scale.

Table 7.20 / Sediment Examination: Crystals

Component	Appearance	Definition	Associate Condition
Ammonium Biurates (Fig. 7.22)	• Yellow brown thorny spheres or brown bundles resembling wheat sheaves	• Alkaline to weakly acidic	• ↑ Numbers indicate: Liver disease or inability to metabolize ammonia, urate urolithiasis
Ammonium Phosphates	• Tiny crystals with no structure	• Found in alkaline urine, disintegrates at 37°C	• ↑ Numbers indicate: Liver disease or inability to metabolize ammonia
Amorphous Urate	• Tiny crystals with no structure	• Found in acidic urine, disintegrates at 37°C	• ↑ Numbers indicate: Liver disease or inability to metabolize ammonia
Bilirubin (Fig. 7.23 and Fig. 7.24)	• Amber needles or irregular shaped stick-like crystals often seen in clusters	• Found in acidic urine	• Can be a normal finding in horses with no clinical significance • ↑ numbers indicate: high levels of bilirubin in body, liver disease, hemolytic anemia
Calcium Carbonate (Fig. 7.25)	• Large striated yellow brown spheres, or small colorless dumbbells	• Found in alkaline urine	• Can be a normal finding in horses with no clinical significance
Calcium Oxalate (Dihydrate) (Fig. 7.26)	• Square with central cross	• Found in acidic to weakly alkaline urine	• Can be a normal finding in horses on a particular diet • Numbers indicate: Oxalate urolithiasis
Calcium Oxalate (Monohydrate)	• Colorless flat picket fences	• Found in acidic to weakly alkaline urine	• Rarely seen • ↑ Numbers indicate: Antifreeze ingestion, oxalate urolithiasis
Cystine	• 6 sided flat plates	• Found in acidic urine	• ↑ Numbers indicate: Renal tubular disease
Sodium Urate	• Colorless to yellowish blunt ended needles or thin prisms in sheaves or clusters	• Found in acidic urine	• ↑ Numbers indicate: Acute liver disease, phosphorus toxicity
Sulfonamides	• Clear brown sheaves of needles or rosettes	• Found in acidic urine	• ↑ Numbers indicate: Associated with drug therapy
Triple Phosphate (Struvite or Magnesium Ammonium) (Fig. 7.27, Fig. 7.28, and Fig. 7.29)	• 3- to 6-sided colorless prisms	• Found in alkaline to weakly acidic urine	• Rarely seen • ↑ Numbers indicate: Cystitis, struvite urolithiasis or infection
Uric Acid	• Often yellow or red brown • Variable in shape—flat plates, hexagonal, or square plates • Known as the "great imitator"	• Found in acidic urine	• ↑ Numbers indicate: Liver disease

Figure 7.22 Ammonium biurate crystals found in unstained urine sediment.

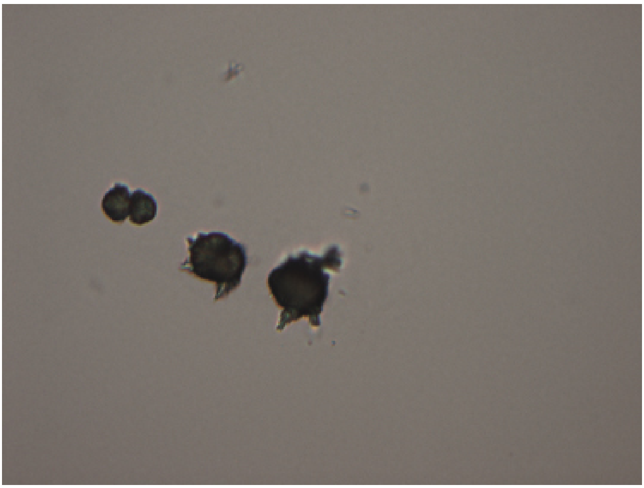


Figure 7.23 Bilirubin crystals found in unstained urine sediment.

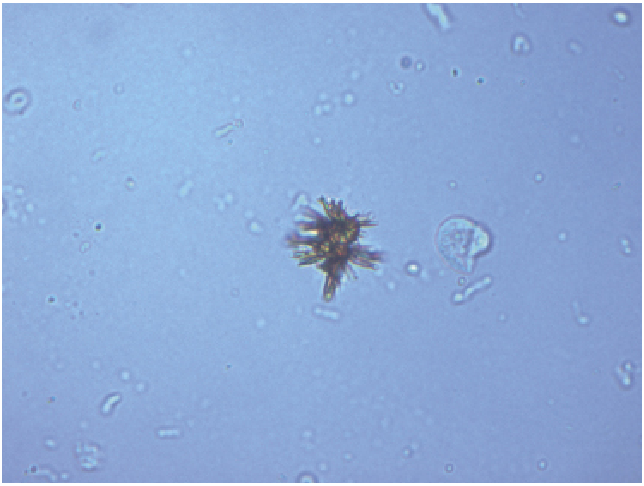


Figure 7.24 Bilirubin crystals found in unstained urine sediment.

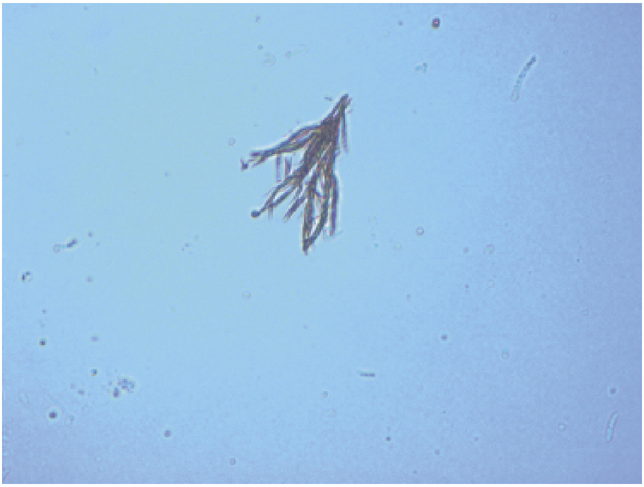


Figure 7.25 Calcium carbonate crystals found in unstained equine urine sediment.

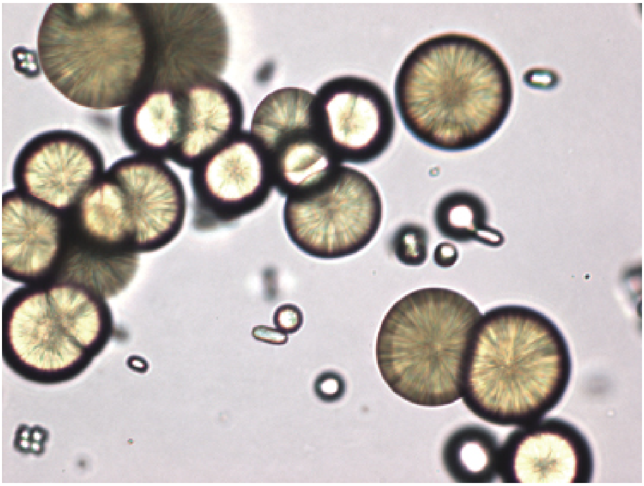


Figure 7.26 Calcium oxalate dihydrate crystal in unstained urine sediment.

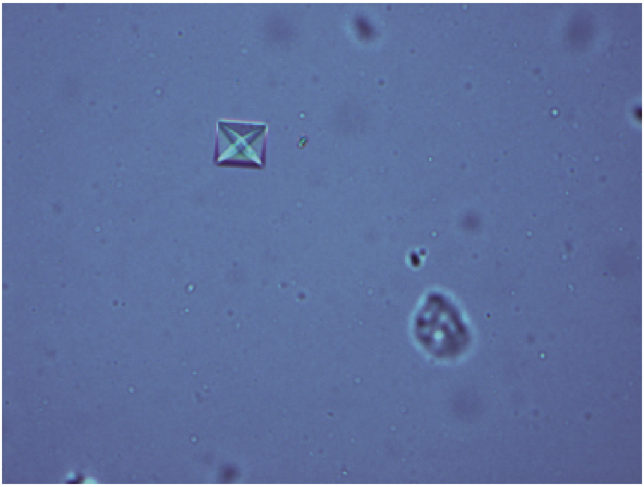


Figure 7.27 Cholesterol crystal in unstained urine sediment.

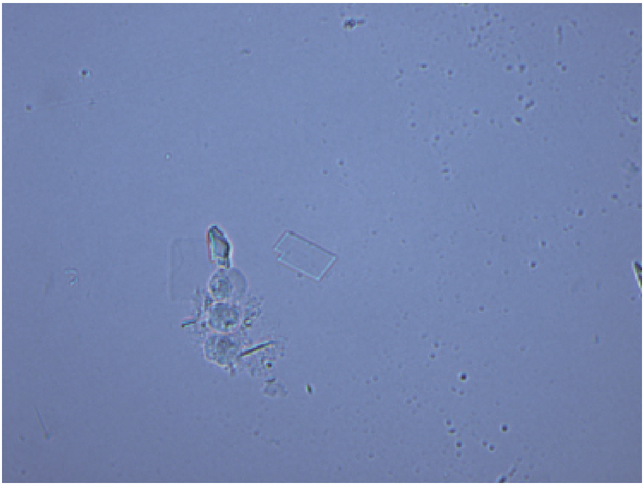


Figure 7.28 Clump of cholesterol crystals in unstained urine sediment.

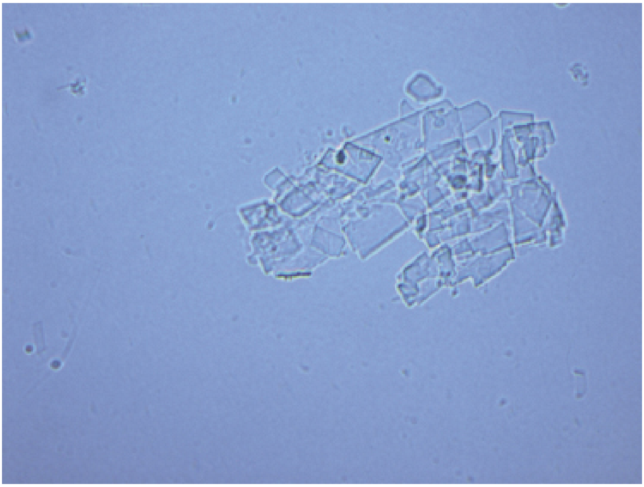
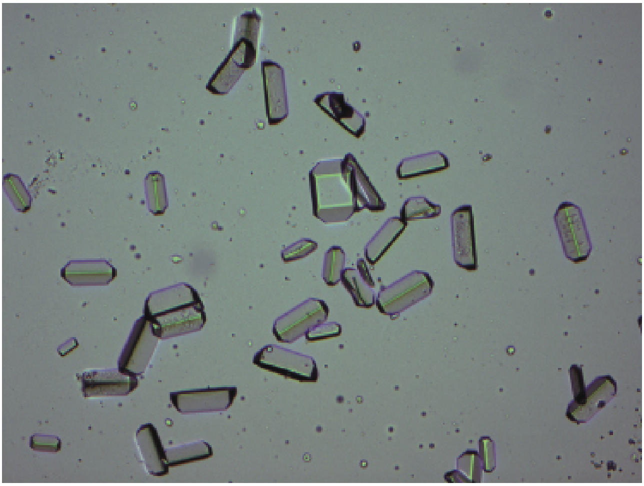


Figure 7.29 Triple phosphate crystals in unstained urine sediment.



Chapter 8

Radiography of the Horse

Sheri Miller

Key Terms and Phrases	Abbreviations
Caudal Cranial Distal Dorsal Lateral Medial Palmar Plantar Proximal Rostral Ventral	CC: Caudal to cranial DLPMO: Dorsolateral to palmar/plantar medial oblique DMPLO: Dorsomedial to palmar/plantar lateral oblique DP: Dorsal to palmar/plantar kVp: Kilovolts peak mA: Milliamperage mAs: Milliamperage per second N/A: Not applicable

Introduction

Radiography is an area of large animal practice where technicians can help to increase the productivity of the veterinarian. Many state practice acts list the exposure and development of radiographs specifically as a duty that can be carried out by technicians. If you are in an environment where it is practical, learning to produce high quality diagnostic radiographs can help to define your value as a member of the veterinary service team.

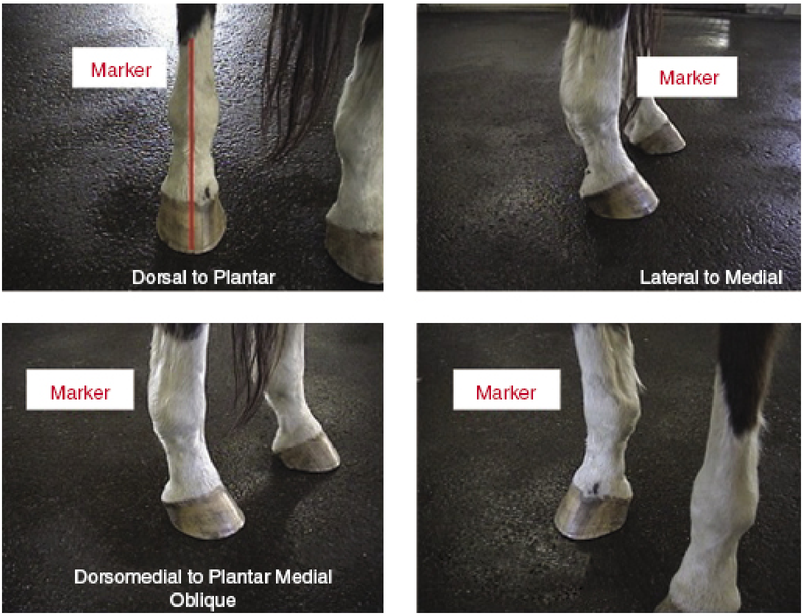
When it comes to large animal radiography, traditionally this service is only utilized in the equine industry. Other large animal species do not routinely have radiographs taken. This may be due to the fact that horses are considered companion animals so owners of horses will seek out these services for their animals. Production animals such as beef cattle and pigs have shorter lifespans due to market weights and animals going to slaughter.

It is essential to have an understanding of the directional terms used to describe the anatomy. These terms are the basis of the titles used to describe the various radiographic views by their correct nomenclature. Dorsal and palmar/plantar, as well as lateral and medial, are used to describe the carpus, tarsus, fetlocks, and feet. Cranial, caudal, lateral, and medial are used to describe the stifle and other joints proximal to the carpus and tarsus. The illustration below shows the axis or the sagittal plane of the fetlock joint and foot. This sagittal plane is the landmark on which we base the positioning of our radiographic markers.

Markers

Right and left markers are essential to identify the limb being radiographed and to provide landmarks from which anatomic orientations of the joints can be understood. A standard method of marking radiographs is important to identify the location of lesions or injury for treatment or for follow-up radiography. Conventional marking for all views, excluding the lateral-to-medial view, is to place the marker lateral to the sagittal plane of the joint. The lateral-to-medial view is labeled with the marker cranial (dorsal) to the joint. Keep in mind that many modern systems will have markers implanted into each particular view, but the plate orientation will affect the position of this marker (Fig. 8.1).

Fig. 8.1 Marker placement for limb radiographs.



Positioning

When exposing radiographs, it is important to remember the purpose. The goal is not simply to expose a view, but to produce images that highlight the areas of the most-common occurrence of injury in each joint. Each view has a specific purpose, and all the views put together provide a comprehensive overview of the joint or region of interest.

To repeatedly obtain any radiographic view, a very important starting point is the positioning of the limbs. For the best images to be acquired, the animal should stand squarely, with each limb perpendicular to the ground and with equal weight bearing on each of the four limbs. With the limbs in this position, standard images can be obtained without distortion or obstruction. Attempting to adjust the primary beam to compensate for angulation of the limb rarely results in high-quality radiographs. When discussing positioning, the following three variables are involved: positioning of the patient, positioning of the imaging plate, and positioning (angulation and elevation) of the radiographic beam.

In this chapter, **angulation** will refer to deviations from cranial to caudal, dorsal to palmar/plantar, and lateral to medial in the coronal plane, around the limb. **Elevation** will refer to deviations from level (parallel with the ground). The angulation and elevation of the radiographic beam is specific to each view and is chosen to image the common sites of injury in the joint of interest. The purpose of exposing a radiograph is to examine specific areas of the joint, not simply to expose a view. Unless indicated otherwise, the imaging plate is positioned in a plane that is perpendicular to the radiographic beam (Fig. 8.2 and Fig. 8.3).

Fig. 8.2 Dorsomedial-to-palmar/plantar lateral oblique (DMPLO) radiograph beam direction.

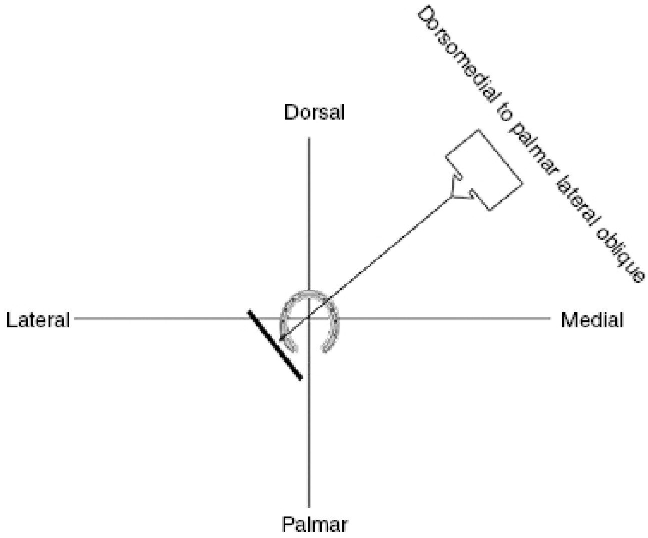
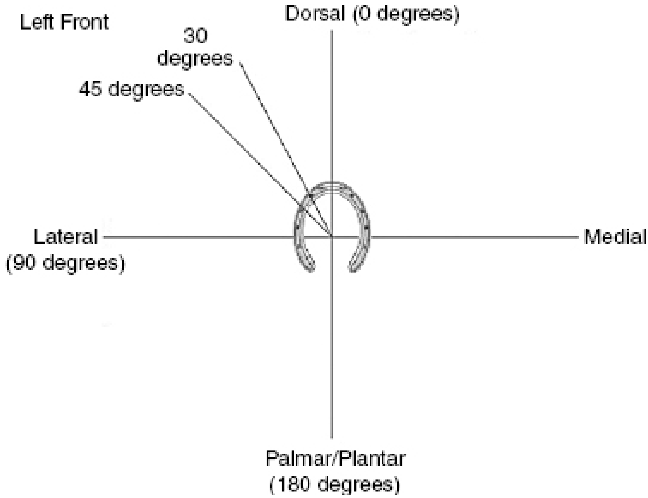


Fig. 8.3 Oblique radiograph positioning direction.



Technique

The current trend in equine radiography is moving toward digital technologies using either computed radiography or direct radiography equipment. The traditional film–screen systems are increasingly being replaced with these new modalities. Technique charts depend on not only the size of the patient but the specific equipment being used. Some of the direct radiography systems in use today come with a suggested technique chart that is not widely varied. Techniques need to be changed less often than with the traditional equipment. It is important to remember that there is no universal technique chart. Charts are created based upon the generator and imaging plate pairing for which they are used.

The variables found on a technique chart are the kilovolts peak (kVp), which determines the penetrating power of the x-rays produced; the milliamperage (mA), which determines the number of x-rays produced; and the time (usually measured in seconds), which determines the length of exposure of the radiographic beam. On certain generators, the mA and time are combined and labeled as mAs.

Radiation Safety

Radiation safety is essential, since it is necessary to have personnel in the room with the patient when exposing equine radiographs. Keeping the number of people in the room to a minimum and collimating the radiographic beam to the smallest dimension necessary to radiograph each particular region are important. Lead aprons, thyroid protectors, and lead gloves should be used at all times. Cassette-holding and positioning devices should be used whenever possible to maximize the distance between the person positioning the cassette and the primary radiographic beam (Fig. 8.4). Monitoring devices, such as dosimeter badges, should also be used to track each person's exposure to ionizing radiation.

Fig. 8.4 Positioning devices should be used to maximize the distance between the person holding the cassette and the beam.

Tranquilization

Horses may be sedated as necessary in order to obtain radiographs without motion and to maintain safe working conditions for all personnel involved.

Foot

When lameness has been isolated to the foot of a horse, the radiographic series needed varies with the use of the horse. A series of five radiographs is routinely taken to assess the third phalanx, the coffin joint, and the navicular bone. Prior to exposing any radiographs, care must be taken to clean the foot of all debris possible. Hoof picks can be used to remove the gross material from the sole and the sulci of the frog. A final cleaning of the sole with a wire brush is a good practice for removal of any remaining small debris such as mud or stone dust. The surface of the hoof wall should also be cleaned as needed. Some publications state that shoe removal is required. We routinely radiograph horses with normal shoes on their feet. Sometimes this requires additional views, but this approach can be substituted for shoe removal in most horses.

Table 8.1 / Foot Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral to Medial (Fig. 8.5)	90	0	• Just above the weight-bearing surface of foot	• Weight bearing (if possible) • Leg perpendicular to the ground and foot placed on wood block
Dorsal to Palmar/Plantar (DP) (Fig. 8.6)	0	0	• Midway between weight-bearing surface and coronary band along sagittal plane of foot	• Weight bearing leg perpendicular to ground and foot placed on wood block
Dorsal to Palmar/Plantar, 65 Degrees (Fig. 8.7 and Fig. 8.8)	65	0	• Coronary band along sagittal plane of foot	• Foot held on positioning device with palmar/plantar surface of foot 65 degrees to ground (Fig. 8.8)
Dorsolateral to Palmar/Plantar Medial Oblique (DLPMO) (Fig. 8.9)	30	0	• Coronary band	• Foot held on positioning device with palmar/plantar surface of foot 65 degrees to ground
Dorsomedial to Palmar/Plantar Lateral Oblique (DMPLO) (Fig. 8.10)	30	0	• Coronary band	• Foot held on positioning device with palmar/plantar surface of foot 65 degrees to ground
Skyline of the Navicular Bone (Fig. 8.11)	180	Follow angle of pastern	• Along sagittal plane of foot, bisecting heel bulbs	• Weight bearing with foot positioned behind the vertical and supported on Plexiglas tunnel

Fig. 8.5 Lateral-to-medial radiograph of the lower limb.

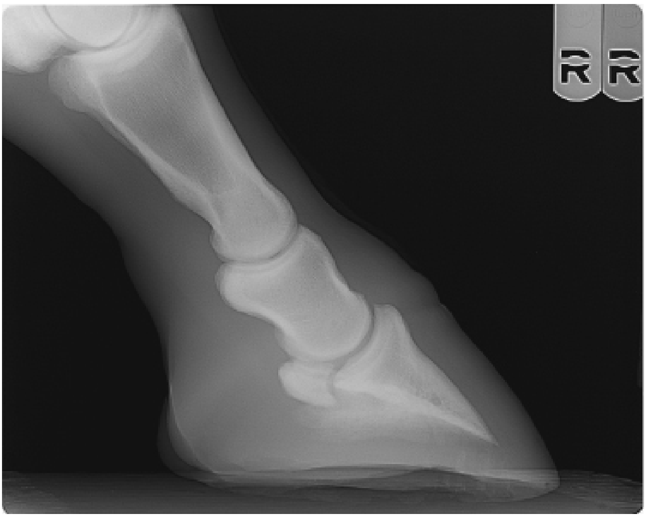


Fig. 8.6 Dorsal-to-palmar/plantar view of the lower limb.

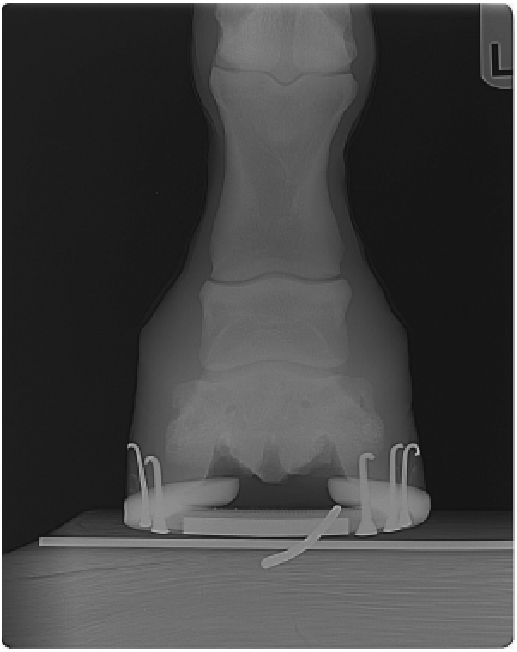


Fig. 8.7 Dorsal-to-palmar/plantar (65-degree) view of the foot.

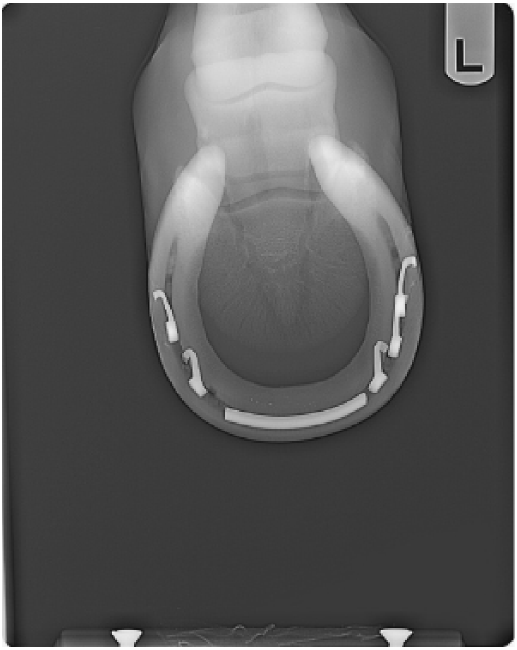


Fig. 8.8 The horse's foot is held in position on the device with the palmar/ plantar surface of the foot at a 65-degree angle to the ground.

Fig. 8.9 Dorsolateral-to-palmar/plantar medial oblique view.

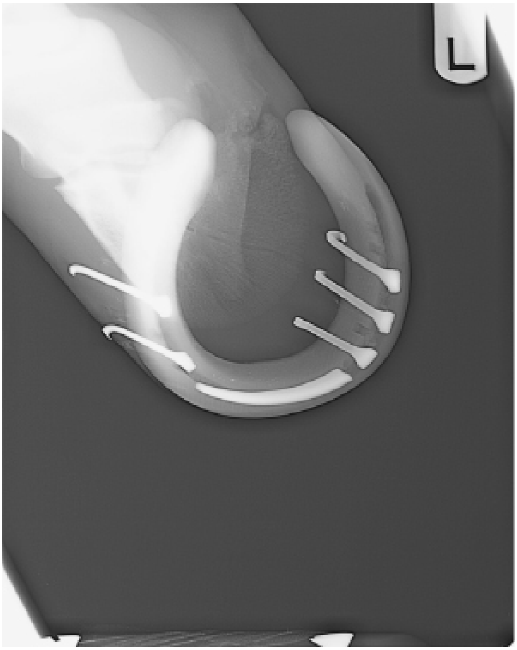


Fig. 8.10 Dorsomedial-to-palmar/plantar lateral oblique view.

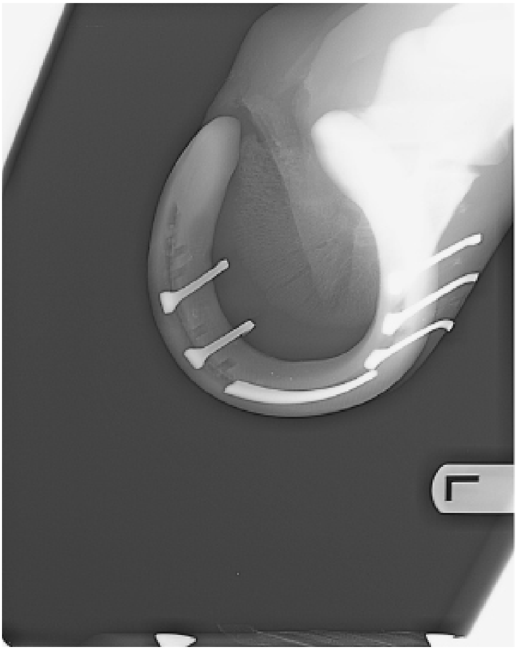
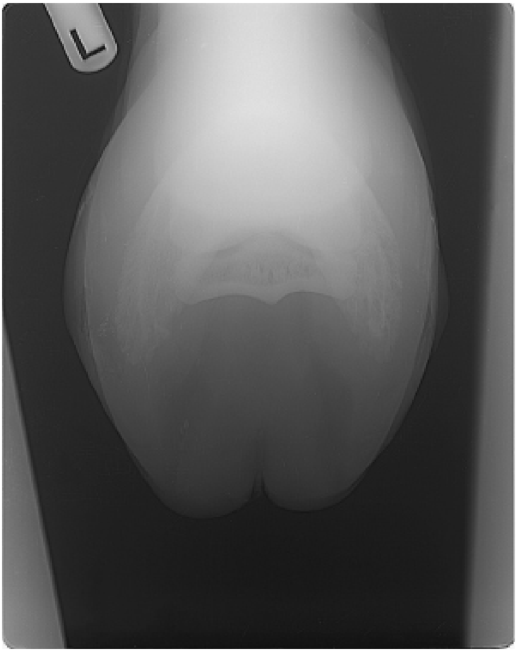


Fig. 8.11 Skyline view of the navicular bone.



Fetlock

Four standing views are generally taken of the fetlock joint, with additional flexed views added to assess problems in horses with specific uses and patterns of injury.

Table 8.2 / Fetlock Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral to Medial (Fig. 8.12)	90	0	• Fetlock joint perpendicular to suspensory ligament	• Leg in weight-bearing position and perpendicular to ground
DP (Fig. 8.13)	0	20 (in forelimb) 30 (in hind limb)	• Fetlock joint along sagittal plane of fetlock	• Leg in weight-bearing position and perpendicular to ground
DLPMO (Fig. 8.14)	30	10	• Fetlock joint	• Leg in weight-bearing position and perpendicular to ground
DMPLO (Fig. 8.15)	30	10	• Fetlock joint	• Leg in weight-bearing position and perpendicular to ground

Fig. 8.12 Lateral-to-medial view of the fetlock joint.

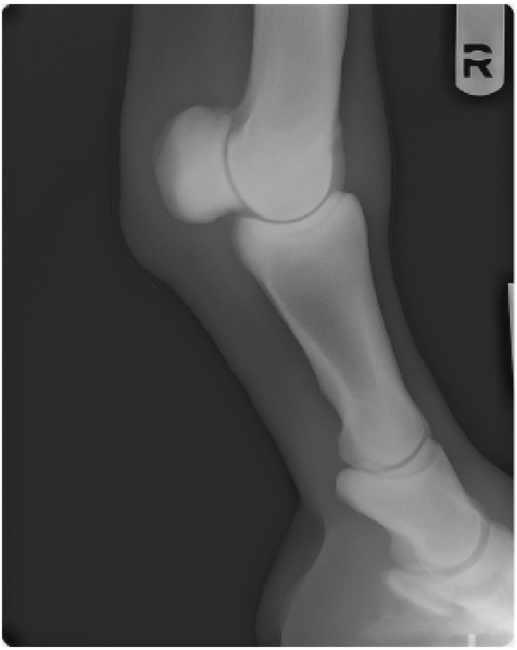


Fig. 8.13 Dorsal-to-palmar/plantar view of the fetlock joint.

Fig. 8.14 Dorsolateral-to-palmar/plantar medial oblique view of the fetlock joint.

Fig. 8.15 Dorsomedial-to-palmar/plantar lateral oblique view of the fetlock joint.

Carpus

Because the carpus has three joints and many articulations between the adjacent bones of each row, it is important to maintain correct limb placement. If horses are allowed to stand with the limb of interest in any position but perpendicular to the floor, it will result in superimposition of bones and joints in areas where unobstructed views are necessary. Therefore, particular attention should be paid to the horse's stance when radiographing the carpus.

Table 8.3 / Carpus Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral to Medial (Fig. 8.16)	90	0	• Middle carpal joint	• Leg in weight-bearing position and perpendicular to ground
DP (Fig. 8.17)	0	0	• Middle carpal joint along sagittal plane of carpus	• Leg in weight-bearing position and perpendicular to ground
DLPMO (Fig. 8.18)	60	0	• Middle carpal joint	• Leg in weight-bearing position and perpendicular to ground
DMPLO (Fig. 8.19)	70	0	• Middle carpal joint	• Leg in weight-bearing position and perpendicular to ground
Flexed Lateral to Medial (Fig. 8.20)	90	0	• Middle carpal joint	• Leg held in flexion with metacarpus directly under radius and in a position where the dorsal aspect of the intermediate carpal bone is positioned perpendicular to the ground (Fig. 8.21)
Skyline of Third Carpal Bone (Fig. 8.22)	0	30–45	• Proximal aspect of third carpal bone along sagittal plane of carpus	• Carpus is flexed maximally so that lower limb contacts forearm. Limb is pushed cranially and held so that cannon bone is parallel to ground. Plate held against proximal dorsal aspect of cannon bone and parallel to ground (Fig. 8.23).

Fig. 8.16 Lateral-to-medial view of the carpus.

Fig. 8.17 Dorsal-to-palmar view of the carpus.

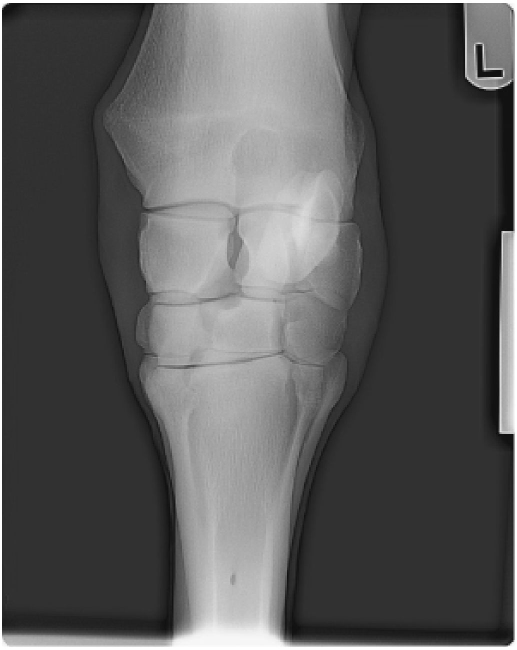


Fig. 8.18 Dorsolateral-to-palmar medial oblique of the carpus.

Fig. 8.19 Dorsomedial-to-palmar lateral oblique of the carpus.

Fig. 8.20 Flexed lateral-to-medial view of the carpus.

Fig. 8.21 The leg is held in flexion with the metacarpus directly under the radius.

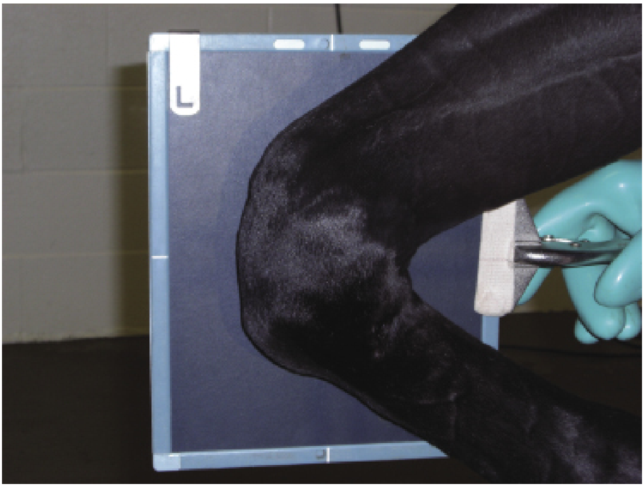


Fig. 8.22 Skyline line view of the third carpal bone.

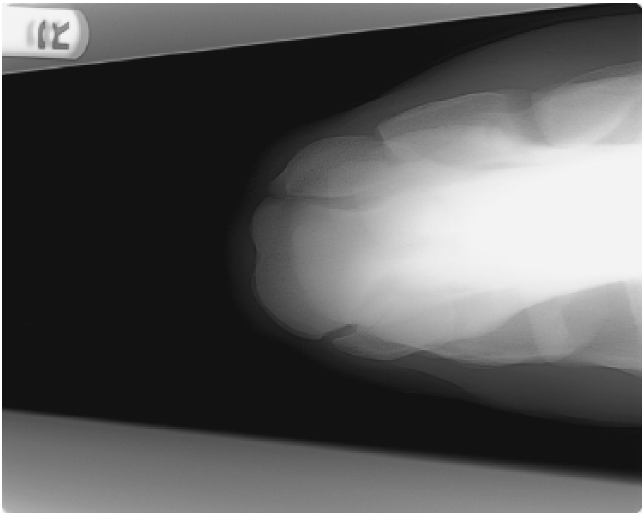
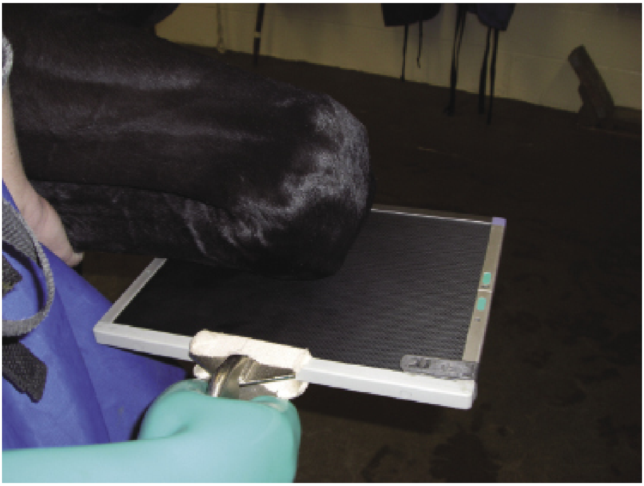


Fig. 8.23 The limb is pushed cranially and held so the cannon bone is parallel to the ground.



Tarsus

One important point to remember when radiographing a horse's tarsi is that horses generally rotate out in the hind limbs. Angles described in the table below are in relation to a sagittal plane that bisects the tarsus, not in relation to the horse's spine.

Table 8.4 / Tarsus Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral to Medial (Fig. 8.24)	90	0	• Proximal intertarsal joint	• Leg in weight-bearing position and perpendicular to ground
DP (Fig. 8.25)	0	0	• Proximal intertarsal joint	• Leg in weight-bearing position and perpendicular to ground
DLPMO (Fig. 8.26)	45	0	• Proximal intertarsal joint	• Leg in weight-bearing position and perpendicular to ground
DMPLO (Fig. 8.27)	45	0	• Proximal intertarsal joint	• Leg in weight-bearing position and perpendicular to ground

Fig. 8.24 Lateral-to-medial view of the tarsus.

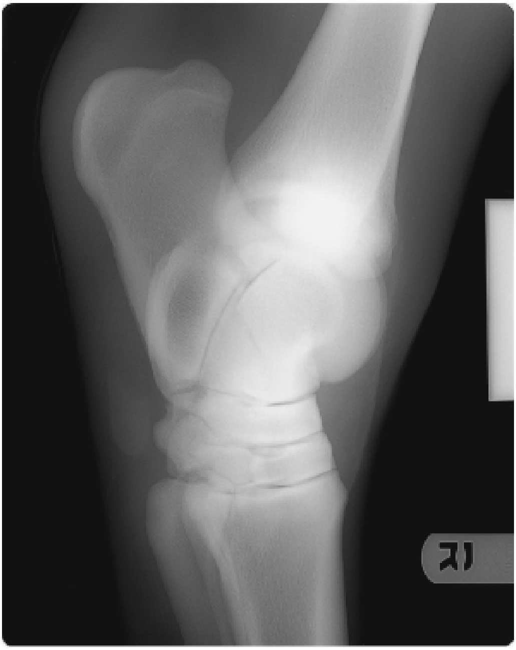


Fig. 8.25 Dorsal-to-plantar view of the tarsus.

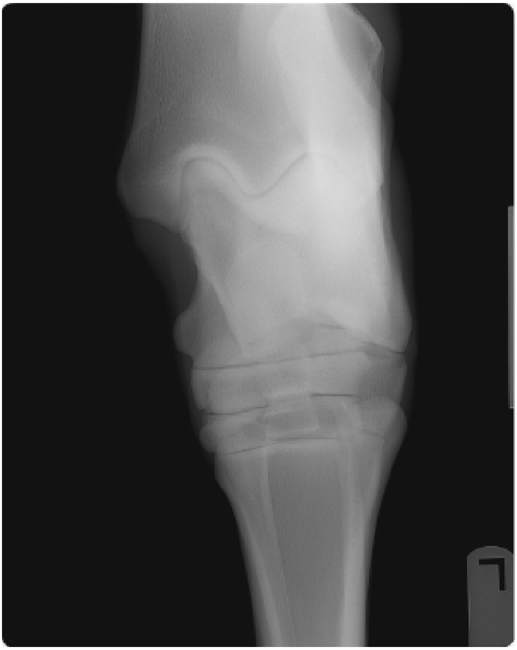


Fig. 8.26 Dorsolateral-to-plantar medial oblique view of the tarsus.

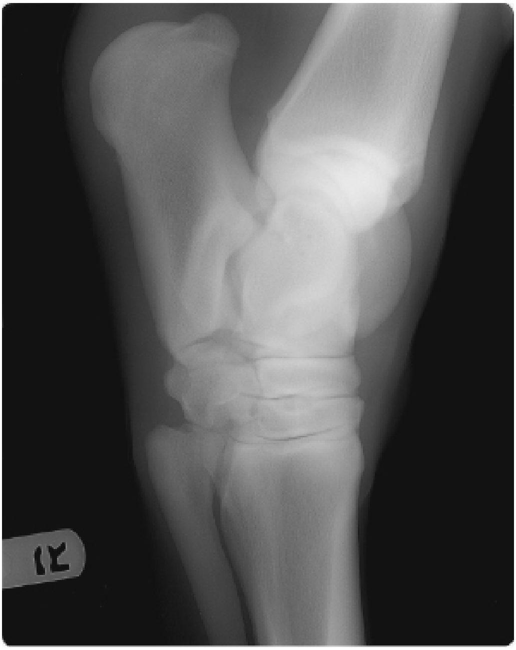
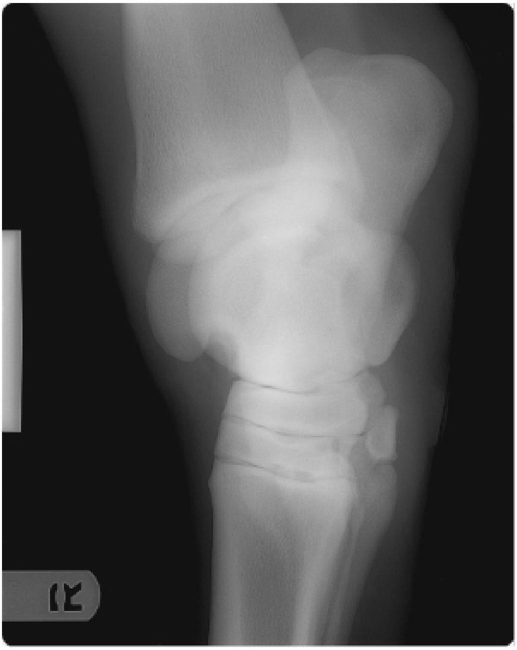


Fig. 8.27 Dorsomedial-to-plantar lateral oblique view of the tarsus.



Stifle

The stifle is evaluated with 3–4 views depending on the use and age of the horse. For well-positioned radiographs to be most easily obtained, the hind limb should be perpendicular to the ground and slightly caudal to the opposite limb in order to facilitate plate placement in the groin. Full weight bearing on the limb being radiographed is necessary for the standing views. Extra caution should be exercised when radiographing the stifles, as horses often object to the plate contacting the flank even when they have tolerated other joints being radiographed without incident.

Table 8.5 / Stifle Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral to Medial (Fig. 8.28)	90	0	• Femorotibial joint (just proximal to top of tibia)	• Leg in weight-bearing stance, perpendicular to ground and slightly caudal to opposite limb to facilitate plate placement • Plate is positioned against medial aspect of stifle with the top of the plate touching the abdominal wall.
Caudal to Cranial (CC) (Fig. 8.29)	180	Perpendicular to tibia	• Femorotibial joint	• Leg in weight-bearing stance, perpendicular to ground
Caudolateral to Craniomedial Oblique (Fig. 8.30)	30	10	• Femorotibial joint	• Leg in weight-bearing stance, perpendicular to ground

Fig. 8.28 Lateral-to-medial view of the stifle.

Fig. 8.29 Caudal-to-cranial view of the stifle.

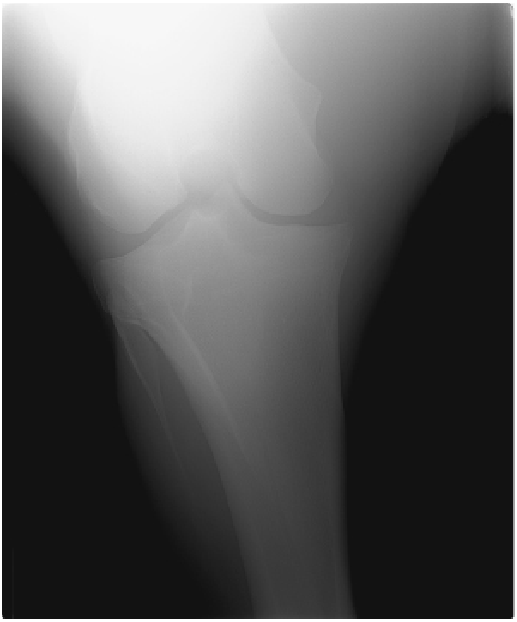
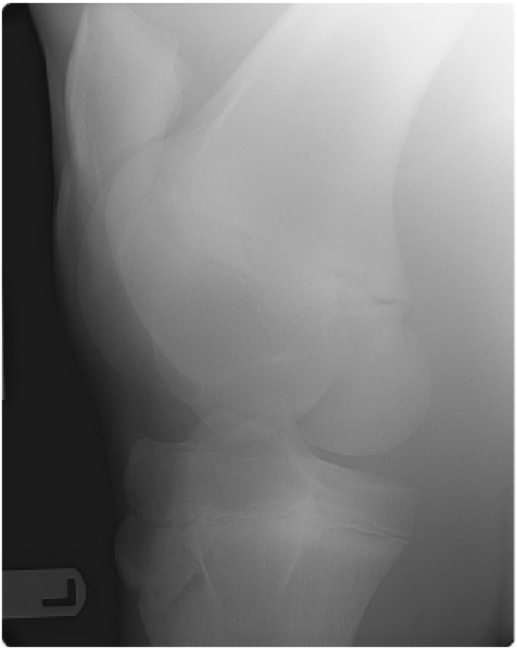


Fig. 8.30 Caudolateral-to-craniomedial oblique view of the stifle.



Elbow

Two views are generally taken to evaluate the elbow joint. For the medial-to-lateral view, the limb is picked up and pulled forward to extend the limb as far cranial as possible. This allows imaging of the elbow joint without superimposition of the body wall. The cassette is placed against the lateral aspect of the limb, and the beam originates medial to the elbow. A cranial-to-caudal view is exposed with the horse in a standing position as described below.

Table 8.6 / Elbow Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Medial to Lateral (Fig. 8.31)	90	0	• Elbow joint	• Leg held in flexed and extended position and pulled cranially • A grid should be used, if available.
Cranial to Caudal (Fig. 8.32)	0	Perpendicular to radius	• Elbow joint	• Leg placed slightly lateral and cranial to vertical

Fig. 8.31 Medial-to-lateral view of the elbow joint.

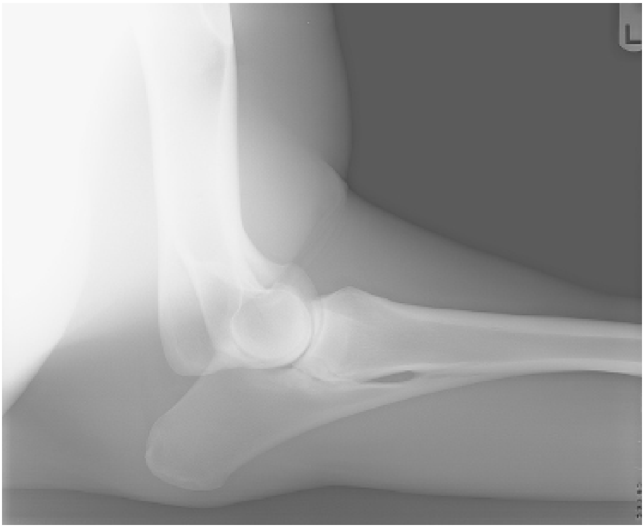


Fig. 8.32 Cranial-to-caudal view of the elbow joint.

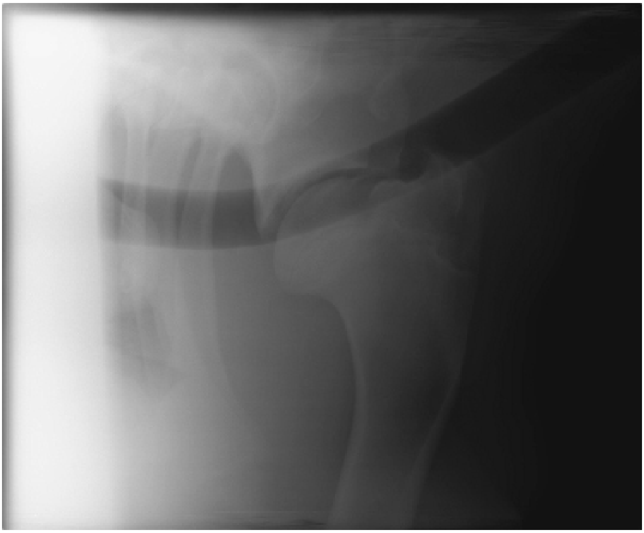
Shoulder

A medial-to-lateral radiograph of the shoulder can generally be obtained with the horse in a standing position with the limb of interest extended cranially and downward. This positioning allows the radiographic beam to be centered on the shoulder joint of interest without superimposition of the opposite shoulder joint.

Table 8.7 / Shoulder Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Medial to Lateral (Fig. 8.33)	90	0 degrees	• Center over trachea just cranial to point of shoulder.	• Leg extended cranially and downward • Leg holder should grasp leg above carpus to provide stability. • A grid should be used, if available.

Fig. 8.33 Medial-to-lateral view of the shoulder.



Radius

If large (14-inch by 17-inch) imaging plates are available, four standing views are sufficient to evaluate the radius. Depending on the size of the horse, more views may be necessary if taken on smaller plates.

Table 8.8 / Radius Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral to Medial (Fig. 8.34)	90	0	• Mid forearm	• Leg in weight-bearing position and perpendicular to ground
Cranial to Caudal (Fig. 8.35)	0	0	• Mid forearm	• Leg in weight-bearing position and perpendicular to ground
Craniolateral to Caudomedial Oblique (Fig. 8.36)	30	0	• Mid forearm	• Leg in weight-bearing position and perpendicular to ground
Craniomedial to Caudolateral Oblique (Fig. 8.37)	30	0	• Mid forearm	• Leg in weight-bearing position and perpendicular to ground

Fig. 8.34 Lateral-to-medial view of the radius.

Fig. 8.35 Cranial-to-caudal view of the radius.

Fig. 8.36 Craniolateral-to-caudomedial oblique view of the radius.

Fig. 8.37 Craniomedial-to-caudolateral oblique view of the radius.

Tibia

The tibia can be imaged in four views if large imaging plates are available. If smaller plates are used, more views may be required to expose the entire tibia.

Table 8.9 / Tibia Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral to Medial (Fig. 8.38)	90	0	• Mid tibia	• Leg in weight-bearing position and perpendicular to ground
Caudal to Cranial (Fig. 8.39)	180	Perpendicular to tibia	• Mid tibia	• Leg in weight-bearing position and perpendicular to ground
Caudolateral to Craniomedial Oblique (Fig. 8.40)	45	0	• Mid tibia	• Leg in weight-bearing position and perpendicular to ground
Caudomedial to Craniolateral Oblique (Fig. 8.41)	45	0	• Mid tibia	• Leg in weight-bearing position and perpendicular to ground

Fig. 8.38 Lateral-to-medial view of the tibia.

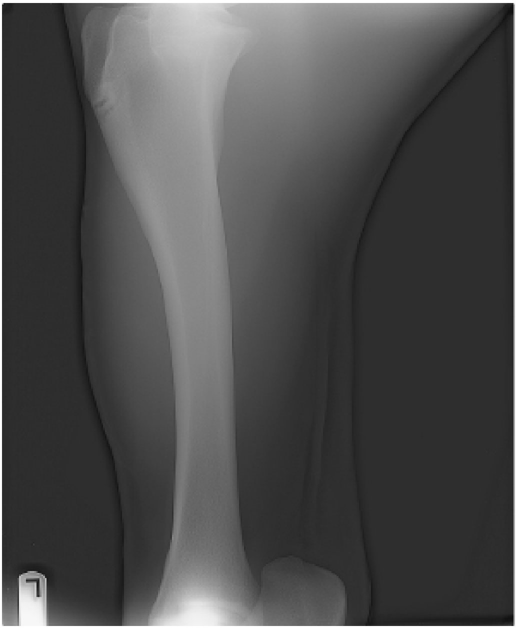
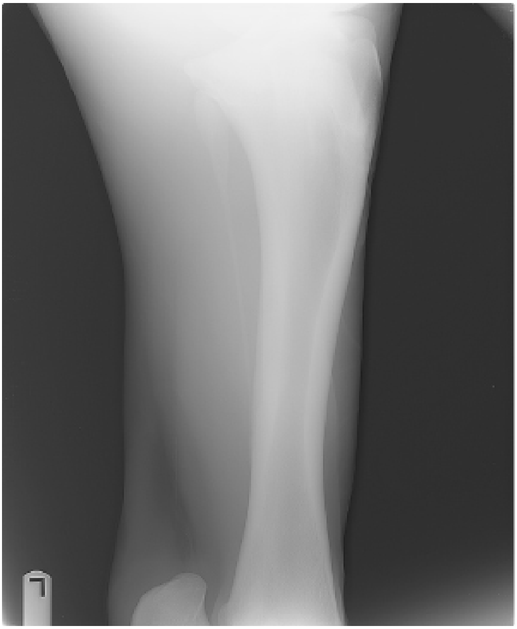


Fig. 8.39 Caudal-to-cranial view of the tibia.

Fig. 8.40 Caudolateral-to-craniomedial oblique view of the tibia.

Fig. 8.41 Caudomedial-to-craniolateral oblique view of the tibia.



Metacarpus (MCIII)/ Metatarsus (MTIII)

The metacarpus and metatarsus series includes four standard views. The two oblique views are useful not only to evaluate MCIII or MTIII, but they also should profile the medial and lateral splint bones (MCII and MCIV or MTII and MTIV) away from the cannon bones.

Table 8.10 / Metacarpus/Metatarsus Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Dorsal to Palmar/Plantar (DP) (Fig. 8.42A)	0	0	Mid shin	Leg in weight-bearing position and perpendicular to ground
Lateral to Medial (Fig. 8.42B)	90	0	Mid shin	Leg in weight-bearing position and perpendicular to ground
DLPMO (Fig. 8.43A)	30	0	Mid shin	Leg in weight-bearing position and perpendicular to ground
DMPLO (Fig. 8.43B)	30	0	Mid shin	Leg in weight-bearing position and perpendicular to ground

Fig. 8.42 (A) Dorsal-to-palmar view of the metacarpus. (B) Lateral-to-medial view of the metacarpus.

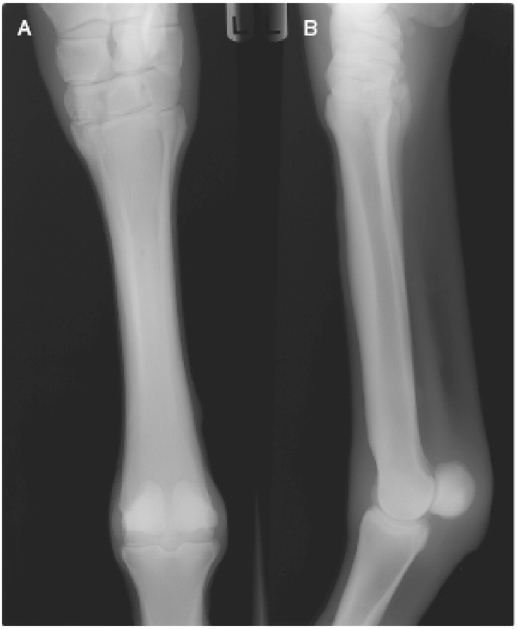
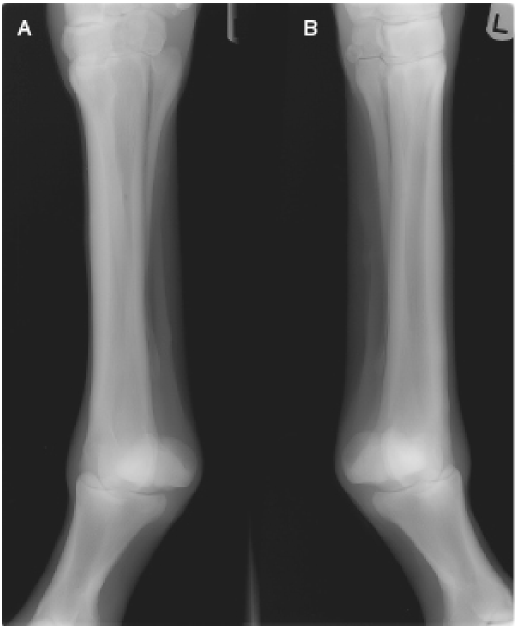


Fig. 8.43 (A) Dorsolateral-to-palmar/plantar medial oblique view. (B) Dorsomedial-to-palmar/plantar lateral oblique view.



Cervical Spine

Multiple images must be taken to evaluate the cervical spine of an adult horse. Table 8.11 describes three views using a 14-inch by 17-inch imaging plate, a cassette-holding system, and a grid. Plates can be handheld if this equipment is not available, but this system allows for a directly perpendicular relationship between the radiographic beam and the imaging plate, which is essential when using a grid. It also reduces possible motion of the plate and the number of people necessary to obtain the image.

It is important to remember that the cervical spine is located in the ventral portion of the neck and that the radiographic beam should be centered appropriately. When radiographing the cervical spine, it is essential to obtain true lateral projections. The dorsal spinous processes and thoracic, lumbar, sacral, and coccygeal vertebrae can be imaged radiographically by using the equipment described and by centering the radiographic beam over the appropriate area of interest.

Table 8.11 / Cervical Spine Radiography

View	Angulation (Degrees)	Elevation (Degree)	Beam Center	Positioning
Cranial (Fig. 8.44)	90	0	• C2	• Patient should be standing squarely with straight alignment of the spine from head to tail (Fig. 8.45). • A grid should be used if available.
Middle (Fig. 8.46)	90	0	• Mid way between ear and shoulder on spine	• Patient should be standing squarely with straight alignment of the spine from head to tail. • A grid should be used if available (Fig. 8.45).
Caudal (Fig. 8.47)	90	0	• Just cranial to point of shoulder	• Patient should be standing squarely with straight alignment of the spine from head to tail. • A grid should be used if available (Fig. 8.45).

Fig. 8.44 Cranial view of the cervical spine.

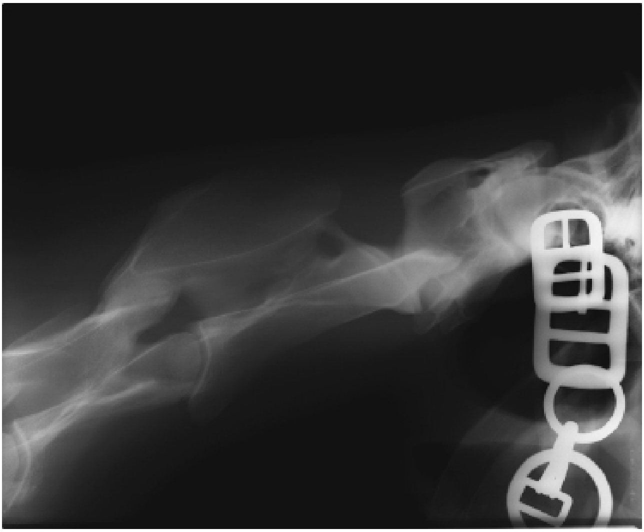


Fig. 8.45 Patient should be standing squarely with straight alignment of the spine.

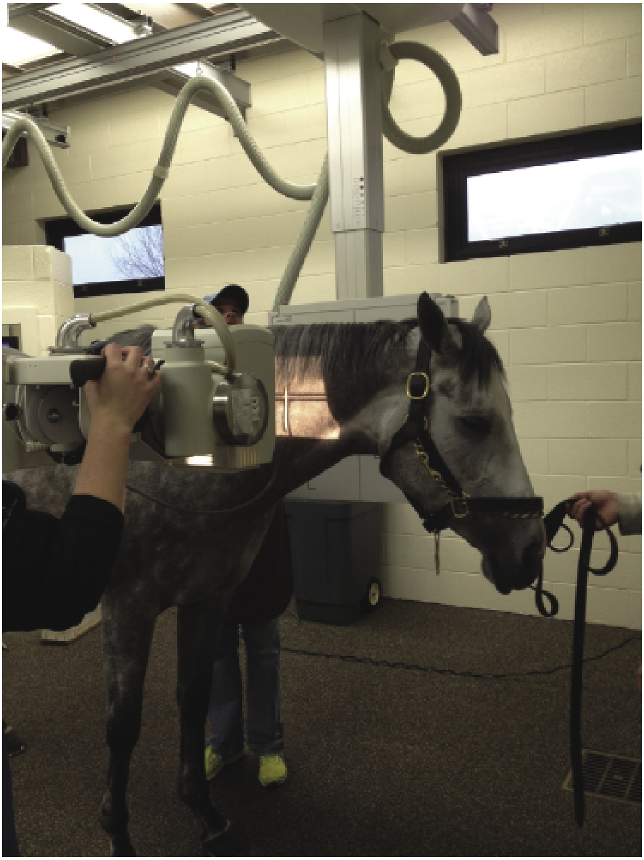


Fig. 8.46 Middle view of the cervical spine.

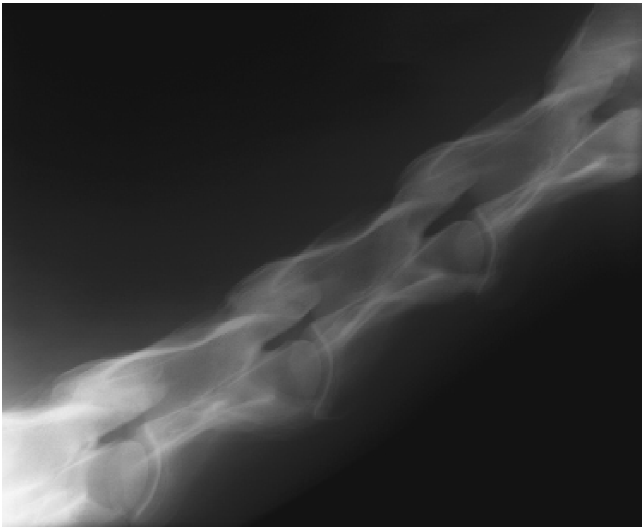
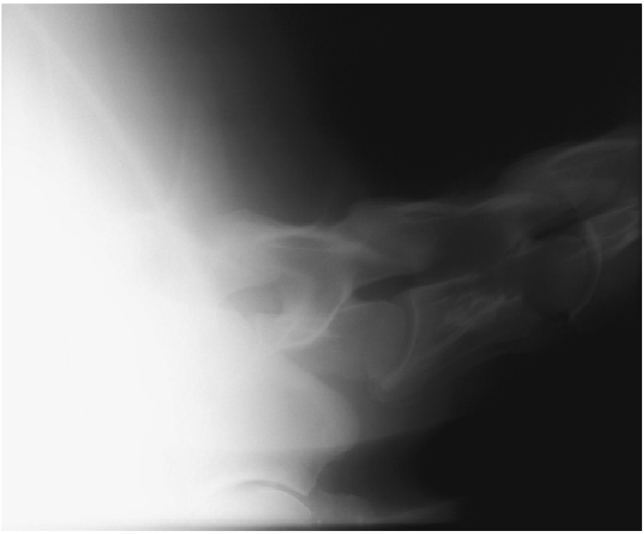


Fig. 8.47 Caudal view of the cervical spine.



Thorax

The high exposure levels required to image the thorax of an adult horse require the use of special equipment. A cassette holder with a grid and a high output generator are used to produce diagnostic quality images of the thorax. Four views are taken on 14-inch by 17-inch imaging plates for a complete series. Timing the exposure to coincide with full inspiration is optimal. A foal's thorax can often be imaged either in a standing position or in lateral recumbency with 1–2 views and lower output equipment.

Table 8.12 / Thorax Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Caudodorsal (Fig. 8.48)	90	0	• Back edge of imaging plate even with horse's last rib • Top of plate in line with top of rib cage • Center beam to plate.	• Exposure taken on full inspiration
Caudoventral (Fig. 8.49)	90	0	• Beam center is just caudal to and in line with elbow joint.	• Exposure taken on full inspiration
Craniodorsal (Fig. 8.50)	90	0	• Plate lowered approximately 1 inch from caudodorsal position and moved cranially	• Exposure taken on full inspiration
Cranioventral (Fig. 8.51)	90	0	• Front edge of imaging plate even with point of shoulder at same level as caudoventral positioning	• Forelimbs must be perpendicular to the ground.

Fig. 8.48 Caudodorsal view of the thorax.

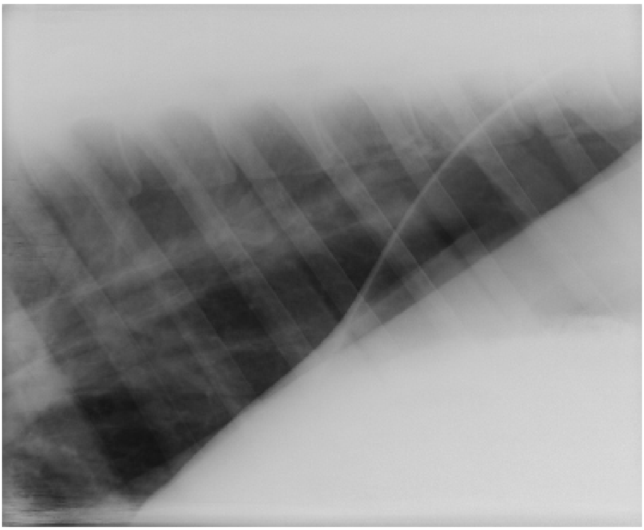


Fig. 8.49 Caudoventral view of the thorax.

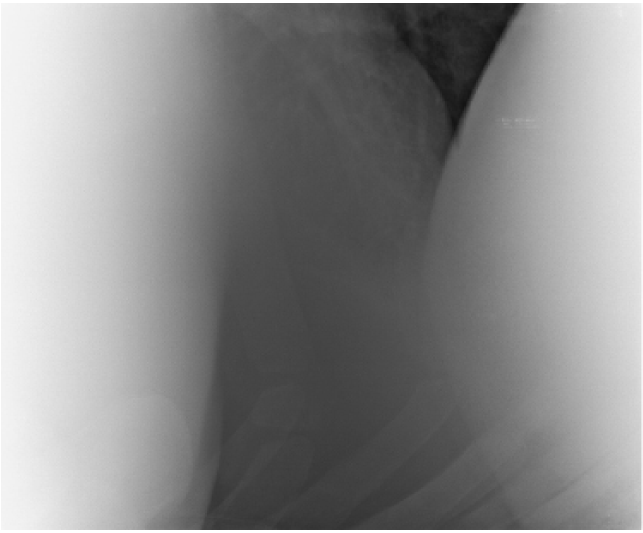


Fig. 8.50 Craniodorsal view of the thorax.

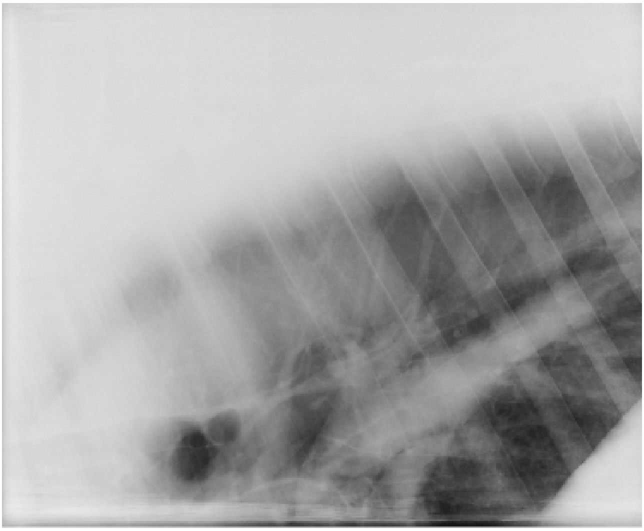
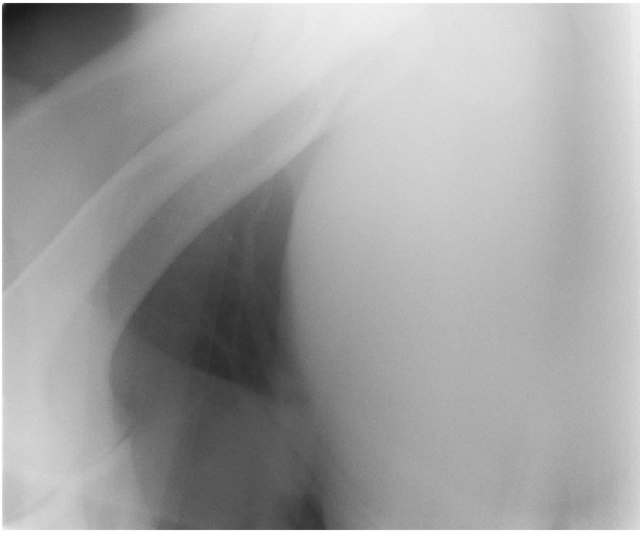


Fig. 8.51 Cranioventral view of the thorax.



Pelvis

Radiography of the pelvis requires general anesthesia and a high output x-ray generator. A grid is also necessary to control scatter radiation because of the thickness of the area of interest. A sheet of lead under the imaging plate is recommended to reduce back scatter. The horse is rolled from lateral-to-dorsal recumbency into a position with the horse's hips resting on the imaging plate. A cassette tunnel is helpful to reduce the weight-bearing load on the plate. The horse is supported near the front limbs and chest region, but allowed to come to rest in a “frog leg” position in the hind. The caudal spine of the horse should be kept in a straight line. Good quality standing lateral views are only possible in foals or small horses.

Table 8.13 / Pelvis Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Ventral to Dorsal (Fig. 8.52)	• N/A	90 (to ground)	• Linea alba	• Patient under general anesthesia in dorsal recumbency (Fig. 8.53). • Rear limbs in symmetrical "frog-leg" position • Three views are taken, starting with back edge of cassette even with caudal-most aspect of horse. Then move cassette cranial approximately 3–4 inches respectively for each of the other 2 views.
Ventral to Dorsal Oblique (Fig. 8.54)	• N/A	90 (to ground)	• 3 inches left or right of linea alba (over coxofemoral joint for first view)	• Patient rolled left or right 10–15 degrees so that the side of interest is nearest the imaging plate. • For second view, move cassette cranial approximately 3–4 inches.

Fig. 8.52 Ventral-to-dorsal view of the pelvis.

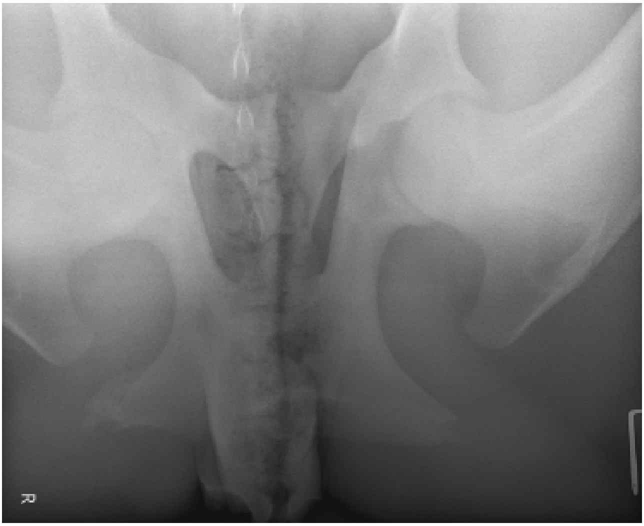
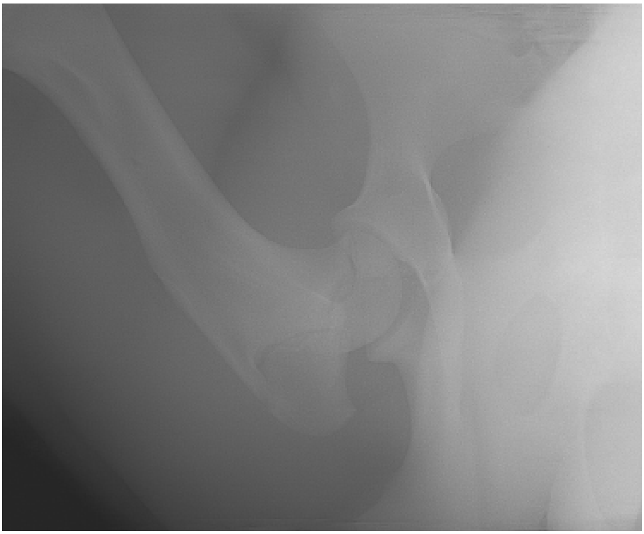


Fig. 8.53 Patient under general anesthesia in a dorsal recumbent position with the rear limbs in a symmetrical "frog leg" position.

Fig. 8.54 Ventral-to-dorsal oblique view of the pelvis.



Skull

A rope halter should be used temporarily in place of a regular halter when radiographing the head of a horse. The metal buckles often found on traditional halters can obstruct important areas on skull radiographs. With the horse in a standing position, the head is held in a relaxed position without rotation. The cassette is placed against the side of the head where the area of interest is located. Oblique views are often exposed to isolate the dental arcades.

Guttural Pouch/Larynx/Pharynx

The pharyngeal region can be imaged in the same manner as the skull, but with the beam centered between the base of the ear and the angle of the mandible.

Table 8.14 / Skull Radiography

View	Angulation (Degrees)	Elevation (Degrees)	Beam Center	Positioning
Lateral of Skull (Fig. 8.55)	90	0	• Over area of interest	• Head is positioned so that there is no rotation.
Dorsal to Ventral (Fig. 8.56)	0	Perpendicular to cassette	• Over area of interest	• Head is positioned as low as possible, and the imaging plate is placed against the ventral aspect under the mandible.
Oblique of Maxillary Teeth	90	30	• Over area of interest	• Imaging plate placed against side of interest
Oblique of Mandibular Teeth	90	45 (ventral to dorsal; angle up)	• Over area of interest	• Imaging plate placed against side of interest
Lateral of Pharyngeal Region (Fig. 8.57)	90	0	• Just caudal to ramus of mandible	• Head is positioned so that there is no rotation.

Fig. 8.55 Lateral view of the skull.

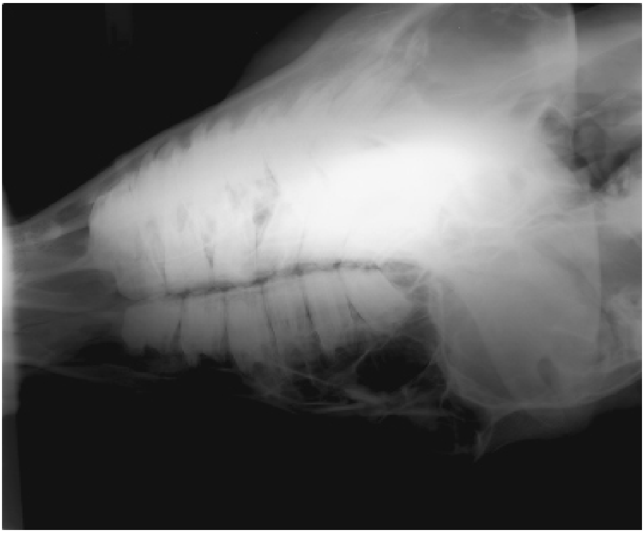
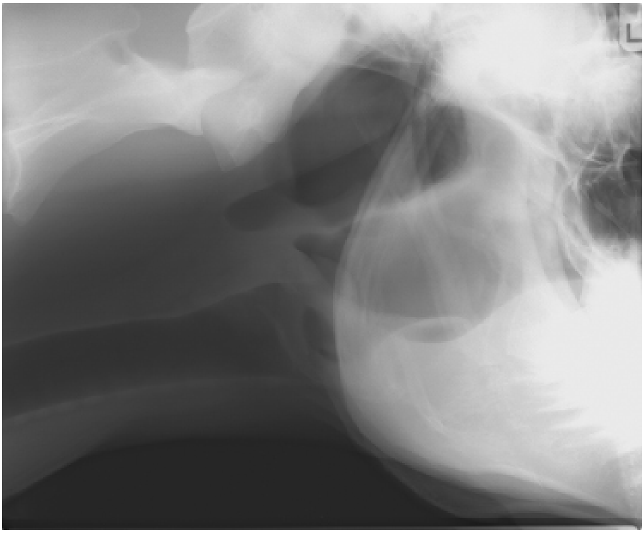


Fig. 8.56 Dorsal-to-ventral view of the skull.

Fig. 8.57 Lateral view of the pharyngeal region.



Chapter 9

Pharmacology

Patrick Hennigan

Key Words and Phrases		Abbreviations	
Adulticide agonist	Hypochloremia	ACE: Angiotensin-converting enzyme	KBr: Potassium bromide
Alopecia	Hypokalemia	aPTT: Activated partial thromboplastin time	KCS: Keratoconjunctivitis sicca
Antagonist	Hyponatremia	ARF: Acute renal failure	L: Liter
Antipruritic	Idiosyncratic	AV: Atrioventricular	LOX: 5-lipoxygenase
Anuria	Intracellular	BP: Blood pressure	LRS: Lactated Ringer's solution
Aqueous humor	Keratin	BW: Body weight	MAOI: Monoamine oxidase inhibitor
Ascites	Keratolytic	C: Concentration	mg: Milligram
Azotemia	Keratoplastic	CBC: Complete blood count	ml: Milliliter
Bactericidal microfilaria	Leukopenia	CHF: Congestive heart failure	N/A: Not applicable
Bacteriostatic	Mesothelioma	CNS: Central nervous system	NSAID: Nonsteroidal antiinflammatory drug
Candidiasis	Microfilaria	COX: Cyclooxygenase	PCV: Packed cell volume
Chemoreceptor trigger zone	Miosis	DDAVP: Desmopressin	PD: Polydipsia
Cholestasis	Mydriasis	DES: Diethylstilbestrol	pH: Potential of hydrogen
Cholinergic	Myelosuppressive	Dic: Disseminated intravascular coagulation	PP: Polyphagia
Concentration	Nephrocalcinosis	DNA: Deoxyribonucleic acid	PSGAG: Polysulfated glycosamine-glycans
COX-2	Neuropathy	DOCA: Desoxycorticosterone acetate	PT: Prothrombin time
Dermatophytosis	Oliguria	DOCP: Desoxycorticosterone pivalate	PU: Polyuria
Diuretics	Ototoxicity	ECG: Electrocardiogram	PZI: Protamine zinc
Dosage	Perivascular	FSH: Follicle stimulating hormone	qod: Every other day
Dose	Peroxidase	G-: Gram negative	RBC: Red blood cell
Edrophonium	Phospholipase	G+: Gram positive	RNA: Ribonucleic acid
Emetic	Polycythemia	GABA: Gamma-aminobutyric acid	SA: Sinoatrial
Ergosterol	Polydipsia	GIT: Gastrointestinal tract	SAMe: S-adenosylmethionine
Erythema	Polyphagia	HCl: Hydrogen chloride	SQ: Subcutaneous
Fungicide	Seborrheic	HPA: Hypothalamic-pituitary-adrenal	SSRI: Selective serotonin reuptake inhibitor
Fungistatic	Tachypnea	IHSS: Idiopathic hypertrophic subaortic stenosis	T_3: Triiodothyronine
Hematopoietic	Teratogenic	IM: Intramuscular	Tx: Treatment
Hyperkalemia	Tetany	INR: Partial thromboplastin time	UTI: Urinary tract infection
Hyperkeratotic	Thrombocytopenia	IOP: Intraocular pressure	V: Volume
Hyperphosphatemia		IV: Intravenous	vWF: von Willebrand's factor

Introduction

All drugs are prescribed by a licensed veterinarian; but, in most cases, they are administered by the veterinary technician or technologist. An understanding of the mechanisms of actions, drug interactions, indications, and contraindications of the drugs is essential. This chapter provides pertinent information for the veterinary technician. A veterinary drug handbook or formulary must be on hand for consultation regarding side effects and interactions, as well as doses. Drugs discussed in this chapter may be kept at room temperature, unless otherwise indicated.

Note: Pharmaceuticals are used in many species. Many drugs are used as off-label use or extra-label use and have different withdrawal times, while some drugs are used only in approved species. The attending DVM needs to give the appropriate dose and approve the off label-use, extra-label use, and withdrawal times.

Skills Box 9.1 / Basic Calculations

Type of Calculation	**Equation**	**Example**

Dosage Calculation	$$\text{Dose(ml)} = \frac{\text{Body weight} \times \text{Dosage(mg/kg)}}{\text{Drug concentration}}$$	A 560-kg horse requires 6.6 mg/kg of Strongid T (50mg/ml): D = (560 kg × 6.6 mg/kg)/(50 mg/ml) D = (3696 mg)/(50 mg/ml) D = 73.92 ml Give 74 ml (3700 mg).
Solutions (Denoted by Their Strength's Ratio or Percentage) 5% denotes 5 g of solute in 100 ml of solution 1:5 ratio denotes 1 part solute in 5 parts solution	Amount of drug needed = Amount of solution needed × Strength required	*Liquids* - Make 250 ml of a 5% dextrose solution: D = 250 ml × (5 ml/100 ml) D = 1250 ml/100 ml D = 12.5 ml of dextrose Add 12.5 ml to 237.5 ml of saline* *Solids* - Make 250 ml of 5% dextrose solution using powdered dextrose and LRS: D = 250 ml × (5 g/100 ml) D = 12.5 - Add 12.5 g powdered

		dextrose to 250 ml LRS.
Dilution of Stock Solution	Desired concentration (C1) = Volume to use (V1) Available concentration (C2) Volume to make (V2) C1 × V2 = C2 × V1	• Prepare 600 ml of 5% dextrose solution using 50% stock solution and sterile water. • You need to find the volume of the stock to use (5% = 5 ml/100 ml): V1 = (C1 × V2)/C2 V1 = (5 ml × 600 ml)/50 ml V1 = 3000 ml/50 ml V1 = 60 ml • Add 60 ml of the 50% stock solution to 540 ml sterile water.*

* Extract an equal volume from the container to which you are adding the solution.

Table 9.1 / Antifungal Drugs

Drug (Trade Name)	Amphotericin B (Abelcet, Fungizone)	Griseofulvin (Fulvicin)	Itraconazole (Sporanox)	Nystatin (Nilstat, Mycostatin)
Action	• Fungistatic and fungicidal	• Disrupts structure of mitotic spindle, arresting cell division	• Fungistatic triazole compound	• Fungistatic and fungicidal
Metabolization	• Liver • Kidney	• Liver	• Liver	• Mostly excreted unchanged in feces
Indications	• Serious systemic mycotic infections (fungal pneumonia, phycomycoses)	• Ringworm and other dermatophytic infections	• Aspergillosis, sporotrichosis, *Coccidioides immitis*, osteomyelitis	• Candida infections
Dispensable Forms	• Injectable (IV)	• Oral	• Injectable • Oral	• Topical (intrauterine)
Species	• Horses	• Horses • Cattle • Small ruminants • Swine	• Horses	• Horses
Cautions	• Nephrotoxic • Tachycardia • Tachypnea • Lethargy • Fever • Restlessness • Anorexia • Anemia • Phlebitis • PU • Collapse	• Anorexia • Vomiting • Diarrhea • Anemia • Neutropenia • Leukopenia • Thrombocytopenia • Depression • Ataxia • Hepatotoxicity • Dermatitis/photosensitivity	• Hepatotoxic	• GI effects are possible at high doses.
Contraindications	• Patients with hypersensitivity reactions	• Hypersensitivity • Hepatocellular failure • Pregnant animals	• Hypersensitivity	• Hypersensitivity
Monitoring	• Renal function qod, liver function weekly	• Liver enzymes • CBC; before therapy and every 1–3 weeks during treatment	• Clinical efficacy • Liver function • Appetite	• Clinical efficacy
Notes	• Extremely nephrotoxic	• No effect on other fungi	• N/A	• Little science available on dosing

Table 9.2 / Anti-Infective Drugs: Aminoglycosides, Cephalosporins, and Chloramphenicol

Drug Class	Aminoglycosides	Cephalosporins	Chlorphenicol

Drug
(Trade Name)
	• Amikacin (Amikin, Amiglyde-V)
	• Gentamicin (Gentocin, Garamycin)
	• Neomycin (Biosol, Neomix)
	• Dihydrostreptomycin (Ethamycin)
	• Tobramycin (Nebcin, TOBI)
		• *First generation:*
		  • Cephalexin, cefazolin, cephapirin (Cefa-drops, Cefa-tabs, Cefazolin)
		• *Second generation:*
		  • Cefoxitin
		• *Third generation:*
		  • Cefotaxime, moxalactam
		• *Fourth generation:*
		  • Cefepime
			• Chloramphenicol (Chloromycetin, Duricol, Viceton)

Action	• Bactericidal	• Bactericidal	• Bacteriostatic
Metabolization	• Kidney	• Liver	• Liver

Indications	• Broad spectrum, predominantly G-aerobic bacilli
	• Intrauterine infusion (mares)
	• Septic arthritis (foals)
	• Gastrointestinal infection (swine)
		• *First generation:*
		  • G+
		• *Second/third generations:*
		  • G–/G+
		• *Fourth generation:*
		  • G–/G+
		• Systemic infections
		• Meningitis (foals)
		• Mastitis (cattle)
			• Broad spectrum
			• Primarily G–/G+ anaerobic bacteria

Dispensable Forms	• Injectable • Oral • Topical	• Injectable • Oral	• Injectable • Oral
Species	• Horses • Cattle • Small ruminants • Swine	• Horses/foals • Cattle • Unweaned calves (moxalactam)	• Horses
Cautions	• Nephrotoxic, ototoxic, neuromuscular blockage	• May cause emesis • Hypotension if given too quickly via IV	• Hepatotoxic
Contraindications	• Patients with hypersensitivity reactions, renal disease, neonates and geriatrics, pyrexia, sepsis, dehydration	• Hypersensitivity, renal disease	• **BANNED** for use in food animals • Hypersensitivity • Do not use with bactericidal drugs. • Use caution in animals with hematologic, hepatic, or renal disorders.
Monitoring	• Renal function • Cardiovascular depression • Deafness and vestibular signs • Respiration	• Renal function • Anaphylactic reactions	• Anaphylactic reactions • GI upset • Myelosuppressive at high doses or long-term use
Notes	• Poor absorption in GI tract	• Excreted renally	• Excreted renally

Table 9.3 / Anti-Infective Drugs: Fluoroquinolones, Lincosamides, and Metronidazole

Drug Class	Fluoroquinolones	Lincosamides	Metronidazole
Drug (Trade Name)	• Enrofloxacin (Baytril) • Norfloxacin (Noroxin) • Orbifloxacin (Orbax) • Danofloxacin (A180, Advocin)	• Erythromycin (Erythro-100) • Lincomycin (Lincocin) • Pirlimycin (Pirsue) • Tilmicosin (Micotil, Pulmotil)	• Metronidazole (Flagyl)
Action	• Bactericidal	• Bacteriostatic	• Bactericidal
Metabolization	• Liver	• Liver	• Liver
Indications	• G–/G+ bacterial infections • Respiratory infections • Bovine respiratory disease	• G+ and anaerobic bacterial infections • Mastitis (cattle) • *Mannheimia haemolytica* • *Rhodococcus equi* • *Lawsonia intracellularis* • *Staphylococcus* species • Scours (pigs) • Dysentery (lambs)	• G-anaerobic bacterial infections in horses • *Clostridium* spp. • *L. intracellularis* • *Clostridium perfringes* (foal)
Dispensable Forms	• Injectable • Oral	• Injectable • Oral	• Injectable • Oral
Species	• Horses • Cattle	• Horses • Cattle • Swine • Sheep	• Horses
Cautions	• GI distress • Crystalluria • CNS excitement • Mouth irritation in horses	• GI distress • Hyperthermia (foals)	• Hepatotoxic
Contraindications	• **BANNED** for use in food animals • Hypersensitivity • Renal or hepatic insufficiency	• Hypersensitivity, diarrhea in adult horses	• Hypersensitivity • Hepatic disorders • Pregnant or nursing animals (controversial)
Monitoring	• Clinical efficacy	• Renal function • Anaphylactic reactions	• Clinical efficacy
Notes	• Enrofloxacin use in horses is controversial. • Excreted renally	• Oral route in ruminants may cause diarrhea. • Give slowly IV. • Excreted in urine or bile	• Excreted renally

Table 9.4 / Anti-Infective Drugs: Penicillin, Sulfonamides, and Tetracyclines

Drug Class	Penicillin	Sulfonamides	Tetracyclines
Drug (Trade Name)	• Amoxicillin (Amoxil) • Ampicillin (Polyflex) • Cloxacillin (Dry-Clox, Dariclox) • Oxacillin • Penicillin G • Penicillin V • Ticarcillin (Ticar)	• *Short acting:* ◦ Sulfadiazine (Tribrissen, Bactrim, Septra) ◦ Sulfamethoxazole (Co-trimoxazole) ◦ Sulfachlorpyridazine (Vetisulid) • *Intermediate acting:* ◦ Sulfadimethoxine (Albon)	• Chlortetracycline (Aureomycin, Pennchlor) • Doxycycline (Vibramycin) • Oxytetracycline (Terramycin) • Tetracycline (Aquadrops, Panmycin)
Action	• Bactericidal	• Bacteriostatic	• Bacteriostatic
Metabolization	• Kidney	• Liver	• Kidney
Indications	• G+ bacterial infections • Bone, skin, respiratory, and soft tissue infections • Intramammary infusion (cattle)	• G–/G+ bacterial infections • Protozoal infections • *Streptococcus equi*	• G–/G+ bacterial infections • Rickettsia spp. • *Bordetella* spp.
Dispensable Forms	• Injectable • Oral	• Injectable • Oral	• Injectable • Oral
Species	• Horses • Cattle • Swine	• Horses • Cattle • Swine	• Horses • Cattle • Small ruminants • Swine
Cautions	• GI upset	• Precipitation in urine, urolithiasis, hematologic effects and diarrhea (horses)	• GI upset
Contraindications	• Hypersensitivity to penicillins	• Hypersensitivity • Hepatic or renal disease	• Hypersensitivity • **Note:** Do not use via IV in horses.
Monitoring	• Clinical efficacy	• Maintain adequate hydration	• Clinical efficacy
Notes	• N/A	• Excreted renally	• Yellowing of teeth in young animals

Table 9.5 / Antiparasitic Drugs: Antinematodals

Drug (Trade Name)	• *Benzimidazoles*: • Albendazole (Valbazen) • Fenbendazole (Panacur, Safe-Gaurd) • Oxfendazole • Oxibendazole • Thiabendazole	• Ivermectin (Ivomec, Ivercide, Sheep-Drench)	• Pyrantel (Strongid-T, Strongid, Strongid-C)	• Piperazines
Action	• Disrupts intracellular microtubular transport systems	• Parasite paralysis	• Depolarizing neuromuscular blocking agent	• Parasite paralysis
Metabolization	• Liver	• Liver	• N/A	• Kidneys
Indications	• Large and small strongyles • Ascarids • Pinworms • Whipworms	• Large and small strongyles • Ascarids • Pinworms • Hairworms • Bots • Lungworms • Summer sores • Threadworms • Cattle grubs • Sucking lice • Scabies	• Ascarids	• Ascarids
Dispensable Forms	• Oral	• Oral • Injectable	• Oral	• Oral
Species	• Horses • Cattle • Small ruminants • Swine	• Horses • Cattle • Small ruminants • Swine	• Horses • Cattle • Small ruminants • Swine	• Horses • Swine
Cautions	• N/A	• *Horses:* Swelling and pruritus at ventral midline may be seen 24 hr after injection due to hypersensitivity reaction to dying *Onchocerca* spp. • *Cattle:* Injection site swelling and discomfort	• N/A	• Diarrhea • Emesis • Ataxia
Contraindications	• Patients with hypersensitivity reactions	• Foals • Lactating dairy animals	• Severely debilitated animals	• GI hypomotility • Chronic liver/renal disease • Seizure disorders • Horses with *Parascaris equorum* infestations
Monitoring	• Vomiting • Diarrhea	• Adverse effects listed	• Clinical efficacy	• Clinical efficacy
Notes	• N/A	• N/A	• N/A	• N/A

Table 9.6 / Antiparasitic Drugs: Anticestodals

Drug (Trade Name)	• Praziquantel (Droncit)
Action	• Interacts with phospholipids
Metabolization	• Liver
Indications	• All spp. of *Moniezia, Stilesia, Avitellina*
Dispensable Forms	• Oral • Injectable
Species	• Small ruminants
Cautions	• N/A
Contraindications	• Diarrhea
Monitoring	• Clinical efficacy

Notes	• Not economically feasible in large animals

Table 9.7 / Cardiovascular Drugs: Antiarrhythmics

Drug Class	Beta-Adrenergic Blockers	Antidysrhythmic Agents
Drug (Trade Name)	• Propanolol (Inderal)	• Lidocaine (Xylocaine) • Procainamide • Quinidine
Action	• Blockade of beta-1 and beta-2 receptors in the myocardium, bronchi, and vascular smooth muscle	• Combines with fast sodium channels which inhibits recovery after repolarization
Metabolization	• Liver	• Liver
Indications	• Tx of ventricular tachycardia	• Local anesthetic • Tx of ventricular arrhythmias (V-tach and VPCs) • Prevention of postoperative ileus and reperfusion injury in horses
Dispensable Forms	• Injectable • Oral	• Injectable • Topical
Species	• Horses	• Horses
Cautions	• Bradycardia • Lethargy • Depression • Impaired AV conduction • Hypotension • Syncope • Diarrhea • Hypoglycemia • Bronchoconstriction • CHF	• Hypotension if given too rapidly

Contraindications	• Renal/hepatic insufficiency • SA node dysfunction	• Hypersensitivity • Hepatic disease • CHF • Shock • Hypovolemia • Severe respiratory depression • Marked hypoxemia
Monitoring	• ECG, BP monitoring if used via IV	• ECG
Notes	• If receiving the drug chronically, wean off.	• Do not use epinephrine combination via IV.

Table 9.8 / Cardiovascular Drugs: Anticoagulants and Calcium Supplements

Drug Class	Anticoagulants	Anticoagulants	Calcium Supplements
Drug (Trade Name)	• Heparin sodium (Heparin)	• Warfarin (Coumadin)	• Calcium gluconate
Action	• Along with antithrombin III, prevents the conversion of prothrombin to thrombin	• Interferes with the action of vitamin K1	• Increases available calcium
Metabolization	• Partially metabolized by liver	• Liver	• N/A
Indications	• Adjunctive tx of DIC • Endotoxic shock • Therapy in prevention of laminitis	• Adjunctive tx of laminitis	• Tx of hypocalcemia
Dispensable Forms	• Injectable	• Oral	• Injectable
Species	• Horses	• Horses	• Horses • Cattle • Small ruminants • Swine
Cautions	• Bleeding • Thrombocytopenia	• Dose-related hemorrhage	• Hypercalcemia
Contraindications	• Hypersensitivity, severe thrombocytopenia	• Preexistent hemorrhagic diseases	• Hypercalcemic or ventricular fibrillation patients
Monitoring	• aPTT monitoring	• PT and INR times monitored	• Serum calcium • ECG
Notes	• N/A	• N/A	• N/A

Table 9.9 / Cardiovascular Drugs: Contractility Enhancers and Positive Inotropes

Drug Class	Beta-Adrenergic Agonist	Cardiac Glycoside	Catecholamine
Drug (Trade Name)	• Isoproterenol (Isuprel) • Dobutamine (Dobutrex)	• Digoxin	• Epinephrine
Action	• Synthetic beta-1 and beta-2 adrenergic agonist • Direct beta-1 with mild beta-2 (dobutamine)	• N/A	• Alpha and beta adrenergic agonist
Metabolization	• Liver	• Kidney	• Liver
Indications	• *Isoproterenol:* Short-term bronchodilation • *Dobutamine:* Tx of hypotension, decreased cardiac output and tissue perfusion	• Supraventricular tachycardia	• Anaphylaxis • CPR
Dispensable Forms	• Injectable	• Injectable • Oral	• Injectable
Species	• Horses	• Horses • Cattle	• Horses • Small ruminants • Swine
Cautions	• Discontinue if heart rate doubles, hypertension	• Usually associated with toxic doses	• Fear • Anxiety • Tremors • Hypertension • Vomiting • Arrhythmias
Contraindications	• Cardiac dysrhythmias	• Ventricular fibrillation • Glomerulonephritis	• Hypersensitivity • Hypovolemia • Glaucoma
Monitoring	• Heart rate and rhythm	• Clinical signs of colic	• Heart rate and rhythm
Notes	• ARCI UCGFS Class 4 and 2 Drugs, respectively • Effects may last for only 1 hr (isoproterenol)	• ARCI UCGFS Class 4 Drug	• ARCI UCGFS Class 2 Drug

Table 9.10 / Renal and Urinary Tract Drugs: Diuretics

Drug (Trade Name)	Furosemide (Lasix)	Mannitol
Action	• *Loop diuretic:* Decreases reabsorption of sodium and chloride; increases excretion of potassium	• Osmotic diuretic
Indications	• CHF with pulmonary edema • ARF • Epistaxis prevention (race horses)	• Treatment of oliguria • Cerebral edema
Dispensable Forms	• Injectable • Oral	• Injectable
Species	• Horses • Cattle	• Horses • Cattle • Small ruminants • Swine
Cautions	• Fluid and electrolyte abnormalities	• Fluid and electrolyte abnormalities

	• Hypokalemia	
Contraindications	• Hypersensitivity • Anuria	• Intracranial hemorrhage • Dehydration • Pulmonary edema • Anuria
Monitoring	• Leukopenia • Hypokalemia • Hyponatremia • Hypochloremic acidosis • Dehydration • Vomiting • Diarrhea	• Electrolytes • UOP • Respiration
Notes	• Refer to state regulations for use in racing horses	• Must be warmed to dissolve crystals in solution before administration. A filter should be used.

Table 9.11 / Renal and Urinary Tract Drugs: Acidifiers and Alkalinizers

Drug Class	Acidifiers	Alkalinizers
Drug (Trade Name)	• Ammonium chloride • DL-methionine	• Sodium bicarbonate
Action	• Acidifies urine	• Alkalinizing agent
Indications	• Urolithiasis prevention • Enhances renal excretion of strychnine (horses)	• Tx metabolic acidosis
Dispensable Forms	• Oral	• Injectable
Species	• Horses • Cattle • Small ruminants	• Horses • Cattle

		• Small ruminants
Cautions	• N/A	• Hypocalcemia • Hypertension • Oliguria • CHF • Nephritic syndrome • Volume overload
Contraindications	• Renal failure • Severe hepatic disease • Pregnant animals	• Metabolic/ respiratory alkalosis • Hypocalcemia • Tetany
Monitoring	• Urine/blood pH • Electrolytes	• Urine/blood pH, • electrolytes
Notes	• *Unpalatable:* Dosing syringe or stomach tube may be needed.	• N/A

Table 9.12 / Renal and Urinary Tract Drugs: Alpha Blocker and Anabolic Steroids

Drug Class	Alpha Blocker	Anabolic Steroids
Drug (Trade Name)	• Phenoxybenzamine (Dibenzyline)	• Stanozolol (Winstrol-V) • Boldenone (Equipoise)
Action	• Alpha blocker	• Anabolic steroid
Indications	• Adjunctive tx to laminitis • Diarrhea	• Anabolic agent (horses) • Acute/subacute aflatoxicosis (small ruminants)
Dispensable Forms	• Oral • Injectable	• Injectable (IM)

Species	• Horses	• Horses • Small ruminants
Cautions	• Constipation	• N/A
Contraindications	• Clinical signs of colic • CHF	• *Cardiac/Renal disease:* Pregnant animals, breeding stallions, food animals
Monitoring	• Blood pressure	• Hepatotoxicity
Notes	• N/A	• ARCI UCGFS Class 4 Drug

Table 9.13 / Antihistamines

Drug (Trade Name)	• Diphenhydramine (Benadryl) • Hydroxyzine (Atarax)
Action	• Inhibits histamine release at H1 receptor
Indications	• Anaphylaxis • Pruritus
Dispensable Forms	• Oral • Injectable
Species	• Horse • Cattle
Cautions	• CNS depression
Contraindications	• Hypertension • Hypotension • Cardiac disease • CNS disorders • GIT disorders • Pregnant animals
Monitoring	• Level of sedation

Notes	• ARCI UCGFS Class 3 and 2 Drug respectively

Table 9.14 / Musculoskeletal Drugs: Adrenal Cortical Steroids

Drug Class	Short-Acting Adrenal Cortical Steroids	Intermediate-Acting Adrenal Cortical Steroids	Long-Acting Adrenal Cortical Steroids
Drug (Trade Name)	• Hydrocortisone	• Methylprednisolone (Depo-Medrol) • Prednisone • Prednisolone (Delta-Cortef) • Triamcinolone	• Dexamethasone (Azium) • Flumethasone
Action	• Inhibits phospholipase	• Inhibits phospholipase	• Inhibits phospholipase
Indications	• Glucocorticoid • Adjunctive tx of photosensitization reaction (cattle)	• Glucocorticoid • Adjunctive therapy of cerebral edema secondary to polioencephalomalacia, aseptic laminitis (cattle) • COPD (horses)	• Glucocorticoid • Adjunctive therapy of cerebral edema secondary to polioencephalomalacia, aseptic laminitis (cattle) • COPD (horses)
Dispensable Forms	• Injectable	• Injectable • Oral	• Injectable
Species	• Horses • Cattle	• Horses • Cattle • Swine	• Horses • Cattle • Swine
Cautions	• Cushingoid effects • PU, PD, PP	• Cushingoid effects • PU, PD, PP	• Cushingoid effects • PU, PD, PP
Contraindications	• Systemic fungal infections • Thrombocytopenia	• Systemic fungal infections • Thrombocytopenia	• Systemic fungal infections • Thrombocytopenia
Notes	• ARCI UCGFS Class 4 Drug	• ARCI UCGFS Class 4 Drug	• ARCI UCGFS Class 4 Drug

Table 9.15 / Musculoskeletal Drugs: Nonsteroidal Antiinflammatory Drugs

Drug (Trade Name)	Acetylsalicylic Acid (Aspirin)	Carprofen (Rimadyl)	Phenylbutazone (Butazolidin)
Action	• COX inhibitor • Antithrombotic	• COX-2 inhibitor (some COX-1 activity)	• Alpha- and beta-adrenergic agonist
Metabolization	• Liver	• Liver	• Liver
Indications	• Inflammation • Pain	• Inflammation • Pain	• Inflammation • Pain • Adjunct tx of colic and laminitis (horses)
Dispensable Forms	• Oral	• Injectable • Oral	• Injectable • Oral
Species	• Horses • Cattle • Swine	• Horses	• Horses • Cattle • Swine
Cautions	• GIT issues	• GIT issues	• Oral and GI erosions and ulcers • Hypoalbuminemia • Diarrhea • Anorexia • Renal effects
Contraindications	• Hepatic failure	• Hepatic failure	• Hypersensitivity • Hematologic or bone marrow abnormalities • GI ulcers • Food production animals
Monitoring	• Liver enzymes	• Liver enzymes	• CBC • Urinalysis
Notes	• N/A	• ARCI UCGFS Class 4 Drug	• N/A

Drug (Trade Name)	Firocoxib (Equioxx)	Ketoprofen (Ketofen)	Flunixin meglumine (Banamine)
Action	• COX-2 inhibitor	• COX catalysis inhibitor	• COX inhibitor
Metabolization	• Liver	• Liver	• Liver
Indications	• Pain and inflammation associated with osteoarthritis	• Pain and inflammation associated with musculoskeletal disorders	• Inflammation • Pain • Adjunct tx of colic and laminitis (horses) • Control of pyrexia associated with swine respiratory dz (swine) • Aseptic lameness, radial nerve injury (cattle)
Dispensable Forms	• Oral	• Injectable • Oral	• Injectable • Oral
Species	• Horses	• Horses • Cattle	• Horses • Cattle • Swine
Cautions	• Mouth ulcers • Facial skin lesions • Excitation	• Gastric mucosal damage • GI ulceration • Renal crest necrosis • Mild hepatitis (horses)	• Anaphylaxis is possible with rapid IV administration. • IM injections may cause pain and swelling.
Contraindications	• Hypersensitivity	• Hypersensitivity	• Hypersensitivity
Monitoring	• CBC • Liver enzymes • Renal function • Electrolytes • Urinalysis	• Adverse effects	• CBC, occult blood in feces with chronic use (horses)
Notes	• N/A	• ARCI UCGFS Class 4 Drug	• ARCI UCGFS Class 4 Drug

Table 9.16 / Central Nervous System Drugs: Anticonvulsants

Drug (Trade Name)	• Diazepam (Valium) • Midazolam (Versed)	• Phenobarbital
Action	• Antagonism of serotonin • Facilitates GABA activity	• Barbiturate
Metabolization	• Liver	• Liver
Indications	• Tranquilization • Acute seizure cessation	• Long-term seizure control

	• Bermuda grass toxicosis (goats)	
Dispensable Forms	• Oral • Injectable	• Injectable • Oral
Species	• Horses • Cattle • Small ruminants • Swine	• Horses • Cattle
Cautions	• N/A	• N/A
Contraindications	• Diminished hepatic function	• Hypersensitivity • Severe liver disease
Monitoring	• Observe horses closely after administration.	• Anticonvulsant efficacy
Notes	• ARCI UCGFS Class 2 Drug	• ARCI UCGFS Class 2 Drug

Table 9.17 / Central Nervous System Drugs: Muscle Relaxers

Drug (Trade Name)	Methocarbamol (Robaxin)	Guaifenesin
Action	• General depressant effects	• Nerve impulse transmission blocking
Metabolization	• N/A	• N/A
Indications	• Muscle spasms • Acute rhabdomyolysis (horses) • CNS hyperactivity (cattle)	• Induction and maintenance of field anesthesia in combination with other sedatives

Dispensable Forms	• Oral • Injectable	• Injectable
Species	• Horses • Cattle	• Horses • Cattle
Cautions	• Sedation • Salivation • Lethargy • Weakness • Ataxia	• Mild hypotension • Tachycardia • Thrombophlebitis
Contraindications	• Hypersensitivity • Renal disease • Food animals	• None listed
Monitoring	• Sedation level	• Sedation level • Heart and respiration rate
Notes	• ARCI UCGFS Class 4 Drug	• ARCI UCGFS Class 4 Drug

Table 9.18 / Central Nervous System Drugs: Alpha-2 Agonists

Drug (Trade Name)	Xylazine (Rompun)	Detomidine (Dormosedan)
Action	• Alpha-2 agonist	• Alpha-2 agonist
Metabolization	• Liver	• Liver
Indications	• Induction • Sedation • Analgesia	• Induction • Sedation • Analgesia
Dispensable Forms	• Injectable	• Injectable
Species	• Horses • Cattle	• Horses • Cattle • Small ruminants

Cautions	• Muscle tremors • Bradycardia • AV block • Increased ICP • Sweating • Decreased mucocilliary clearance (horses) • Salivation • Ruminal atony • Bloating • Regurgitation • Hypothermia • Diarrhea • Bradycardia • Ataxia (cattle)	• Initial hypertension followed by bradycardia/ block • Piloerection
Contraindications	• Cardiac disorders • Debilitated animals	• Cardiac disorders • Debilitated animals
Monitoring	• Heart rate and rhythm • Respiration • Hydration	• Heart rate and rhythm • BP, if possible
Notes	• Yohimbine is antidote. • ARCI UCGFS Class 3 Drug	• 50–100 times as potent as xylazine • ARCI UCGFS Class 3 Drug

Table 9.19 / Central Nervous System Drugs: Dissociative Agents

Drug (Trade Name)	Ketamine	Tiletamine/Zolazepam (Telazol)
Action	• Dissociative • Inhibits NMDA receptors	• Similar to ketamine + benzodiazapine
Metabolization	• Liver	• Liver

Indications	• Induction of anesthesia and analgesia	• Induction of anesthesia
Dispensable Forms	• Injectable	• Injectable
Species	• Horses • Cattle • Small ruminants • Swine	• Horses • Cattle • Small ruminants • Swine
Cautions	• Cardiac disease • Seizures, if given alone • Increased ICP	• Cardiac disease • Seizures, if given alone • Increases ICP
Contraindications	• Hypersensitivity • Head trauma • Food animals	• Hypersensitivity • Head trauma • Food animals
Monitoring	• Heart rate and rhythm • Respiration • Temperature • Lubricate eyes.	• Heart rate and rhythm • Respiration • Temperature • Lubricate eyes.
Notes	• ARCI UCGFS Class 2 Drug	• ARCI UCGFS Class 2 Drug

Table 9.20 / Central Nervous System Drugs: Opioids

Drug Class	Mixed Opioid Agonist/Antagonist			
Drug (Trade Name)	• Butorphanol (Torbugesic)	Meperidine (Demerol)	Morphine	Oxymorphone
Action	• Agonist at kappa receptors • Antagonist at mu receptors	• Mu agonist	• Mu agonist	• Mu agonist
Metabolization	• Liver	• Liver	• Liver	• Liver
Indications	• Premedication • Analgesia	• Analgesia	• Analgesia	• Analgesia
Dispensable Forms	• Injectable	• Injectable	• Injectable	• Injectable
Species	• Horses • Cattle	• Horses • Cattle • Small ruminants • Swine	• Horses • Cattle • Small ruminants • Swine	• Horses • Swine
Cautions	• Ataxia • CNS excitement	• Respiratory depression, histamine release, bronchoconstriction, CNS depression • Tachycardia, PVC's, profuse sweating, hyperpnea (horse)	• Respiratory depression, histamine release, bronchoconstriction, CNS depression • Hyperthermia (horse, cattle, goat)	• Respiratory depression, histamine release, bronchoconstriction, CNS depression
Contraindications	• Liver disease • Renal disease • Hypothyroidism	• Hypersensitivity	• Hypersensitivity	• Hypersensitivity
Monitoring	• Respiratory rate/depth	• Respiratory rate/depth	• Respiratory rate/depth	• Heart rate and rhythm
Notes	• ARCI UCGFS Class 3 Drug • Naloxone reverses	• Can mask mild signs of colic (horse) • Naloxone reverses	• ARCI UCGFS Class 1 Drug • Can mask mild signs of colic (horse) • Naloxone reverses	• ARCI UCGFS Class 1 Drug • Can mask mild signs of colic (horse) • Naloxone reverses

Chapter 10

Emergency Care

Jamie Defazio

Key Words and Phrases	Abbreviations
ACE inhibitor	AV: Atrioventricular
Antiarrhythmics	CPR: Cardiopulmonary resuscitation
Antihistamine	CSF: Cerebrospinal fluid
Antispasmodic	CTnI: Cardiac troponin inotrope
Antithrombotic	DMSO: Dimethyl sulfoxide
Antiulcer	ECG: Electrocardiogram
Auscultation	EHV: Equine herpesvirus
Bronchodilator	EPM: Equine protozoal myeloencephalitis
Colic	FUO: Fever of unknown origin

Coagulant	IOP: Intraocular pressure
Diuretic	IVC: Intravenous catheter
Dystocia	NSAID: Nonsteroidal antiinflammatory
Emergency	OD: Right eye
Isotonic fluid	OS: Left eye
Nasogastric intubation	OU: Both eyes
Nonsteroidal antiinflammatory	PCV: Packed cell volume
Prokinetic	PLR: Papillary light response
Sedative	PPV: Positive pressure ventilation
Triage	TP: Total protein
Vasodilator	TPR: Temperature, pulse, respiration
	WNV: West Nile virus

Introduction

Knowledge and experience are vital when assisting in stressful emergency situations. Emergencies are never planned, so you should always be prepared for the unexpected. A good mindset is to "expect the worst and hope for the best." Every clinic should have a triage and emergency protocol implemented to make these intense situations run as smoothly as possible.

As a technician, it is important to remember your role of support. You should not diagnose the patient or institute your own treatment. A well-trained technician is able to work alongside the veterinarian, anticipating needs and following through with prescribed diagnostics and treatment procedures.

This chapter will cover equipment, triage, emergency workups, as well as monitoring. It will focus on four different large animal species: equine, bovine, small ruminant, and swine.

Emergency Supplies

It is essential to have emergency supplies and drugs at hand for an emergency workup. Stock and arrange supplies in a designated area like a cart or a tote for easy access in an emergency (Fig. 10.1). By staying organized, you will be much more prepared to assist the veterinarian during the emergency. A good example of this is a crash cart, along with a general emergency workup cart or tote. If your clinic is given ample notice in a given emergency, there will be ample time to set up specifically for that patient and their needs. On the flip side, however, the crash cart is a good idea to have for the emergencies that come with no warning.

Table 10.1 / Emergency Equipment and Supplies

Equipment	• Ambu bag • Blood gas analyzer • Crash cart • Defibrillator • Electrocardiogram • Fluid pump • Heat lamp • Oxygen tank • Pulse oximeter • Ventilator • Demand valve • Suction unit • Ultrasound machine

Supplies	• Bandage material
	• Splints:
	    • PVC
	    • Kimzey®
	• Buckets
	• Dose syringe
	• Nasogastric and orogastric tubes
	• Laryngoscope
	• Endotracheal and nasotracheal tubes
	• Oxygen tubing, bubbler, and flowmeter
	• Penlight
	• Ophthalmoscope
	• IV catheters
	• Urinary catheters
	• *IV fluids:*
	    • Isotonic and hypertonic crystalloids
	    • Colloids (natural and/or synthetic)

	• *Needles and syringes:*
	    • 22–14 g needles
	    • 1–60 ml syringes
	• Fluid and blood/plasma administration sets
	• Rectal sleeves and lubrication
	• *Restraint device:*
	    • Halters
	    • Lead ropes
	    • Twitch
	    • Nose tongs
	    • Snare
	    • Pig boards
	• Ropes and hobbles
	• Down animal sled
	• Gurney
	• Slings

Figure 10.1 Emergency cart.

Table 10.2 / Monitoring/Nursing Equipment

Equipment	Technique/Types of Machines	Notes
Capnograph		• High respiratory rates can cause false readings.
Blood Pressure	• Oscillometry	• In adult horses, place at base of tail for best reading. • Make sure that cuff size is appropriate, or false readings will occur. • In smaller patients, can use a limb.
	• Direct arterial pressure	• Flush catheter frequently to prevent clotting.
Pulse Oximeter	• Depends on probe	• Can place on lip or tongue of anesthetized/comatose patient, or can try on ear. • Clean rectal probes of manure frequently during use.
ECG		• Make sure that leads are in appropriate places.
Blood Gas Analyzer		• Determining the body temperature is necessary for accurate results.
Ventilator	• PPV	• Use only for neonatal foals and calves.

Humifier	• Oxygen bubbled through water	• Keep bubbler level at appropriate levels.
	• Heat and moisture exchanger (HME filter)	• Use on intubated animals on ventilatory support (typically neonatal foals and calves). • Provides heat and moisture to airway and filters bacteria and viruses
	• Nebulizer	• Use along with sterile water or saline.

Triage

It is very important to have a trained member of your team available to take phone calls and start the triage process. This employee should understand what constitutes a true emergency and what can be handled with less urgency. When working in either a referral hospital or a field unit, information is vital to preparing everyone involved in the case. It is necessary to communicate when the veterinarian will arrive and whether the animal is coming to your referral clinic so that everyone can be prepared. Remind the client to remain calm. Refer to the individual tables to see specific triage questions related to each specific type of emergency.

A general triage at the time of admission starts with an initial physical examination. See chapter 2 for preventative health care and normal values. When working with various species, it is important to realize that the normals for these patients can vary dramatically.

Table 10.3 / Assessment Triage (General)

Assessment	Abnormality	Possible Indications
Temperature	• Hyperthermia • Hypothermia	• Infection, inflammation, heat stress • Gastric rupture, secondary to anorexia; body shutting down

Heart Rate/ Pulse	• Tachycardia
	• Bradycardia
	• Irregular heart rate
		• *Pain:*
		  • Ventricular tachycardia
		  • Atrial fibrillation
		• Poor perfusion, hyperkalemia, can lead to cardiac arrest.
		• Could be any cardiac arrhythmia

Respiratory Rate	• Tachypnea • Bradypnea	• Pain, pneumonia, lung abscess, chronic obstructive pulmonary disorder, left-sided heart failure • Underdeveloped lungs
Integument	• Prolonged skin tent • Cresty neck	• Dehydration • Insulin resistance, Cushing's disease
Mentation	• Dull/depressed • Hyperresponsive • Nonresponsive	• Pain, any illness • Neurologic, pre-seizure • Neurologic, metabolic, or toxicological issue may be to blame.
Blood Pressure	• Hypotensive • Hypertensive	• Poor perfusion, blood loss • Abnormal electrolyte imbalance
Mucous Membranes	• Dry or tacky • Bright red • Blue/cyanotic • Pale/white • Yellow	• Dehydration • Toxic shock. (A "toxic line" may be present.) • Poor perfusion, hypoxemia; usually a predecessor to respiratory arrest • Anemia, shock • Icterus, liver dysfunction
Capillary Refill Time	• Rapid (<1 sec) • Prolonged (>2 sec)	• Hyperdynamic state, fever, shock • Poor perfusion, vasoconstriction, dehydration
Borborygmi	• Decreased • Increased	• Colic, ileus, obstruction • Colitis, diarrhea

Lung Sounds	• Crackles • Wheezes • Moist	• Interstitial pneumonia in foals, *Rhodococcus equi* • COPD, pneumonia (e.g., granulomatous, interstitial) • Aspiration pneumonia

Table 10.4 / Cardiac Emergencies

Causes	• Bradyarrhythmias (second- and third-degree AV block), sinus bradycardia, sinoatrial block, atrial fibrillation, congestive heart, failure, ventricular tachycardia, cardiac arrest, electrolyte disturbances (hyperkalemia, hypokalemia, hypomagnesemia, hypocalcemia, hypercalcemia, hyperkalemic periodic paralysis in the equine patient, pericarditis, pericardial effusion, ionophore toxicity in the equine patient, aortic root rupture, rupture of the mitral valve chordae tendinae, quinidine toxicity, torsades de pointes, left-sided heart failure	
Triage: By Telephone	• Collapse	• What was the animal doing at the time? Is it currently standing? Does the heart sound normal?
	• Weakness	• What color are the animal's mucous membranes? • Make sure that patient is stable before referral. Ask the RDVM to evaluate heart rate and rhythm.
Triage: At Evaluation	• General	• Auscultate the heart and listen for any irregularities. Listen to rhythm, rate, quality, and intensity to detect possible murmurs or irregular beat patterns. Obtain a heart rate, as well as a pulse. The pulse should be palpated and also evaluated for quality, intensity, and regularity. The pulse rate should match the heart rate. Perform an

		electrocardiogram (ECG) if possible. Perform blood work: packed cell volume, total protein, fibrinogen, white blood cell count, full chemistry panel. Obtain a temperature and respiratory rate in addition to the full overall physical performed by the veterinarian. It is important to have cardiac drugs available at the emergency triage for lifesaving measures. • For cardiac arrest, CPR can be attempted in the smaller patients, as well as in neonate foals and calves. Resuscitative medications should be on hand in a crash cart/emergency box. Cardiac compressions can be maintained by the technician until the veterinarian orders cessation. Only a veterinarian should attempt open-chest cardiac massage.
Clinical Signs	• Poor performance, decrease in milk production, weight loss, dull, depressed, tachycardia, bradycardia, heart murmur, heart arrhythmias, cold extremities, pale mucous membranes, weakness, dyspnea, jugular vein distention, bounding pulses, abnormal blood pressure, abdominal discomfort, edema of pectoral, ventral, and preputial areas, coughing, foamy nasal discharge	

Diagnostics	• Physical examination	• A thorough exam should be completed and a list of differentials made. The heart should be auscultated thoroughly on both sides and a record made of any murmurs, abnormal heart sounds, rate/quality of heart rate, and pulses.
	• Blood work	• Complete blood count • Chemistry • Fibrinogen • Arterial blood gas • Urinalysis • CTnI levels
	• Radiology	• Can evaluate better in smaller species. Depending upon the size of the patient and the ability of the machine, radiology can be used to detect hardware disease in cattle that can lead to pericarditis.
	• Ultrasound	• Can detect mechanical abnormalities and fluid and can look at the size of the heart and its compartments
	• Electrocardiogram	• A 12-lead ECG is preferred, but in an emergency the base-apex lead may be all that is needed to diagnose a disturbance, if one is present.
	• Miscellaneous	• Central venous pressure measurement • Indirect blood pressure measurement (see Skills Box 10.1) • Pericardiocentesis

Treatment	• General	• Limit stress • Keep warm • Supply oxygen therapy, if necessary

	• Medication	• Antiarrhythmic medications, ACE inhibitors, diuretics, vasodilators, inotropes, sedatives, antithrombotic medications, atropine, epinephrine, potassium and calcium chloride, coagulants, lidocaine, fluid therapy (contraindications)
		    • *Antiarrhythmic medications:* Diltiazem, dexamethasone sodium phosphate, procainamide, digoxin, aspirin, phenytoin
		    • *ACE inhibitor:* Enalapril
		    • *Diuretic:* Furosemide
		    • *Vasodilators:* Acepromazine, hydralazine, nitroglycerin ointment, diltiazem, enalapril
		    • *Inotropes:* Digoxin, dobutamine (cardiogenic shock, hypotension, third-degree AV block), dopamine
		    • *Sedatives:* Morphine, butorphanol, buprenorphine, xylazine, detomidine
		    • *Antithrombotic:* Aspirin, heparin
		    • *Atropine:* Sinus bradycardia
		    • *Coagulants:* Aminocaproic acid
		    • *Kaliuretic diuretics:* Acetazolamide, hydrochlorothiazide (for

			treatment of hyperkalemic periodic paralysis) • *Hyperkalemia:* Calcium gluconate, dextrose, sodium bicarbonate, insulin • *Chemical defibrillator:* Potassium chloride • *Ventricular asystole:* Calcium chloride, epinephrine • *Ventricular fibrillation:* Bretylium • *Ventricular tachycardia:* Procainamide, bretylium, magnesium sulfate • *Other:* Lidocaine, glycopyrrolate (to treat bradycardia), naloxone (for suspected abdominal hemorrhage), milrinone (congestive heart failure), quinidine sulfate (for treatment of atrial fibrillation)
Monitoring	• Respiratory rate • Heart rate and rhythm • Pulse • Urination • Watch for edema. • Mucous membranes (to help gauge perfusion status) • Blood pressure		

Skills Box 10.1 / Procedure for Indirect Blood Pressure Measurement for the Large Animal Patient

Supplies:

- Blood pressure monitor, appropriate-size cuff, recording sheet, and stethoscope

General information:

- Uses the oscillometric method; is easy to use; measures systolic, diastolic, and mean pressures, along with the heart rate

Procedure:

1. In adult equine, bovine, and small ruminant patients, the measurement is taken from the coccygeal artery. The cuff is placed at the base of the tail, and in smaller species and neonates it may be placed on a limb. (Most sheep do not have enough tail.)

2. Place the appropriate cuff on the patient. Then make sure the cuff size is correct by measuring the circumference of the leg to the cuff. The cuff should be about the same size as the leg. Then attach it to the monitor.

3. Turn the machine on, press the start button, and wait. Every machine type is different, but the same principle still remains.

4. You should have a reading in 45–60 seconds. Most machines will give you the diastolic, systolic, and mean blood pressures.

5. Make sure that the actual heart rate matches the monitor, as most monitors will give you a heart rate along with the pressures.

6. Repeat the process 3–5 times for average pressures.

Troubleshooting:

- What if the time runs out without a reading?
  - The cuff could be too large or there could be a loose connection.
- What if the cuff keeps blowing off?
  - The cuff could be too small.
- What if the actual heart rate does not match the machine?
  - You should retry and check the actual heart rate again, remembering that, as the cuff expands and creates pressure, some animals will respond with a mild tachycardia.
  - Retry as the patient becomes more comfortable with the procedure.

Table 10.5 / Respiratory Emergencies

Causes	• Pneumonia (aspiration, bacterial, fungal), obstruction, (laryngeal hemiplegia, arytenoid chondritis, pharyngeal collapse, choke, soft tissue swelling), collapsing trachea (in miniature horses), trauma, wry nose, neoplasia, pulmonary edema, pneumothorax, pleural effusion, smoke inhalation (barn fire), hyperkalemic periodic paralysis in the equine patient, upper respiratory infections, including strangles, *Streptococcus Equi, Rhodococcus Equi*, COPD, rhinopneumonitis (EHV-1), choanal atresia

Triage: By Telephone	• Difficulty breathing	• Does the cause seem obstructive? • Keep the animal quiet; do not stress. If the animal is housed with others, keep it away from other animals until evaluated in case it is an infectious disease.
Triage: At Evaluation	• General	• Evaluate the respiratory rate and rhythm. Look for any abnormal breathing patterns, paradoxical, increase in respiratory effort in either inspiration or expiration. Listen for any respiratory noise such as wheezing, coughing, or forced air sounds. Look for any nasal discharge, and make note of whether it is bilateral. The lungs and trachea should be auscultated thoroughly and evaluated for quality of air flow, any abnormal noises such as crackles, wheezes, or moist air sounds. A rebreathing examination may be warranted in some cases to make the lungs work harder and to emphasize a condition. An arterial blood gas may be performed to evaluate PaO2, PCO2, and pH. Intranasal oxygen may be warranted, but it is usually not started until the blood gas has been obtained in order to measure the baseline values. Radiographs of smaller species or neonates can prove as good diagnostic tools for the diagnosis of pneumonia, whereas ultrasound is of great benefit with larger species. • In the case of an obstructive respiratory emergency it is lifesaving to have the materials available to perform an emergency tracheotomy. In some cases the obstruction could be from a foreign body or from a

		mechanical failure of the airway as in laryngeal hemiplegia or arytenoid chondritis. It is very important to have an emergency tracheostomy kit on hand, including a hard-back scalpel with blade, a local anesthetic, a tracheostomy tube (metal preferable for emergencies, but a softer tube with inflatable cuff may be warranted, at least when the patient is stable), and long tape ties or suture to hold the tube in place. It is a valuable diagnostic tool to perform an endoscopic exam on patients with a possible obstructive disorder, but stabilization may be necessary first as a lifesaving matter. • If the patient has enlarged lymph nodes, a fever, and/or purulent nasal discharge, it is important that it is isolated immediately until a diagnosis is made. Certain upper respiratory infections (e.g., *S. equi*) are extremely contagious. • For animals in respiratory arrest, it is important to have various sizes of nasal-tracheal and oral-tracheal on hand, as well as a laryngealscope and bite block. It is easier to intubate and perform resuscitative therapy to smaller animals or neonate foals and calves. In the larger adult equine and bovine patients, it is extremely difficult to near impossible. The best possibility is when the animal is intubated and placed on a ventilator. Having an Ambu bag available and an oxygen source and line with demand valve are ideal. • Emergency respiratory medications should be on a nearby crash cart or emergency box for use as needed.

Clinical Signs	• Exercise intolerance, shallow breathing, rapid breathing, tachypnea, bradypnea, stridor, collapse, moist airway sounds, dark or cyanotic mucous membranes, nasal discharge	
Diagnostics	• Physical exam	• A complete and thorough physical exam should be performed, with emphases on mucous membrane color, respiratory rate, and respiratory quality. Lungs should be auscultated, and a rebreathing exam may be warranted if the patient is stable. If there is an upper airway obstruction, an emergency tracheotomy may be performed (Fig. 10.2, Fig. 10.3, Fig. 10.4)
	• Blood work	• Arterial blood gas • Venous blood gas • Complete blood count • Fibrinogen • Chemistry • Lactate
	• Radiology	• Easier in the smaller of the large animal species or neonates. Look for consolidation (radiopaque areas), comet tails, and fluid.
	• Ultrasound	• Look for fluid and abscesses
	• Miscellaneous	• Perform endoscopic evaluation of the upper airway, transtracheal wash, or bronchoalveolar lavage.

Treatment	• Oxygen therapy	• Equipment to have available:
		    • A wall hookup or a portable oxygen tank
		    • Various sizes of masks, as well as nasal cannulas
		    • All oxygen tubing
		    • A nebulizer, sterile water for the nebulizer, and a flow meter (Fig. 10.5).
		    • A demand valve and Ambu bag should also be available for smaller species and neonates that are intubated due to respiratory distress.

	• Miscellaneous	• Thoracocentesis to remove any fluid from lungs. Chest tubes may be secured and left in place to facilitate continued draining (Fig. 10.6). • Isolate the patient if its condition is suspected of being transmissible to other patients or zoonotic. Wear protective gear such as caps, masks, gowns, and gloves.

	• Medication	• Bronchodilators, stimulants, antiinflammatory, aminophylline, and glycopyrrolate
		    • *Bronchodilators:* Epinephrine, albuterol, clenbuterol, atropine
		    • *Stimulants:* Doxapram hydrochloride (Dopram®), caffeine
		    • *Antiinflammatory:* Dexamethasone
		    • Respiratory smooth muscle relaxant: Aminophylline
		    • *Glycopyrrolate*: Antimuscarinic agent for treatment of COPD

Monitoring	• Respiratory rate • Depth and effort	

	• Mucous membrane color

Figure 10.2 Tracheostomy site (courtesy of Jennifer Horner).

Figure 10.3 Tracheostomy tube (Bivona®) placement.

Figure 10.4 Tracheostomy tube (Bivona®) placement.

Figure 10.5 Oxygen supply from wall source (courtesy of Jennifer Horner).

Figure 10.6 Chest tube placement (courtesy of Jennifer Horner).

Table 10.6 / Ophthalmic Emergencies

Causes	• Orbital trauma (Fig. 10.7), fractures of the orbit, eyelid lacerations, corneal lacerations (Fig. 10.8), ulcers (Fig. 10.9), or infection (bacterial and/or fungal), keratitis, uveitis, blindness, foreign body, globe rupture, iris prolapse (Fig. 10.10 and Fig. 10.11)	
Triage: By Telephone	• General	• Protect the animal from rubbing the eye or causing self trauma. It should be evaluated and have treatment instituted immediately.
Triage: At Evaluation	• General	• Initial examination should include examination of both eyes to determine whether the emergency is just related to one eye and to get a baseline of normal for that patient. It is important

			to gauge the patient's pain by looking at the eye and observing the animal's behavior (squinting, keeping the eye tightly closed, blinking frequently, displaying sensitivity to light), and performing baseline TPR values. • Diagnostics include examination with ophthalmoscope, slit lamp, and tomometer, as well as various corneal stains. • If the eye is lacerated or if there is a laceration near the eye that needs surgical intervention, it is always a good idea to evaluate the eye itself for trauma. • Ophthalmic emergencies can progress quickly, and small problems can progress to major problems in a matter of hours. Remember to prevent self trauma.
Clinical Signs	• Obvious eye trauma, ocular discharge, animal rubbing eye (irritated), squinting, light sensitive, walking in circles, panic, head shy, head tilt, easily startled, appearing to be blind, walking in circles		

Diagnostics	• Physical exam	• A complete physical should be performed, paying special attention to the animal's mentation and level of awareness if skull trauma is involved. Pay special attention to the patient's history. Use caution with sedation if brain trauma is suspected.
	• Ophthalmic exam	• Evaluate both eyes, especially in older animals where there already may have been a symmetrical visual deficit that the owner was unaware of. Evaluate menace, papillary light response (PLR), discharge, and dazzle.
	• Cytology	• A corneal scraping may be performed and sent for cytology before treatment starts to determine if the medication needs to be changed.
	• Special ophthalmic equipment used	• Ophthalmoscope • Slit lamp • Tomometer • Different eye stains (fluorescein, Rose Bengal)
	• Blood work	• Complete blood count • Fibrinogen
	• Ultrasound/ Radiology	• Can be used to evaluate the orbit and other structures around the eye. • Can detect fractures in structures around the eye.

Treatment	• Subpalpebral lavage (equine)	• Device for administration of liquid ophthalmic medication. • Medication is delivered directly into the eye through tubing that is attached to a "foot" that sits under either the upper or the lower eyelid (Fig. 10.12).
	• Topical medications	• Topical ointments or drops can be used. • Use caution not to further damage the eye. (Use a gloved finger to administer, if necessary.)

	• Medication	• Mannitol, glycerol, topical and local anesthetics, corneal stains, and mydriatic medications, ophthalmic medications; antibiotic, antifungal, antiinflammatory, serum, atropine
		  • *Reduces intraocular pressure (IOP):* Mannitol, glycerol
		  • *Topical anesthetics:* Proparacaine hydrochloride, tetracaine
		  • *Local anesthetics:* 2% mepivicaine
		  • *Stains:* Fluorescein strips, Rose Bengal
		  • *Mydriatic:* Atropine

	• Surgery	• Surgery may be necessary to repair a laceration or to perform corneal restoration.
Monitoring	• Monitor patient for self trauma. Use of an eye cup may be necessary. Also pay attention to light sensitivity, whereas a fly mask may be used. • Monitor animals on atropine for manure production. These animals (especially equine) should be walked multiple times daily to prevent an impaction. (Atropine causes rumen atony. This should also be noted.)	

Figure 10.7 Blunt ocular trauma (courtesy of Dr. Mary Utter).

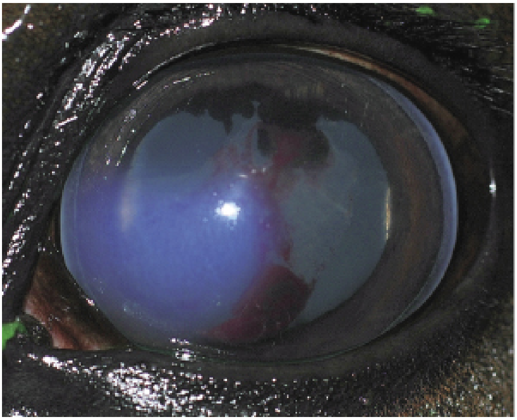


Figure 10.8 Corneal laceration (courtesy of Dr. Mary Utter).

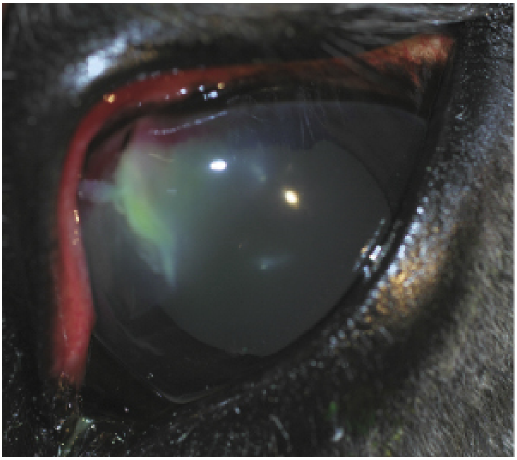


Figure 10.9 Melting corneal ulcer (courtesy of Dr. Mary Utter).

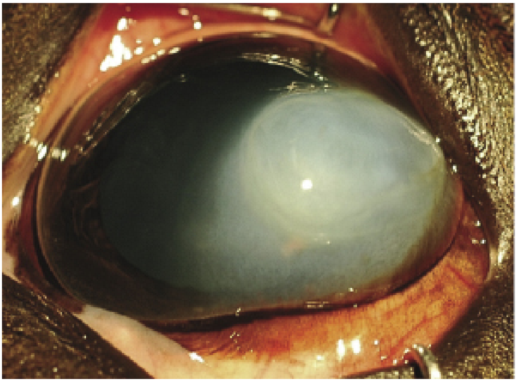


Figure 10.10 Traumatic iris prolapse (courtesy of Dr. Mary Utter).

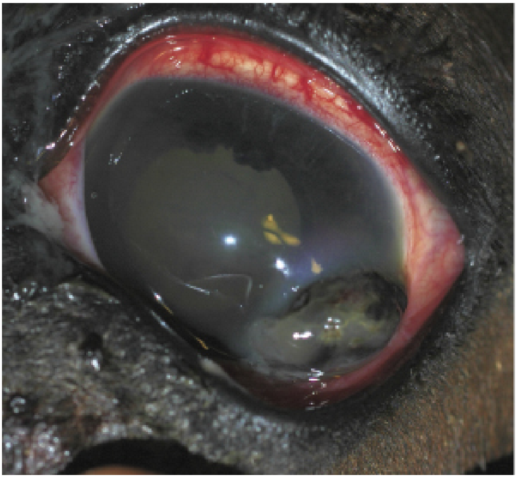


Figure 10.11 Ulcerative iris prolapse (courtesy of Dr. Mary Utter).

Figure 10.12 Subpalpebral lavage placement (courtesy of Dr. Mary Utter).

Table 10.7 / Gastrointestinal Emergencies

Causes	• *Colic:* Vovulous/torsion, impaction, strangulating lesion, foreign body obstruction, displacement, parasite overload. *Hernias:* Inguinal, scrotal, diaphragmatic. Peritonitis, colitis, clostridium, salmonella, neoplasia, rectal prolapse, atresia coli, atresia ani, neoplasia (lymphosarcoma), bloat, RDA,

	abomasal emptying defect, intussusception, and grain overload.	
Triage: By Telephone	• Colic	• Do not feed until evaluated. • How long has the animal been colicky? • Is the patient violently uncomfortable? • What are the TPR values? • Is the animal passing manure? • Has the patient had any recent change in routine?
	• Diarrhea	• How long has the animal had diarrhea? • Has the animal recently been on antibiotics? • Does this seem to be a herd problem? • Isolate from other animals until seen by veterinarian and until evaluated for infectious disease (salmonella).
Triage: At Evaluation	• General	• Evaluation should begin with a complete physical, including a heart rate, temperature, and respiration. The patient should be evaluated using these tools for the level of pain, especially in cases of equine colic or displaced/torsed abomasum in ruminants. • It is important to evaluate the animal for any signs of vomiting or regurgitation; and in the equine patient, it is lifesaving to pass a nasogastric tube to decompress the stomach, if necessary (Skills Box 10.2). • Once the patient is stable, evaluate borborygmi and note

			rumen motility in ruminants. The animal should also be evaluated for gas, indicated by "pings."
			• *Blood work includes:*
			  • Packed cell volume
			  • Total protein
			  • Lactate
			  • Venous blood gas
			  • Chemistry profile
			  • Creatinine
			  • Complete blood count
			  • Fibrinogen
			• The clinician will perform a rectal exam and can try to determine if there are any abnormalities such as distention or displacement.
			• On some occasions ultrasound or radiographs are necessary to help support the presumed diagnosis and rule out diseases on the differential list.
			• If the lesion is thought to be surgical, the patient should be prepped for an exploratory laporotomy for the final diagnosis and attempted correction of the lesion.
			• Sometimes an abdominocentesis is performed to look at the integrity and cell count of the abdominal fluid. This is also used as a reliable diagnostic tool.
			• Intravenous catheters and intravenous fluids are usually implemented to stabilize and treat the patient at the veterinarian's discretion. Some patients may be able to be treated with oral fluids through either a nasogastric or an

		orogastric tube (Skills Box 10.2). • In patients with either gastric reflux/vomiting or diarrhea, it is important that those losses are taken into consideration when monitoring the patient to keep the intake greater than the outs. • If the patient has diarrhea, it should be isolated immediately until tested for infectious and potentially zoonotic diseases, such as salmonella.
Clinical Signs	• Pawing, rolling, looking at flank, kicking at abdomen, depression, anorexia, weight loss, decreased or absent manure production, abdominal distention, tachycardia, sweating, restlessness, lying down more than usual, diarrhea, rectal prolapse, decrease in milk production	

Diagnostics	• Physical exam	• A complete physical exam should be performed to rule out other disorders with some of the same clinical signs (e.g., toxicological, reproductive, and urogenital emergencies). If diarrhea is present, the animal should be isolated until testing can be completed to rule out an infectious or zoological cause, like salmonella. • Listen for a diagnostic "ping" in ruminants suspected of having a displaced abomasum.
	• Rectal exam	• A rectal or digital (if a neonate or small species) exam should be performed to feel for any anatomical abnormalities.
	• Blood work	• Venous or arterial blood gas • Lactate • Chemistry panel • Complete blood count • Fibrinogen
	• Ultrasound	• Helpful diagnostic tool for looking at the small intestine and colon. Also helpful in looking for fluid for abdominocentesis.
	• Abdominocentesis	• Used to detect peritonitis or bowel rupture. The area that is usually clipped and prepared at the lowest point of the abdomen just caudal to the Xiphoid process on the ventral midline. • Just to the right of midline usually is preferred to avoid sticking the spleen.

	• Trocarization (of cecum)	• Used to decompress the cecum of gas. May be performed before surgery to lessen the chance of rupture by relieving gas or in nonsurgical cases to relieve pressure that may lead to a resolution of simple colic. • Procedure is performed in the right paralumbar fossa where the gas "ping" was heard.
	• Radiographs	• Not a good diagnostic tool for larger species, but can be used to detect sand in smaller equine species and neonates. • Contrast radiographs may be taken after barium administration.

Treatment	• Medical treatment	• NPO, nasogastric intubation used for decompression or administration of a medication (cathartic, water, or electrolytes) or to reflux the patient) (Skills Box 10.2) • If a nephrosplenic entrapment is suspected, patient may be administered phenylephrine and jogged or lunged. The patient may also be placed under general anesthesia and rolled.
	• Surgical treatment	• Exploratory laporotomy to diagnose and correct the problem. Resection with anastamosis may be performed. In bovine or small ruminant patients, an exploratory will usually be performed through the flank, with the patient in standing stocks.
	• Miscellaneous	• For rectal prolapse, a purse-string suture may be used to hold the prolapse in until fully resolved.

	• Medication	• Antispasmodic, NSAID, antiemetic, antidiarrheal, antiulcer, prokinetic, cathartic, and absorbent medications. Also phenylephrine for nephrosplenic entrapment and plasma.
		  • *Antispasmodic:* Butylscopolamine (Buscopan®), dipyrone (no longer available)
		  • *NSAID:* Flunixin meglumine

			• *Antiemetic:* Metoclopramide, erythromycin • *Antiulcer:* Omeprazole, ranitidine, cimetidine, sucralfate • *Prokinetic:* Lidocaine • *Cathartic:* Mineral oil, magnesium sulfate • *Protectants/Absorbents:* Psyllium, Bio-sponge®, bismuth subsalicylate, kaolin pectin, activated charcoal • *Other:* Phenylephrine (used to cause splenic contraction for aiding in the correction of left dorsal displacement), plasma, loperamide (antidiarrheal)
Monitoring	• Monitor closely for any further signs of colic. • Monitor reflux, and pay close attention to ins/outs. • Monitor intravenous fluids if indicated. • Monitor abdominal distention.		

Skills Box 10.2 / Procedure for Nasogastric Intubation in the Equine Patient

Supplies:

- Nasogastric tube
- Buckets
- Dose syringe (450 ml)
- Warm water
- Bilge pump
- Funnel

Procedure:

1. Hold a hand on the patient's muzzle to help steady its head. (Make sure that you are not occluding other nostril.)

2. Lubricate the tube with water, lube, or viscous lidocaine. Insert the nasogastric tube medial and ventral into the nostril, with the tube curved ventrally (downward).

3. If you feel bone, stop, back out, and try to pass past the turbinates. **Never force the tube.**

4. Once you feel a "bouncy" resistance, you should be at the nasopharynx.

5. Once at the pharynx, rotate the tube 180° and wait to advance the tube with a swallow. The tube should be curved dorsally (upwards), to aid in anatomical approach into the esophagus.

6. You should feel the resistance of the esophagus. If the horse is agitated and begins coughing, and you have no resistance at all, you are probably in the trachea.

7. You should be able to see the tube pass down the esophagus (on the left), and you should be able to feel the tube. Be mindful of the tube's movements, and make sure not to confuse the tube with the carotid pulse.

8. You should also attach a dose syringe and check for negative pressure.

9. An average horse should take a 9-foot long tube with no problems. The usual diameter is 1/2 inch.

10. Make sure not to force the tube, as it can kink on itself and double back.

11. Check for reflux by creating a siphon, by either aspirating or infusing water.

12. Always check for reflux before administering medications or large amounts of water via the nasogastric tube.

13. Always clear the tube, kink the tube before removing it, and steady the horse's head. Pull in a steady, downward sweeping motion.

Common medications delivered via nasogastric tubes:

- Water with electrolytes (isotonic), mineral oil, $MgSO_4$ (Epsom salts), psyllium

Table 10.8 / Neurologic Emergencies

Causes	• Rabies, West Nile virus, equine protozoal myelitis, encephalitis (viral/bacterial), meningitis, trauma, wobblers disease, equine herpesvirus 1(EHV-1), equine motor neuron disease, hyperkalemic periodic paralysis, myopathy, myositis, white muscle disease, liver disease, cerebral abscess, peripheral nerve disease, embolism, cerebral swelling, motor neuron disease, liver disease, polio, *Parelaphostrongylus tenuis* (*p. tenuis*), parturient paresis

Triage: By Telephone	• General	• Check patient's vaccine status, **especially rabies** (WNV, botulism, and tetanus in endemic areas). • Is the animal recumbent?
	• Seizures	• Keep the animal calm, and **do not stimulate.** • How long has the patient been seizuring?
Triage: At Evaluation	• General	• Before working on any neurologic emergency, always speak to the owner and the veterinarian regarding rabies vaccine status. If rabies vaccine status is not known, precautions should be taken to ensure the safety of everyone involved. (Double gloves, face shields, and gowns should be worn; and caution labels should be placed on any blood or bodily fluid obtained from the patient.) A log of persons in contact with the animal should be kept, and then contact should be limited. Ask about other vaccines, such as West Nile virus and botulism in the equine patient, as well as tetanus. • In the case of a neurologic animal, it is very important to evaluate the animal's gait closely. If the animal is referred into the clinic, it is a good idea that the veterinarian and technician are present to watch the animal from presentation off the trailer. If the patient is stable, then a full neurologic evaluation should be performed by the veterinarian. It is the technician's role to maintain the animal safely and understand the needs of the veterinarian during the exam. • If the patient is recumbent, this provides a greater challenge for all involved. If the patient is maintained at

		the farm, it is important that the person involved in managing the animal understands that the animal will need supportive therapy, including changes in recumbency, and nutritional support. It is usually in the best interest of the animal to be referred to a clinic that can maintain it and provide the supportive therapy necessary. The animal can be pulled onto a trailer with the use of a sled and can be removed from the trailer using the same method and a great deal of assistance. The animal should be placed in a location that has a rated hoist and sling available, if necessary. • Diagnostics include recent history, blood work, and a possible sample of the cerebral spinal fluid.
Clinical Signs	• Ataxia; stumbling; tripping; swaying; weakness; head pressing; low head carriage; head tilt; stiffness in neck, back, or limbs; recumbency; falling over; collapse; paralysis, paresis; loss of hind limb sensation; muscle fasciculations; colic; ptyalism; depression; seizures	

Diagnostics	• Physical exam	• A complete physical exam should be performed to rule out a toxicological or gastrointestinal problem as the underlying problem. It is best to use caution during examination as these patients may be unstable. The signs may have come on acutely, and the patient may deteriorate rapidly. If the animal does not have a current rabies vaccine history, it is important to take proper precautions if rabies is a possible differential.
	• Neurologic exam	• A full neurologic exam should be performed with caution. If the animal can ambulate, pay close attention to gait and proprioception. Make note whether any lameness or ataxia is symmetrical or asymmetrical.
	• Blood work	• Complete blood count • Chemistry panel • Fibrinogen • Venous blood gas • Lactate • Serum for specific neurologic disorders
	• Radiographs	• May be taken of the spine. In an adult equine patient, these are usually performed while the horse is under general anesthesia and lateral. Sometimes contrast radiographs (e.g., myelogram) are performed.
	• MRI	• Depending on the size of the MRI unit and the patient, anywhere from the head to the entire body may be examined.
	• CSF tap	• A sample of the cerebrospinal fluid may be taken to have the cells and

		protein level evaluated. Samples may also be sent away for diagnostics since some diagnoses are more definite from CSF samples than those of serum (e.g., WNV and EPM). Samples may be taken from the atlantooccipital space (under general anesthesia) or the lumbosacral space.
Treatment	• Supportive therapy	• Keep the animal isolated if the disease could be infectious. If the animal is ataxic or unstable, do not move it and use caution when treating. Have options available to sling the patient to standing if weak or unable to rise (Fig. 10.13, Fig. 10.14, and Fig. 10.15). Turn the patient frequently if recumbent to avoid sores or decubital ulceration. If the patient is unable to eat or drink, parenteral nutrition may be necessary.
	• Medications	• Antiinflammatory medications, antiseizure medications, antiprotozoal medications, and muscle relaxants • *Antiinflammatory:* DMSO (also known to improve antiprotozoal uptake), mannitol • *Antiseizure:* Diazepam, phenobarbital, potassium bromide • *Muscle relaxant:* Methocarbamol • *Antiprotozoal:* Ponazuril, primethamine sulfadiazine, diclazuril, toltrazuril sulfone
Monitoring	• Monitor for any signs of deterioration. If the animal is still standing and mobile at the time of treatment, it will likely remain standing.	

Figure 10.13 Horse in the Anderson Sling®.

Figure 10.14 Alpaca in the Davis Large Animal Lift®.

Figure 10.15 Alpaca in the Davis Large Animal Lift®.

Table 10.9 / Reproductive Emergencies

<table>
<tr><td rowspan="2">Causes</td><td>Dam</td><td>Dystocia:
Fetal origin: Due to atypical presentation, fetal/dam disproportion, twins, or fetal anomaly (hydrocephalus, congenital defect) dead fetus
Maternal origin: Due to mechanical failure of dam, hydrops, body wall tear, vaginal tear, uterine torsion, red bag, uterine artery hemorrhage, abortion, retained placenta, prolapsed uterus, post-foaling colic in mares (large colon vovulous most common), metritis (septic), mastitis</td></tr>
<tr><td>Sire</td><td>Paraphimosis, castration complications (evisceration, peritonitis, edema, hemorrhage), scrotal herniation, penile laceration, penile hematoma, testicular torsion, trauma</td></tr>
<tr><td>Triage: By Telephone</td><td>Dystocia</td><td>How many days of gestation?
What is the stage of her labor?
How long has the dam been in labor, and was someone there from the start?
Has there been any attempt at assisted delivery?
Is a C-section an option?
Who is more valuable—the dam or the fetus?
Send to referral clinic immediately for best outcome. (This depends upon the type of practice.)</td></tr>
</table>

Triage: At Evaluation	• General	• Reproductive emergencies are sex specific, and vary dramatically based in this. • For the female, most reproductive emergencies are parturition related and must be evaluated as soon as possible to try to maintain her breeding integrity. Some problems can occur during breeding itself, and these must be evaluated early to ensure breeding soundness. A palpation exam is usually performed, as well as a possible rectal ultrasound for determination of fetal viability and the health of the placenta. • If a mare presents colicky postpartum with a low packed cell volume, she may have a uterine artery rupture and should have an appropriate blood donor identified. • For the male, it is important to know if the male is still intact. If the male was recently castrated, the problem could be related to the castration site. Once again, these emergencies (in the intact male especially) should be assessed as soon as possible to maintain breeding integrity. • Stallions should not be sedated with acepromazine, as it may cause paraphimosis.
Clinical Signs	• Abdominal discomfort, straining, dull/depressed, off feed, frequent lying down and getting up, generalized signs of agitation, pawing, kicking at abdomen, low-hanging abdomen, signs of shock, large amounts of bleeding	

Diagnostics: Sire	• Physical exam	• It is important to get a history including whether the animal is a breeding male. A full physical should be performed, paying special attention to the penis and testicles.
	• Treatment	• Have hemostats ready in case bleeding is present due to castration complications. • Hydrotherapy is used to aid in the treatment of many male penile emergencies, including castration complications and swelling of the prepuce and sheath.
	• Monitoring	• Monitor for urination, as well as for swelling/new swelling. A penile sling may be used as a support for male animals with significant swelling or paraphimosis.
	• Miscellaneous	• Do not sedate a breeding stallion with acepromazine, as it may lead to further complications of paraphimosis.

Diagnostics: Dam	• Physical exam	• A complete physical exam should be performed on the dam, and also include as much of a fetal exam as possible. It is important to ask the owner which one is more valuable if it comes to a decision of dam or fetus. In some large breeding operations, the owner or farm manager will indicate which is more valuable, either due to breeding or sentiment. It is important to rule out colic in mares, as a large colon vovulous may be the true cause of pain.
	• Ultrasound	• A very good diagnostic tool for detecting how many fetuses there are and to detect fetal viability. Often, a fetal heartbeat can be detected. Ultrasound can be used to detect a body wall tear or any internal bleeding (e.g., broad ligament or uterine artery).
	• Vaginal exam	• A vaginal exam can be performed as aseptically as possible to detect the position of the fetus for delivery. The cervical dilation can also be gauged.
	• Rectal exam	• Used to rule out colic or any other possible gastrointestinal involvement
	• Telemetry	• Can use telemetry to obtain a fetal ECG/heart rate. Tracking the fetal heart rate is an easy way to detect whether the fetus is under stress.
	• Uterine lavage	• The uterus may be lavaged with sterile lubricant during parturition to aid in delivery. Most commonly the

		dam is lavaged with warm sterile water postpartum to clean the uterus of any placental remnants or stagnant fluid.
Treatment	• Assisted delivery	• For mares and cows, the use of obstetrical chain or nylon web straps are used to assist in a delivery if the dam is either standing or under general anesthesia in dorsal recumbency (Figure 10.16 and Figure 10.17). A snare can be used for smaller species like goats and sheep. Use caution with this method to avoid causing damage to the dam that might impair further breeding soundness. A snare may be used with smaller species, such as goats and sheep. • If the fetus is dead and unable to come out vaginally with minimal assistance, a fetotomy may be performed. (Use caution in animals that are solely used for breeding, as this may hinder future reproductive soundness.)
	• Caesarian section	• Used when vaginal delivery will cause excessive trauma to the fetus or dam, when the position of the fetus makes vaginal delivery impossible, or if there is a disproportionate fetal/dam size. Remember that any anesthetic agents the dam receives will also be circulated through the fetus. This approach should be used if it seems that there will be reproductive damage to an animal that is intended only as a breeding animal.
	• Medications	• Oxytocin, clenbuterol, Regumate®,

		• Oxytocin, clenbuterol, progesterone, progestin
Monitoring	• Monitor the dam for any signs of abortion or labor if continued to be monitored periparturiently. If the fetus has been delivered, monitor the dam for any signs of bleeding or reproductive trauma, such as prolapsed uterus or vaginal tear, and always check for a twin.	

Figure 10.16 Calf during a dystocia birth (courtesy of Jennifer Horner).

Figure 10.17 Calf during a dystocia birth (courtesy of Jennifer Horner).

Table 10.10 / Toxicological Emergencies

Causes	• Maple leaf toxicity, heavy metals poisoning, copper toxicity in ruminants, snake venom from bite, venomous spider bite, insecticide poisoning (Amitraz in horses), atropine toxicosis (either via improper administration or from natural occurrence of the substance (jimsonweed, belladonna, potato foliage), black locust toxicity, blister beetle ingestion, buttercups, castor bean plant seeds and foliage, horse chestnut, oak, organophosphate and carbamate insecticides, tobacco, arsenic, mercury, salt, ammonia, clostridial diseases (*C. botulinum and C.tetani*), bracken fern, lead, ryegrass, aflatoxicosis, iron toxicity in newborn pigs, black walnut, ionophore antibiotic poisoning in horses, Japanese yew toxicity, oleander toxicity, anticoagulant rodenticide poisoning, wild onion toxicity, NSAID toxicity, mercury poisoning, cyanide poisoning, marijuana ingestion, algal poisoning (blue-green algae), fluoride poisoning, herbicide poisoning, mycotoxicoses

(Triage: By Telephone	• General	• What is the animal currently eating? If referred, bring a sample with you for toxicological screening. • Has the animal had access to another species' grain or eaten a toxic plant? • Are there any old cars, machinery, batteries in the pasture? • Ask about the water source and any changes to it.
	• Vomiting	• Vomiting or regurgitation will not be seen in equine patients or ruminants, but it can be seen in other species that may have eaten something toxic. • Did the animal eat something abnormal or get out of the field and have access to a toxic plant? • How long has the animal been vomiting?
Triage: At Evaluation	• General	• For toxicological emergencies a full physical exam is a good way to start. • Ask the owners if there has been any change to the diet or if the animal has eaten anything unusual that could be potentially toxic. Also ask about any vomiting or diarrhea. • In many cases where ingestion of a toxic substance is suspected, the animal may be given either an antidote or an absorbent to start with. Saline or oily cathartics are also sometimes used to accelerate defecation. Many of these animals will need to have either a nasogastric or orogastric tube passed to deliver the treatment. • Any unknown feed samples or exposed substances can be evaluated by a toxicology lab for complete diagnosis of the toxin. These results may take days or weeks to come

		back, so treatment should be based on clinical signs and supportive care. • For some conditions as in maple leaf toxicity in the equine patient, some diseases attack red blood cells. The patient may need to be evaluated for a blood transfusion and a proper donor may need to be identified. • If an antivenin is used in the case of envenomation, it is very important to monitor the patient closely, as the antivenin could also be toxic.
Clinical Signs	• Signs of colic, neurologic disease, dull attitude, many animals on property showing signs of illness, laminitis, gastrointestinal ulceration, bloat, vomiting, diarrhea, hyperesthesia, seizures, collapse, sudden death, sweating, diarrhea, increased salivation, dysphagia, trembling, weak tongue (Fig. 10.18), tail, anal, and eyelid tone, recumbency, weakness, laryngeal paresis, acute blindness, excitement, abortion, heart arrhythmias, anorexia, icterus, hemolysis, Heinz body formation, methemoglobinemia, anemia, abnormal mucous membrane color, teeth staining, edema in various areas, hemoglobinuria, hematuria, uticaria (hives) (Fig. 10.19)	

Diagnostics	• Physical exam	• A complete physical should be performed, along with a detailed patient history of feed material and plants/trees/soil at the farm. Evaluate mucous membranes, as they are a good indication of toxic changes within the body, as well as perfusion. Ask the owner if the animal is up-to-date on botulism vaccine in endemic areas where *C. botulinum* is suspected.
	• Blood work	• Complete blood count • Fibrinogen • Complete chemistry panel • Arterial blood gas • Lactate • Serum submitted to a toxicology department for elemental testing • Coombs test
	• Urinalysis	• May be helpful to check urine pH, as well as to look for hemolyzed blood (e.g., maple leaf toxicity)
	• Feed and environmental testing	• Samples of feed, trees, soil, and other potentially ingested materials may be sent in for toxicological studies to detect heavy metals poisoning or toxic plant exposure.
	• Gastric intubation	• Passage of a nasogastric or orogastric tube to remove any toxins from the gastrointestinal tract. It can be used to lavage the stomach and also to administer activated charcoal if indicated.

Treatment	• Antidote or antiserum	• An antidote may be available if the causative agent is known. Botulism antiserum for the treatment of *C. botulinum*, sodium thiosulfate.
	• Medications	• Antidotes, adsorbents, cathartics, detoxicants, antihistamines, bronchodilators, diuretics, gastrointestinal protectants, epinephrine, muscle relaxants, isotonic intravenous fluids, NSAIDs, thiamine, vitamin E, ammonium molybdate for copper poisoning • *Adsorbent:* Activated charcoal • *Antidotes/Detoxicants:* Ammonium molybdate (Cu poisoning in sheep), atropine (bovine organophosphate toxicity), calcium EDTA (for lead poisoning), lactulose (ammonia detoxicant) • *Saline cathartics:* Sodium sulfate and magnesium sulfate used in equine patients • *Oily cathartics:* Mineral oil • *Antihistamine:* Diphenhydramine • *Bronchodilator:* Aminophylline • *Diuretic:* Mannitol • *GI protectant:* Kaolin, sucralfate • *Inotropic agent:* Epinephrine • *Muscle relaxant:* Methocarbamol • *Other:* Whole blood (for treatment of red maple leaf toxicity in equine patients as an example), mild dish detergent (to wash off topical toxins), polyethylene glycol with electrolytes (used in smaller species for whole bowel

	• Other	• For red maple leaf toxicity, a whole blood transfusion may be indicated. Oxygen therapy may be used to help carry oxygen through the body and help with perfusion until a transfusion is performed (if warranted).
	• Supportive Care	• For patients with botulism, care must be taken to manage them if they become recumbent. The use of mattresses, mats, and thick bedding and availability of a sling is ideal, as well as appropriate staff to help with turning and standing the patient (Fig. 10.20). • For patients with wounds related to the cause of intoxication, as in with clostridial diseases or snake bites, take care to clean and address areas such as fasciotomy sites (Fig. 10.21), or bites
Monitoring	• Monitor closely for signs of deterioration. Look for neurological changes or deficits and evaluate the mucous membranes for signs of toxic indication. Evaluate the patient's urine and note its color, especially looking for blood tinge. Ask the owner or farm manager to bring in feed, soil, and plant samples. Ask the owner to monitor animals still at the farm for similar signs.	

Figure 10.18 Loss of tongue tone due to botulism.

Figure 10.19 Uticaria (hives) in a mare.

Figure 10.20 Recumbent weanling recovering from botulism.

Figure 10.21 Fasciotomy site.

Table 10.11 / Metabolic Emergencies

Causes	• Hypocalcemic tetany in horses (eclampsia); transport tetany in horses and ruminants; parturient paresis in cows, sheep, and goats (milk fever); hypomagnesemic tetany in adult cattle and sheep, as well as calves; hypophosphatemia; fatigue; fever of unknown origin; hepatic lipidosis;

	pregnancy toxemia; ketosis in cows; malignant hyperthermia in swine; hyperglycemia; hypoglycemia; hyperkalemia (hyperkalemic periodic paresis in horses); lactic acidosis; laminitis; rhabdomyolysis (tying up in equine patients)	
Triage: By Telephone	• General	• Is the animal standing? • What is the animal's temperature? • Is the animal currently on any medication or being supplemented for a condition?
Triage: At Evaluation	• General	• For metabolic emergencies, a full patient history and physical exam, as well as blood work, should be performed. • Blood work should include a comprehensive electrolyte panel.
Clinical Signs	• Depression, dull, fever, increased muscle tone, stiffness in gait, decrease in milk production, tremors, prolapse of third eyelid, cardiac arrhythmia, recumbency, dystocia, bloat, impaction, dull hair coat, poor body condition	

Diagnostics	• Physical exam	• A complete physical must be performed by the veterinarian to diagnose the problem. The metabolic disorder may be the secondary diagnosis, as the patient may present with a more prominent complaint.
	• Blood work	• Complete blood count • Fibrinogen • Full chemistry panel • Electrolyte panel • Testing serum for trace minerals • Lactate • Venous blood gas • Liver panel
	• Urinalysis/ Dipstick	• Useful to use urine dipstick for the diagnosis of ketosis
	• Radiographs/ Ultrasound	• May be used to localize cause of a FUO in case it is a walled off lung abscess
Treatment	• Electrolyte replacement	• In the case of a deficiency, the treatment must be started as soon as diagnosis is made by the veterinarian, but not before the return of all blood work. • In animals with fatigue, especially racehorses, offering them salt water or a salt lick is helpful for replenishment.

	• Medications	• Electrolytes, dextrose, hypertonic saline, Mannitol, and insulin
		  ◦ *Electrolytes:* Sodium chloride, calcium gluconate, phosphorus, magnesium
		  ◦ *Hormones:* Insulin
		  ◦ *Other:* Mannitol, hypertonic saline, dextrose

Monitoring	• Patient should be closely monitored for any signs of deterioration. Temperature and milk production should be closely monitored. If the patient is recumbent, care must be used to attempt standing and turning to avoid sores. Hydrotherapy may also be used in cattle, sheep, and goats that are showing signs of weakness.

Table 10.12 / Neonatal Emergencies

Causes	• Dystocia, hypoxemia, prematurity, dysmaturity, postmaturity, hypoxic ischemic encephalopathy, sepsis, colic (meconium impaction, intussesception, enterocolitis), hepatoencephalopathy, ruptured bladder, limb laxity, limb contracture, loss of suckle, pneumonia, peripartum asphyxia (neonatal maladjustment syndrome), pneumonia (meconium aspiration), hypothermia, metabolic abnormalities, hypoglycemia, respiratory arrest, cardiac arrest, failure of passive transfer, neonatal isoerythrolysis, patient urachus	
Triage: By Telephone	• Weak/Not nursing	• Did the neonate ever stand after birth? • Did the neonate nurse at all? • Does the neonate have a suckle? • When was the animal born? • Transport carefully with dam if stable enough or where patient can be held/ stabilized by someone. • Do NOT feed if the patient is unresponsive, has a poor suckle, or is hypothermic. **The animal must be assessed immediately.**
	• Seizuring	• How long has the animal been seizuring? • Should been seen by a veterinarian as soon as possible. Refer to a clinic, if necessary.
	• General	• When was the neonate born? • Was the neonate the product of a dystocia birth? • Was the birth attended? • Did the neonate nurse from the dam?

Triage: At Evaluation	• General	• For neonate emergencies, it is important to have detailed information regarding labor and delivery, as well as any other pertinent information about the pregnancy (was the dam treated for anything?). It is important to ask if the neonate has been able to stand and if it has nursed.
		• Important diagnostics include:
		  • *A physical exam:* TPR, mucous membrane evaluation, examination of limbs/joints, umbilical evaluation
		  • *Blood work:* IgG, arterial/venous blood gas (arterial recommended if it is likely the animal will need oxygen therapy), complete blood count, fibrinogen, packed cell volume, total protein, blood glucose, lactate, as well as full chemistry panel, including creatinine and bilirubin.
		  • A urine dipstick and specific gravity are also important diagnostics.
		• If it is suspected that the animal has a failure of passive transfer, either a substitute for colostrum may be necessary or hyperimmunized plasma should be on supply.
		• For neonatal foals that are suspected to be premature, they should be confined to lying on a mat or kept in a confined area until the cuboidal joints are radiographed before being allowed to stand or move around.
		• Both radiographs and ultrasounds are valuable diagnostic tools for neonates, to diagnose anything from pneumonia to ruptured bladder.
		• For neonatal foals presenting with a low packed cell volume, neonatal

		isoerythrolysis may be the case, and an appropriate blood donor should be identified if necessary. • Ventilator support may be necessary for respiratory therapy.
Clinical Signs	• Dull, lack of suckle, circling, unable to stand, weakness, hypothermic, pyretic, dehydration, forgetting how to nurse, seizure activity, labored breathing, lack of tone, swollen joints, tachycardia, bradycardia, unresponsive	

Diagnosis	• Physical exam	• A complete physical should be performed, along with a detailed history of gestation, labor and delivery. Questions to ask as part of the history should include:
		  • Was the birth attended?
		  • Did the neonate stand and nurse?
		  • Did the neonate receive any supplementation in the form of colostrum or plasma?

	• Blood work	• Complete blood work should be submitted:
		  • Arterial blood gas (should be obtained before the start of oxygen therapy if situation permits)
		  • Packed cell volume
		  • Total protein
		  • Blood dextrose
		  • Lactate measurement
		  • Complete blood count
		  • Chemistry panel
		  • Fibrinogen
		  • IgG level
		• A blood culture should also be taken before any antibiotic treatment isstarted.

Treatment	• Intravenous access	• Intravenous access should be attempted as soon as possible, with the jugular veins in most species being used (ear veins in piglets, cephalic in pygmy goats). In many cases an over-the-wire catheter is preferred for jugular vein catheterization and many times with multiple lumens (for incompatible drugs and for parenteral nutrition).
	• Oxygen therapy	• It is important to have flow by oxygen available for these patients. After the blood gas has been submitted, a nasal cannula should be introduced (measured first from nares to medial canthus of the eye), and attached to tubing connected to an oxygen source with a nebulizer and flowmeter.
	• Nutrition	• If the neonate is able to tolerate oral feedings, they can nurse from the dam or, if separated, nurse from a bottle or bucket (foals and calves) or have an indwelling feeding tube placed. Feeding should be approximately every 2 hours for small ruminants and foals, but usually every 8–12 hours for most calves. • If the patient is unable to tolerate oral feedings, then an intravenous parenteral nutrition is recommended. Total parenteral nutrition is preferred to partial, because it has lipids added in addition to the dextrose and amino acids.
	• CPR	• If the animal has arrested, CPR should be started. Having a crash cart available with emergency medications (epinephrine, atropine), as well as nasotracheal intubation tubes, is very important.

	• Ventilator	• If the animal is in respiratory failure and meets the size requirements, it may be maintained on a ventilator with PPV. Some neonatal foals with botulism (“shaker foal syndrome”) are placed on the ventilator due to involuntary muscle paresis.
	• Medications	• Epinephrine, atropine, antibiotics (ceftiofur sodium, potassium penicillin, cefuroxime), norepinephrine, vasopressin, dopamine, dobutamine, dextrose, IV fluids, potassium chloride, calcium
Monitoring	• Neonates should be monitored very closely for signs of deterioration. It may be ideal to keep the foal confined to a smaller area like a half stall or pen. When making this plan, take into consideration the mare and how she will tolerate the separation. If the foal is recumbent, it is ideal to use a thick mat or mattress for support (Fig. 10.22). The neonate should have their temperature, pulse, respiration, and respiratory rhythm and quality monitored frequently. Urination and manure production should be monitored closely, paying close attention for anuria, distended abdomen and straining. Monitoring the neonate's blood pressure is also very important, especially if the animal is on medication to adjust blood pressure. Closely evaluate animals on ventilator treatment; pay attention to the settings. It is important to make sure that the tracheal tube is in place and not leaking. These patients should be kept warm with heating pads and warm air blankets that circulate warm air. Heat lamps are also available, but make sure that they are not close enough to the patient to cause overheating.	

Figure 10.22 Foal on a mattress with mare separated by partition (courtesy Jennifer Horner).

Table 10.13 / Urogenital and Renal Emergencies

Causes	• Urethral blockage, bladder stones, urethral stricture, ruptured bladder, trauma, vaginal prolapse, kidney failure (acute and chronic), cystitis, dehydration	
Triage: By Telephone	• General	• When was the last time the animal was observed urinating? • Was the urine bloody? • Is the animal acting uncomfortable? • Is the animal drinking? • The animal should be seen and assessed immediately to rule out urethral obstruction to prevent rupture.
Triage: At Evaluation	• General	• Patient history should start with information about urination. When

		was the last time the patient urinated? Was it a normal amount and color (check for hematuria)? Does the animal appear painful, that is, vocalizing, straining, tachycardic, or tachypneic? Has the animal been urinating more frequently in small amounts or posturing to urinate with little to no urine? • An abdominal ultrasound, or in some cases radiographs, is usually warranted to look at the bladder, kidneys, and urethra, as well as the entire urinary tract. This is a good diagnostic tool used to detect any stones in the bladder or the urethra. In many species, a urinary catheter can be passed, with the exception of bulls, boars, and small ruminants. The inability to catheterize small ruminants is due to the sigmoid flexure of the urethra, and this usually indicates surgical intervention for “blocked” male goats in order to clear the urethra and bladder of stones. • In some cases of suspected anuria with a small bladder (noted from diagnostics), a urine catch may be placed on male animals. • Blood work is very important in evaluation of kidney function and should include creatinine level, BUN, full renal panel, as well as a packed cell volume, total protein, a complete blood count, fibrinogen, and chemistry panel.
Clinical signs	• Straining to urinate, anuria, polyuria, vocalizing, bloody urine, dull, anorexic, frequent posturing with either very little or no urine produced	

Diagnosis	• Physical exam	• A complete physical is necessary, paying close attention to abdominal distention and urogenital anatomy (vulva, penis). Anuria could be secondary to another condition (e.g., a neurologic issue like EHV).
	• Blood work	• A complete blood count and chemistry panel should be done. Special attention to kidney values is important (e.g., creatinine and BUN).
	• Radiographs	• Used in smaller species to identify stones
	• Ultrasound	• Used to evaluate the integrity of the bladder and urethra
	• Bladder catheterization	• Can be effective to relieve the bladder to avoid possible rupture. • Not effective in male goats and boars due to the sigmoid flexure, since it would need to be straightened out first. Bulls are also unable to be catheterized due to a fold of mucous membrane over the opening of the urethral diverticulum.

Treatment	• Surgical intervention	• A common procedure is a cystotomy. Urethrotomy is performed in males, as opposed to females, usually due to the small size of their urethral opening. If surgery is unsuccessful, a permanent urethrostomy is performed in males with recurrent problems.
	• Intravenous fluid therapy	• Used as support for the kidneys to overhydrate and cleanse of toxic buildup. In larger animals, dialysis is not an option for kidney failure, so administering fluids is usually the next best option.
	• Medications	• Ammonium chloride, phenazopyridine • *Other:* Bethanechol (for bladder atony), phenazopyridine, intravenous fluids to provide flushing of bladder and urinary tract
	• Miscellaneous	• *Intravenous fluids:* It is important to check blood work first.
Monitoring	• Animals with a Foley catheter should be monitored for urine production (Fig. 10.23). (Check to see if the tip is wet.) Monitor for urination, and use a urine catcher in male animals if necessary.	

Figure 10.23 Foley catheter in a goat.

Table 10.14 / Musculoskeletal Emergencies

Causes	• Fractures, radial nerve paralysis, laminitis, ligament and tendon damage (especially in distal limb), deep digital flexor tendon injury, suspensory apparatus damage, back/spinal fracture, cellulitis, rhabdomyolysis, trauma (lacerations, puncture, crushing)	
Triage: By Telephone	• Fractures/ Orthopedic	• Is the animal weight bearing? If there is a suspected fracture and is it open? Should be evaluated prior to referral to the surgery center. May need splint or

		bandage (which you should do yourself only if instructed by your veterinarian). Do not attempt to trailer the animal in a way or direction that is not typical for that particular animal.
Triage: At Evaluation	• General	• For musculoskeletal emergencies, it is first and foremost important to stabilize the injury. Once the veterinarian has evaluated the suspected injury—whether it be tendon, ligament, or bony in nature—a bandage may be placed. It is important to have a variety of bandage material at hand, including pound cotton, brown gauze, cast padding, and other wrapping materials like Vetwrap® or Elastikon®. • If the condition requires a splint, then have various sizes available. Splints can be purchased or made from PVC pipe cut in half and made to size. A Kimzey® leg-saver splint (Fig. 10.24) is also a good splint to have on hand. • Limiting movement is important. Radiographs should be performed as soon as possible if there is a suspected fracture. Ultrasound can be used to detect tendon or ligament damage.
Clinical Signs	• Lameness, non–weight bearing on a limb, shifting weight, tachycardia, tachypnea, wound with bony protrusion, lying down frequently, hesitant to lie down, grimacing, anorexic, increased heat in feet, and an increase in digital pulses in equine patients	

Diagnosis	• Physical exam	• If a fracture is suspected, stabilize first. • A complete physical should be done, including a TPR and full body system check. The animal may be suspected to be lame but may actually be ataxic and neurologic. • A history of what the animal was doing at the time of injury is also important if known, for example racing (in horses), or jumping off something (goats).
	• Blood work	• A complete blood count and fibrinogen should be performed. If the animal is going to surgery or being treated with NSAIDs, additional testing (e.g., creatinine) may be warranted.
	• Radiographs	• Radiographs should always be performed to detect a fracture, especially if the injury is localized
	• Nuclear scintigraphy	• Valuable at detecting more subtle areas of inflammation or bony change. Takes more time to do this procedure, and there is a 24-hour holding period after the animal is injected with the radioactive isotope. Special equipment is needed.
	• Ultrasound	• Useful in evaluating tendons, ligaments, and soft tissue areas
	• MRI	• Uses radio waves to detect tissues not picked up by radiographs. Depending on the size of the machine, larger species may be able to have only a localized area evaluated.

Treatment	• Bandaging	• Bandages are very useful in stabilizing a limb, either in the time it takes for a more thorough examination to be performed, during transportation, or while awaiting surgery. It is often a good idea to support the opposing limb in the case of equine long bone fractures and laminitis to give support to the limb that may be compensating for the injured limb. A thick Robert Jones bandage provides good support (Fig. 10.25).
	• Splinting/ Casting	• Splits are used once again to stabilize. Splints can be made to accommodate the smallest of species and can be custom cut out of PVC pipe. Not all injuries or fractures warrant splints, so it is important to listen to the veterinarian's recommendations. A Kimzey® leg-saver splint is used with some equine patients where there is extensive damage and you want to take pressure off of the tendons and ligaments. • Casts are usually applied after surgery to stabilize the area. Not all postsurgical repairs are casted.
	• Surgical intervention	• Surgery is recommended in cases of fractures that are eligible. Some fractures (e.g., pelvis and femur) are not surgical candidates in larger species like the horse and cow. In many cases of fracture repair, a plate or rod is placed to stabilize the bone and the joint, and screws are placed to hold the fixture in place. In some cases an arthrodesis is performed to fuse and stabilize a joint if there are multiple fractured pieces.

	• Other	• Stall rest may be necessary for the long term.
	• Medications	• *Diuretics:* Acetazolamide • *Opiate partial agonist:* Butorphanol tartate • *NSAID:* Phenylbutazone (not approved for use in animals intended for food)
Monitoring	• These animals need to be closely monitored for signs of pain and discomfort (increase in heart rate, anorexia, frequent lying down). • If the patient is wearing a splint, pay special attention that it does not shift and impair another area, doing more harm than good.	

Figure 10.24 Examples of Kimzey Leg Saver® splints.

Figure 10.25 Robert Jones bandage on a yearling (courtesy of Christopher Rizzo).

Table 10.15 / Trauma/Shock

Causes	• Septic shock (bacteremia, endotoxemia), dehydration, hypotension, hemolysis, a localized insult to an organ system, unregulated body temperature (heat stroke and frostbite), hypoxia, decreased oxygen to tissue, lactic acidosis, multiple organ system failure, cardiogenic shock (acute heart failure, congestive heart failure, cardiomyopathy), toxic insult, hit by car, predator attack (dogs, cougars, coyote, wolves, bears), impalement, certain types of colic in horses (large colon vovulous), hypovolemia (hydrops in the equine parturient mare), anaphylactic shock, burns (see Figure 10.26 and Figure 10.27), electric shock, lightening strike

Triage: By Telephone	• General	• Generally if an animal is in shock it is due to a primary issue. Evaluate that animal for injury, diarrhea, bleeding, etc., and remember to keep the patient calm. Do not allow the patient to eat or drink to avoid potential aspiration.
Triage: At Evaluation	• General	• For animals in shock, it is important to treat the signs until the patient is stabilized. Starting with initial blood work is important before treatment, but an intravenous catheter should probably be placed immediately and ready for intravenous fluids. Hypertonic saline should also be available for cases of shock and severe dehydration. Oxygen therapy should also be available, especially if there is trauma to the chest. • In cases of hemorrhage, an appropriate blood donor should be arranged. Colloid therapy like plasma or Hetastarch should also be available.
Clinical Signs	• Trembling, muscle fasiculations, fever, bright red mucous membranes, tachycardia, tachypnea, respiratory distress, hemorrhage, wound, restlessness, dehydration, hyperthermia, fever	
Diagnosis	• Physical exam	• A complete physical exam should be performed to determine the main cause of the problem, but clinical signs should be addressed in the meantime to stabilize the patient
	• Blood work	• Blood work should include: • Packed cell volume • Total protein, lactate • Venous or arterial blood gas • Complete blood count • Fibrinogen • Chemistry panel

		• Possible clotting profile, if necessary

Treatment	• Intravenous access	• IV access in these patients is very important (see Skills Box 10.3). Intravenous fluids (Figure 10.28 and Figure 10.29) should be started immediately, including the administration of hypertonic saline if hypovolemia or severe dehydration is present. An isotonic crystalloid should always follow the administration of hypertonic saline
	• Whole blood transfusion	• A whole blood infusion may be warranted in cases of acute and major blood loss and anemia. In many large animal species there is no bank of blood, so having donor animals is ideal. If a donor animal is not available, the owner may allow for the blood to be harvested from another animal of the same species on the farm. In the equine patient, it is best to cross match if able due to the diversity in blood types. If a cross match is unable to be performed and the donor has not previously had a transfusion, you can start by using blood from a horse of the same breed (a gelding is preferred). Synthetic blood products are on the market (Oxyglobin® for instance) that are able to help with the colloid replacement of blood as well as help with some of the oxygen carrying capabilities
	• Plasma	• May be used once again, as a colloid replacement and to aid in the loss of protein
	• Oxygen therapy	• Oxygen may be used to help stabilize a patient in respiratory shock, or with trauma causing hemorrhage. Oxygen can be administered as flow-by or by placing an intranasal cannula

	• Medications	• *Other:* Prednisolone, hypertonic saline
Monitoring	• It is very important to monitor these animals closely for signs of deterioration and further shock that can lead to acute death. It is important to monitor TPR vitals, as well as mucous membrane color/texture. In animals that have been hemorrhaging, monitor for further blood loss as well as monitoring the packed cell volume. If whole blood or plasma is being administered, it is important to monitor for signs of reaction (hives, anaphylactic shock) by monitoring the TPR values as well as the general status of the patient. These patients can be kept warm with a heat lamp, or cooled down with a fan or cool water baths. Alcohol baths may also be used to bring down a fever, but use caution in animals with skin irritation (burns). Monitoring blood pressure and central venous pressure may also be indicated.	

Figure 10.26 Burned skin on horse that was in a barn fire (courtesy of Jennifer Horner).

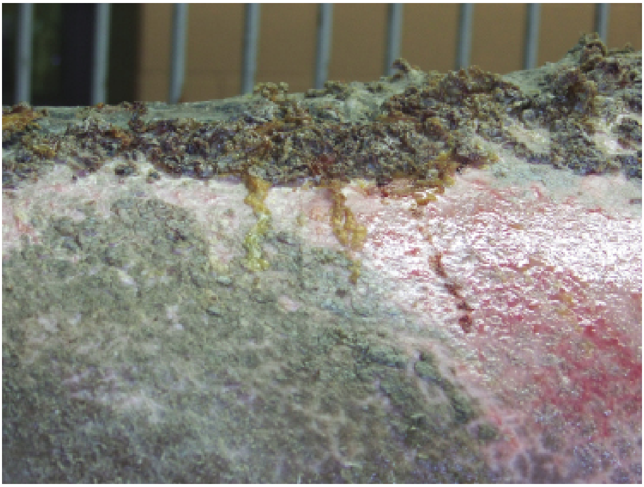


Figure 10.27 Horse recovering from burn wounds (courtesy of Jennifer Horner).

Figure 10.28 Horse on intravenous fluids using the International Win Ltd. Stat IV® (www.internationalwin.com).

Figure 10.29 Mare on intravenous fluids using the Stat IV® from IWIN (www.internationalwin.com).

Skills Box 10.3 / Over-the-Needle and Over-the-Wire Intravenous Catheter Placement in the Jugular Vein

Supplies:

- Clippers with #40 blade
- Scrub
- Rinse or spray
- Gloves/Facemasks
- +/− Local analgesic
- Sterile gloves
- Catheter or catheter kit
- +/− Extension set
- Heparinized saline flush
- Injection cap
- +/−scalpel blade

- Tray
- Suture, bandage material, and/or superglue

Preparation:

1. Clip an area.

a. About 4″ x 6″

2. Scrub using aseptic technique.

a. 5-minute contact time

b. Chlorhexidine or betadine

3. Rinse or spray the area.

a. Alcohol

4. Know the length of catheter the patient can take.

5. Place your sterile gloves on.

"*Dirty-Hand*" *Procedure for Over-the-Needle Placement:*

1. Stick IVC with stylet through skin.

2. Keep a 45° angle.

3. Find the vein. (Feel for the "pop.")

4. Watch for a "flashback" of blood.

5. Place the IVC parallel the IVC with stylet to the vein and feed half way.

6. Hold the stylet in place and feed the IVC.

a. Should go smoothly

7. Once the catheter is in the vein, pull off the stylet.

8. Flush the catheter with heparinized saline

a. Check for "flashback" again.

9. Secure catheter

a. Suture or superglue.

10. Bandage over the catheter.

NOTE: For this placement you can have one "dirty hand" to hold off the vein. Use that hand only to hold the stylet when feeding the catheter.

Sterile Procedure for Over-the-Wire Placement:

1. Stick vein with the needle that comes in the kit at a 45° angle.

2. Find the vein.

3. Watch for a "flashback" of blood.

4. Hold the needle and pass the wire through needle.

a. About ¾ way (some wires have check marks)

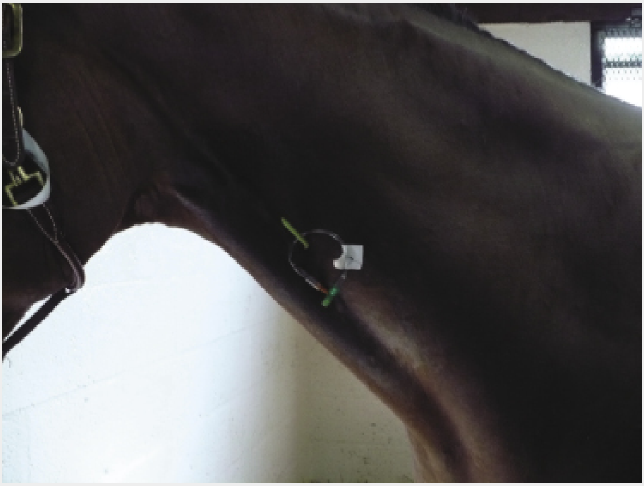
5. Note: Never lose hold of the wire, and don't let the wire touch the horse.

6. Pull the needle out of the vein and over the wire.
7. Feed the dilator over the wire and dilate the skin at the insertion site.
    a. For 14 g or larger or if the animal has thick skin (e.g., bovine, camelids)
8. Pull the dilator off.
9. Feed the catheter over the wire.
10. Once the catheter is in place, pull the wire.
11. Attach the clamp to the appropriate place if the patient cannot take the entire length.
12. Attach extension set
    a. Some catheters come with extension sets attached.
13. Flush the catheter with heparinized saline.
    a. Check for "flashback" again.
14. Secure the catheter.
    a. Suture or superglue.
15. Wrap over the catheter.

Note: Keep both hands sterile throughout the procedure since there are multiple steps and parts.

See Figure 10.30.

Figure 10.30 Intravenous catheter placement.



Chapter 11

Holistic Medicine for Horses

Jessica Sjogren

Holistic Medicine

- Massage Therapy
- Hydrotherapy
- Chiropractic Therapy
- Herbology
- Oils
- Acupuncture

Key Words and Phrases			Abbreviation List
Brace	Immuno	Stimulant	N/A: Not applicable
Calmative	Infused oils	Styptic	
Carminative	Infusion	Temperature	
Carrier oils	Laxative	Tenderness	
Demulcent	Mucilage	Tension	
Emmenagogue	Nervine	Texture	
Emollient	Phytotherapy	Tinctures	
Expectorant	Poultice	Tonic	
Febrifuge	Poultices	Vermifuge	
Flavonoid	Refrigerant	Volatile Oils	
Galactagogue	Salves	Vulnerary	
Hepatic	Sedative		

Holistic Medicine

Many trainers and riders use holistic medicine. Holistic medicine requires looking at the horse in its totality—all of its physical and psychological traits. Any and all dysfunctions of the musculoskeletal system require knowledge of the animal's history to determine the contributing factors.

Table 11.1 / Massage Therapy

Definition:
- Manipulation of soft tissue in the body to help accomplish goals of drainage, relaxation, or stimulation. Aids in muscle-related issues, helps in circulation, reduces stress on the nervous system, and speeds up recovery of an injury.
- Check with your state for requirements on certification

Duration of a Massage	• First massage lasts 10–15 minutes. • Adapt the massage depending on how the horse reacts.	• The next massage should last 45–60 minutes.		
When to Massage	• Do not do a massage until approved by a veterinarian.	• Before or after being worked	• When the horse is restless	• When inflammation has occurred
Contraindications	• The horse's temperature is over 102°F • Massaging a horse with a fever will make the horse worse.	• Avoid an open wound or a healing wound.	• Acute trauma such as a torn muscle or hematoma	• Severe forms of functional nervous stimulation; tetanus
	• Colitis, diarrhea, pregnancy, or hernias	• Rheumatism and arthritis are very painful to the horse.	• Calcification around the joints or within the soft tissue	• Inflammatory conditions
	• Cancerous tumors or cyst	• Skin problems such as fungal infections	• Disease like tetanus	• Acute stages of viral disease
4 T's of Massage	*Temperature:* • 99°F-100.5°F • *Abnormally cool:* May indicate muscle contractions or deep chronic tension • *Abnormally hot:* May indicate inflammation and a sign of an underlying problem	*Texture:* • Density and elasticity of the skin and muscle fibers • Tissues that are too soft or too puffy are a sign of swelling, slow blood or lymph circulation, or an underlying inflammatory condition.	*Tenderness:* • Muscles, tendons, ligaments, and joints that respond to touch. • High sensitivity; nerve endings are irritated or possibly damaged.	*Tension:* • Result of a heavy workload or overwork • Can also occur from scar tissue build-up. • Increase in toxins build-up causing inflammation • Tension also causes the blood circulation to be poor, which leads to less nutrient absorption and less oxygen.
Pressure and Rhythm	*Pressure in pounds:* • *Finger stroking touch:* 0.1–1.0 • *Light touch:* 2–3 • *Regular touch:* 3–5 • *Firm touch:* 8–10 • *Heavy horse:* 15	*Pressure:* • Greater than 25 pounds can bruise the fibers. • Use up to 30–35 pounds for thicker muscle layers. • Use up to 35 pounds for scar tissue	*Rhythm:* • One stroke per second is soothing. • Strokes at the start of the session are calming. • Faster rhythm stimulates the horse. Excites the horse before riding or warms it when cold.	

Massage Strokes	*Effleurage:*
	• Used most often
	• Starts and finishes the massage and is also used every 20–30 seconds after the different strokes to allow proper drainage
	• Helps with the natural flow of the blood circulation
	• Drains body fluids (i.e., blood and lymph
	• Use both hands in a gliding movement, keeping the fingers closed.
	• Adjust the pressure depending on what area is being worked on.
	Direct Pressure:
	• Using the thumb or elbow, put direct pressure on the spot.
	• Used mainly to relieve adhesions
		Petrissage:
		• Kneading, compression, muscle squeezing, and skin rolling are all part of petrissage.
		• Soothing if done slowly; but, if done at a fast speed, it will stimulate the horse.
		  • *Kneading:* Increases circulation and helps with oxygenation; aids in separating and draining muscle fibers
		  • Small half circles overlapping one another
		  • Can be done using the thumbs and palm of the hand
		• *Compression:*
		  • Used for large muscles like the hindquarters
		  • Increases circulation
		  • Palm of the hand or fist can be used by applying pressure in a pounding action.
		• *Muscle squeezing:*
		  • Break up and relax tense muscles, mainly next to the crest of the neck, legs, and tail
		  • Use the heel of the hand and opened fingers, keeping the surface of the palm in complete contact with the body.
		  • Use 5–10 pounds of pressure, 15 pounds of pressure for bigger muscles
		  • A slow rhythm has a calming effect on the nervous system.
		  • A fast rhythm stimulates the circulatory system and nervous system and warms up the muscles during cold weather.
			Cross Fiber Friction:
			• Used in sports therapy. Breaks down adhesions and scar tissue over the muscle fibers, tendons, ligaments, fascia, joint capsules, and bones.
			• Using the tip of the fingers, go the opposite direction of the muscle in deep circular motions.
			• 10–15 pounds of pressure for the breakdown of the fibrous tissue. Build up to 30 pounds if needed.
			• Do not stay on one spot for more than 3 minutes.
				Tapotements:
				• Sequence of gentle, hitting, rhythmic motions to the body.
				• Consist of clapping, cupping, hacking, beating, and pounding
				  • *Clapping:* The palm of the hand is flat on the horse with 2–3 pounds of pressure, working up to 5–10 pounds of pressure. Not to be used on bony structures except for the ribcage.
				  • *Cupping:* The palm of the hand is cupped with 5–10 pounds of pressure. This is softer than clapping. Used over the ribcage and around bones like the scapula and withers or over curved muscles.
				  • *Hacking:* A bouncing method using the flat side of the hand with 5–10 pounds of pressure (up to 15 pounds) when working with bulky muscles.
				  • *Pounding:* Making a fist using 15–25 pounds of pressure. Used for deep stimulation of large muscle groups

Table 11.2 / Hydrotherapy

Definition:
- Water treatment applied externally to the horse's body. If water is used before and after a massage, it will increase the success of the massage. Hydrotherapy can create both temporary and longer-lasting effects.
- Check with your state for requirements on certification.

Water Temperatures	• *Cool:* 65–75°F	• *Tepid:* 85–95°F	• *Warm:* 90–100°F • *Hot:* 100–110°F
Duration of Treatment	• *Average duration:* 2 minutes for hot therapy	• *Prolonged duration:* 3–10 minutes for warm and cold therapy	• *Very long duration:* 10–30 minutes for tepid or cool therapy and poultices
Stages of Recovery of the Injury	• *Subacute stage:* 24–72 hours after the injury, using the vascular flush and going back and forth between cold and hot	• *Chronic stage:* After 72 hours, heat to increase blood circulation	
Cold Water			
Effects of Cold Water	• Chills the skin, which causes constriction and pushes the blood to the middle of the body	• Decreases pain by numbing the nerve endings	• Application lasts longer than heat
Techniques Used for Cold Therapy	• Cold packs can be used for bruises and sprains for the first 24 hours. • Leg boots filled with water • Spray water on the area. • Cotton towel soaked in cold water and placed in the refrigerator or freezer • Buckets of water • Sponging with cool water • Poultice • *Ice-cup massage:* Freeze water in a Dixie Cup. Peel the edge of the cup. In a circular motion, rub the ice on the affected area. Pressure should be 1–2 pounds and keep it on no longer than 5 minutes.	• Once the cold has been taken away, there is a secondary reaction. The capillaries enlarge and the blood returns to the surface of the body. The body's defense mechanism makes the whole body warm.	• Stimulation increases the body temperature and blood pressure, contracts the muscles, strengthens heart action and stimulates the nervous system. Metabolism slows and makes breathing deeper.
Hot Water			
Effects of Heat	• Decreases pain by relaxing the sensory nerve endings	• Dilation occurs, which helps in circulation and brings more oxygen and nutrients to tissue.	• Loosens muscle fibers, tendons, and ligaments and helps with relaxation
Application of Heat	• Alleviates pain and inflammation with acute or chronic issues, decreases pain and muscle tension	• The hotter the water, the shorter the application	
Techniques Used in Heat Therapy	• Hot water bottles • Hot towels • Heat lamps • Electrical heating pad • Poultice • Hot water from a hose • Whirlpools		
Poultices	• Moist heat made with a semi-moist mixture of different substances and put on the body while it's hot	• Treats arthritis, rheumatism, and other inflammations	
How to Make Poultices	• Put the mixture on a cotton cloth. Then put the cloth on the skin and cover with a piece of flannel to hold the warmth. Flexible plastic can then be placed on top to draw out more inflammation.	• Leave on for 15–30 minutes.	

Table 11.3 / Chiropractic Therapy

Definition:
- Returns motion to joints and aids in stiffness and back pain.
- When restoring motion, check with your state for requirements on certification.

Definition of Chiropractic Therapy	• Drugless, noninvasive approach that offers different benefits for the performance and health of the horse	• Performing an exam before the adjustment will help the chiropractor recognize the issues with the spinal column.	• Adjustments are made directly on the misaligned vertebrae.
Spinal Column	• Bones, ligaments, muscles, and blood vessels	• *Cervical vertebrae:* 7 bones of the neck • *Thoracic vertebrae:* 18 bones of the withers and upper back • *Lumbar vertebrae:* 6 bones of the lower back • *Sacrum:* 5 fused segments; joins the vertebral column to the pelvis • *Coccygeal:* 16–18 modified vertebrae	
Functions of the Spinal Column	*Support:* • Allows the horse to carry weight on the thoracic and lumbar vertebrae • Attachment to the legs and organs • Supports the head and gives shape to the back and neck	*Attachment:* • Attaches major muscle groups that aid in movement	*Protection:* • Protects the central nervous system, also known as the spinal cord • Protects kidneys, heart and lungs, large blood vessels in the chest and abdomen
Subluxation	*Causes:* • Injury and trauma • Trauma can be caused at birth by a difficult delivery. • Conformation faults • Always being kept in a small area, which decreases balance and coordination • Athletic performances such as jumping, racing, dressage • Being ridden often • Poor fitting tack • Age • Not giving proper foot care • Stressful conditions in the horse's environment	*Symptoms:* • Abnormal posture • Discomfort when riding • Discomfort when saddling • Extending the head and neck and hollowing the back • Wringing the tail • Pinning ears • Grinding of teeth • Not wanting to jump • Odd behavior • Facial expressions • Sensitivity to touch • Gait may be off. • Stiffness • Muscle atrophy • Shortened walk • Problem lengthening the top line • Improper frame • Decreased stride length • Problem flexing the poll • Not coming onto the bit • Tilting the head • Obscure lameness • Resisting one rein • Rider cannot ride center • Dragging toes, or odd shoe wear	*Exams:* • *Posture:* Abnormal foot placement, tucked up posture, stretched out stance, unusual head placement • *Gait and performance:* While the horse walks straight and circling on a lunge line, does the hip move evenly and are the hocks stable? • *Spinal palpation:* Tops of the vertebrae should be level. • *Spinal Mobility:* Should move column freely
Subluxation Correction	*Adjustment:* • Short, rapid thrust onto a vertebra in the direction that will free the vertebra from the fixed position	• Veterinary chiropractor must have great knowledge of anatomy. • Manipulate the joints of the legs and jaw.	*Adjusting Tools:* • Hands • Activator • *Mallets:* Strike on a pad
Chiropractic Techniques for Horsemen	*Spinal flexibility:* • *Neck:* Stand at the horse's shoulder and pull the halter to one side. Then do the same thing on the other side. • *Back:* Move the thoracic and lumbar regions in a normal range of motion • *Bend laterally:* Stand near the flank and grab the tail. Place the heel of the other hand on top of the vertebrae. Bend the tail above the hand on the pelvis. • *Whole spinal column:* Bring the horse's head between its front feet.	• Abdominal muscles can be exercised to increase the rounding on the back.	*Extremity stretching:* • *Scapula and shoulder blade:* For a leg lift, pull the leg in front of the horse. • *Pastern Joints:* Grab the hoof and rotate the foot in both directions.

Table 11.4 / Herbology

Preparing the Herbs	*Infusion:* 1. Bring water to a boil. 2. Add 1 tablespoon of dried herbs or 3 tablespoons of fresh herbs per cup of hot water. 3. Strain liquid. 4. Keep refrigerated for 3–4 days. 5. Add to the horse's drinking water.	*Brace:* • Stimulating liquid to wash down a horse after a ride • Can be used in a bandage for a sprain or minor wound	*Poultice:* • Draws out infection • Use hot water and add herbs until soft. • Use a bandage to keep in place.	*Tincture:* • Cold infusions of herbs that take about 2–6 weeks to steep • Made with high-proof alcohol like apple cider vinegar
Herbs Used in Aromatherapy	**Parts of the Plant Used**	**Each Herb's Use**	**Effects of Herbs**	**Dosages and Cautions**
Bilbery (*Accinium myrthillus*)	• Purple to black, ripe fruit and green leaves	• Astringent, antibacterial, antiseptic, laxative, diuretic, refrigerant	• Can lower blood pressure behind the eye • Helps with glaucoma, and cataracts • Diuretic	• 10–20 grams per day
Boneset (*Eupatorium perfoliatum*)	• Leaves and new blossoms	• Aperient, antispasmodic, diaphoretic, emetic, febrifuge, stimulant, tonic	• When used warm, can help pass fecal matter and help with impaction	• 5–20 grams per day • Should not be used long term, which may lead to liver damage • Dried is safer than fresh.
Borage (*Borago officinalis*)	• Leaves	• Aperient, diaphoretic, diuretic, demulcent, emollient, febrifuge, galactagogue, refrigerant, stimulant	• *Ingested:* Treats fever and congestion; restores stressed adrenal glands • *Externally:* Reduces bruises and inflamed muscles and joints	• 5–10 grams per day • **Note:** Overstimulates the nervous system in large doses and not recommended to be used in pregnant or nursing mares
Burdock (*Arctium lappa*)	• Leaves and roots	• Alterative, demulcent, diaphoretic, diuretic, nutritive	• Blood cleansing herb • *Internally:* Detoxifies the liver, blood, kidneys, and lymphatic system; helps reduce inflammation in the joints and muscles • *Externally:* Skin conditions; helps to regrow hair when infused in oil	• 15–30 grams per day

Herbs Used in Aromatherapy	Parts of the Plant Used	Each Herb's Use	Effects of Herbs	Dosages and Cautions
Calendula (*Calendla officinalis*)	• Flower petals	• Antispasmodic, antiinflammatory, antiseptic, detoxifier, slightly estrogenic, astringent, diaphoretic, stimulant, vulnerary	• Treatment of burns, rashes, eczema, ringworm, thrush	• 20–80 grams per day
Celery (*Apium graveolens*)	• Seeds, stem, and leaves	• Antirheumatic, antiinflammatory, antispasmodic, carminative, diuretic, emmenagogue, nervine, stimulant, stomachic, tonic	• Regulates and lowers blood sugar levels and blood pressure • Mild sedative	• 510 grams per day • **Note:** Do not use in pregnant mares.
Chamomile (*Matricaria chamomilla*)	• Flowers and leaves	• Anodyne, antiinflammatory, antiallergenic, antispasmodic, carminative, diaphoretic, emmenagogue, nervine, tonic, sedative, somatic, vulnerary	• Relaxing and soothing • Given after foaling and can be given to nursing mares	• 15–45 grams per day • **Note:** Do not use in pregnant mares.
Chaparral (*Lerrea divaricate*)	• Leaves and stems	• Alterative, antibiotic, antitumor, diuretic, expectorant, laxative, parasiticide, tonic	• In combination with other herbs, it can be used to treat rashes, inflammation, bruises, and warts	• 5–10 grams per day • **Note:** Use in moderation; do not use in pregnant mares.
Chaste Tree (*Agnus castus*)	• Berry	• Adaptogen, emmenagogue, galactagogue, vulnerary	• Helps with the production of progesterone • Lowers hormones when high	• 2–8 grams per day • **Note:** Do not use in pregnant mares.
Cleavers (*Galium aparine*)	• Leaves, stems	• Alterative, aperient, diuretic, refrigerant, tonic	• Detoxify the lymphatic system • Treat kidney stones and chronic skin conditions	• 5–10 grams per day
Clover, Red (*Trifolium pratense*)	• Flowers	• Alterative, anticancer, antispasmodic, antitumor, deobstruent, expectorant, sedative	• Helps treat hormonal imbalances	• Up to 90 grams per day
Comfrey (*Symphytum officinale*)	• Leaves	• Alterative, antiinflammatory, antitussive, astringent, demulcent, expectorant, tonic, vulnerary	• Helps with treatment of wounds • Helps with sprains, arthritis, and broken bones	• 1–5 grams per day • **Note:** Not to be used in pregnant mares; roots contain high amounts of toxins that can damage the liver.

Herbs Used in Aromatherapy	Parts of the Plant Used	Each Herb's Use	Effects of Herbs	Dosages and Cautions
Dandelion (*Taraxacum officinale*)	• Leave and Roots	• Alterative, aperient, astringent, cholagogue, detoxifying, diuretic, galactagogue, lithotriptic, stomachic, tonic	• Help with rashes and allergies • Helps stimulate milk in mares	• 30–90 grams per day
Devils Claw (*Harpagophytum radix*)	• Root	• Anodyne, antiinflammatory, stomachic	• Helps reduce inflammation • Helps with joint pain	• 1–5 grams per day • **Note:** May stimulate the uterus; do not use in pregnant mares.
Echinaccea (*Echinacea angustifolia*)	• Whole herb	• Alterative, antibacterial, antibiotic, antiseptic, antiviral, detoxifying, immune stimulant, vulnerary	• If the horse has a fear of walking through water, adding 2–4 drops into the drinking water may help. • *Externally:* Treat wounds, insect stings, snake bites	• 10–20 grams per day • **Note:** Use for 2–8 weeks then do not use for 2–4 weeks for the herbs to work in full effect • Do not give to horses with autoimmune disorders or severe allergies.
Elecampane (*Imula helenium*)	• Flower and root	• Antiinflammatory, antiseptic, astringent, carminative, cholagogue, diaphoretic, diuretic, expectorant, stimulant, tonic	• *Lungs:* Warming and healing	• 5 grams per day • **Note:** Do not use in pregnant mares.
Garlic (*allium sativum*)	• Bulb	• Alterative, antibiotic, antiseptic, antispasmodic, carminative, diaphoretic, digestant, diuretic, expectorant, hypotensive, parasiticide, stimulant	• *Externally:* Antifungal, antiseptic treatment	• 15–45 grams per day
Ginseng (*Panax ginseng*)	• Root	• Demulcent, rejuvenate, stimulant, tonic	• N/A	• 5–20 grams per day
Goldenrod (*Solidago odoratum*)	• Leaves	• Antioxidant, astringent, carminative, diaphoretic, diuretic, stimulant	• Helps prevent colic and flatulence	• 10–20 grams per day
Hawthorn (*Crataegus oxyacantha*)	• Berries, flowers, and leaves	• Astringent, antidiuretic, antispasmodic, digestant, sedative, tonic	• Treats heart murmurs, high and low blood pressure, pulmonary inflammation, and heart disease	• 5–10 grams per day
Horsetail (*Equisetum arvense*)	• Leaves and stems	• Antibiotic, astringent, diuretic, styptic	• Used to help develop healthy hooves, bones, and joints	• 5–15 grams per day • **Note:** Do not use for longer than 6 weeks.
Kelp (*Fucus vesiculosis*)	• Whole plant	• Demulcent, emollient, diuretic, nutritive, tonic	• Good source of iodine, alkali, calcium, and silicon	• 10–200 grams per day • **Note:** Do not use during pregnancy. Use as little as possible in a nursing mare.
Marshmallow (*Althea officinalis*)	• Root, leaves, or whole plant	• Alterative, antiinflammatory, demulcent, diuretic, emollient, expectorant, galactagogue, laxative, lithotriptic, tonic, vulnerary	• Stimulates milk production	• 15–75 grams per day • **Note:** Do not give to pregnant mares.
Meadowsweet (*Filipendula ulmaria*)	• Leaves and flowering tops	• Anodyne, febrifuge, antiinflammatory, antirheumatic, antiseptic, diuretic	• Helps promote tissue repair • Helps prevent colic • Helps wth pain and inflammation	• 10–30 grams per day
Milk Thistle (*Silybum marianum*)	• Seeds	• Antidepressant, demulcent, galactagogue, hepatoprotective, tonic	• Improves the appetite and prevents colic	• 5–45 grams per day
Mullein (*Verbascum blattaria*)	• Leaves and flowers	• Anodyne, astringent, antispasmodic, demulcent, diuretic, emollient, expectorant, pectoral, vulnerary	• N/A	• 30–90 grams per day
Nettle, Stinging (*Urtica dioica*)	• Leaves and aerial parts	• Antiinflammatory, astringent, diuretic, expectorant, galactagogue, hemostatic, nutritive, tonic	• Helps keep the horse's coat shiny • Reduces inflammation	• 15–150 grams per day • **Note:** If raised bumps appear, they should disappear within 24 hours. If they don't disappear in that time, discontinue use.

Herbs Used in Aromatherapy	Parts of the Plant Used	Each Herb's Use	Effects of Herbs	Dosages and Cautions
Peppermint (*Mentha piperita*)	• Leaves and aerial plant parts	• Alterative, aromatic, calmative carminative, diaphoretic, stomachic	• Helps prevent colic • Helps promote digestive health	• 15–150 grams per day
Plantain (*Plantage major*)	• Leaves and seeds	• Alterative, antiinflammatory, antiseptic, astringent, diuretic, emollient, expectorant, refrigerant, vulnerary	• Can draw out poisons from insect bites • Helps with burns, cuts, and wounds	• 15–75 grams per day
Raspberry (*Rubus idaeus*)	• Leaves	• Alterative, antispasmodic, astringent, hemostatic, parturient, stimulant, tonic	• Helps prevent miscarriages	• 15–100 grams per day
Thyme (*Thymus vulgaris*)	• Leaves, stems, and blossoms	• Antiseptic, antispasmodic, carminative, emmenagogue, stimulant, tonic	• Treats spider bites, thrush, and fungal infections	• 50-20 grams per day • **Note:** Do not use with pregnant mares.
White Willow (*Salix alba*)	• Bark and leaves	• Anodyne, antiinflammatory, astringent, febrifuge, tonic	• One of the original sources of aspirin	• 10–50 grams per day
Yarrow (*Achillea millefillium*)	• Flowers and leaves	• Alterative, antibacterial, antispasmodic, astringent, carminative, diaphoretic, diuretic, hemostatic, tonic	• N/A	• 5–50 grams per day

Table 11.5 / Oils

Carrier Oils	*Almond and apricot:* • Light oils • Absorb into the skin when massaged • Shelf life is short, but adding vitamin E will extend the life.	*Avocado:* • Rich and thick • Good for dry skin	*Jojoba:* • Best for skin and hair • When at room temperature, it is a solid oil. • Long shelf life, but add to other oils to increase the shelf life. • Good for condition of the hair coat	*Grapeseed:* • Light oil • Antiinflammatory properties • Good for liniment and wound salves
Essential Oils	*Basil:* • *Ocicum basilicum* • Works on viruses and nerve disorders • Used to treat liver, kidney, and urinary tract problems • Helps with calming and warming	*Benzoin:* • *Styrax benzoin* • Calming and relaxing • Antiseptic, antiinflammatory properties • Makes the shelf life longer in other oils and salves • Increases circulation • Helps in reliving pain • Natural skin conditioner	*Calendula:* • *Calendula officinalis* • Calming • Helps with skin conditions	*Chamomile, German:* • *Matricaria chamomilla* • Antiinflammatory and anodyne properties • Helps aid in insect bites
	Fennel: • *Foeniculum vulgare* • Treat bloat and urinary disorders • Helps heal bruises • Appetite suppressant	*Geranium, Rose:* • *Pelargonium graveolens* • Skin conditioner • Treat wounds, burns, scars, bites, inflammations, and infections • Calming	*Lavender:* • *Lavandula angustifolia* • Calming and soothing • Antiinflammatory • Antiseptic	*Lemon Eucalyptus:* • *Eucalyptus citriodora* • Antiinflammatory • Antibacterial
	Mugwort: • *Artemisia vulgaris* • Helps heal bruises and swelling • Helps with fevers and wounds	*Myrrh:* • *Comminphora myrrha* • Treats dry, cracked skin • Speeds up the wound healing • Make sure the wound is clear before applying. • Can be used on the gums and to help heal sores • Antiseptic	*Opopanax:* • *Illicium verum* • Flea and tick deterrent	*Rosemary:* • *Rosemarinus officinalis* • Antiinflammatory • Helps with overall energy • Placing a drop on the saddle can help with training
	Sage: • *Salvia officinalis* • Antioxidant • Antiseptic • Stimulates hair growth • Saddle sores • Thinning tails • **Note:** May reduce lactation	*Sandalwood:* • *Santalum album* • Antiinflammatory • Helps with soreness and nerve problems • Relaxation	*Tea Tree:* • *Melaleuca alternifolia* • Antiseptic • Antifungal • Treats minor wounds, bites, or skin infections • Can be put on the skin without carrier oil	*Thyme:* • *Thymus vulgaris* • Used in liniment and salves for sore and tired muscles • Combined with rosemary, it produces a antiinflammatory liniment.
	Yarrow: • *Achillea millefolium* • When combined with geranium or myrrh, it becomes a balm for wounds and rashes and can calm aggrieved skin.	*Ylang-ylang:* • *Cananga odorata* • Stimulates hair growth		

Table 11.6 / Acupuncture

Definition:
- Acupuncture should be used in combination with another treatment, stretching or chiropractic.
- In most states a veterinarian is the only one who can perform acupuncture.

Definition of Acupuncture	• Insertion of fine needles into a particular predetermined spot on the body to control bodily functions	• Chi is the Chinese medicine flow of energy. • Consists of positive (Yang) and negative (Yin) • Yang and Yin channel through the body called meridians—a path in which life energy flows. • Imbalance of energy levels between Yang and Yin with blockage in meridians causes pathogenic factors.	• Stimulating acupuncture points adjust the levels of energy and reestablish a homoeostatic condition and healing.
Acupuncture Points	• 1–2 mm areas of the skin in certain areas of the body that are small indentations or nodules that are associated with organs	3 types of acupuncture points • *Primary:* Found along the route of large nerves in the skin and muscles • *Secondary:* Smaller nerves • *Third:* Found in smaller nerve muscle fibers	All points are divided into the following 2 categories based on their therapeutic properties: • *Local Points:* Treat disease in a neighboring or local area • *Distant Points:* Treat conditions in isolated areas

	• The points are then broken down into deeper categories
	  • *Permanent points:* These are there all the time and are on extra points
	  • *Temporary points:* Appear only when a pathological progression occurs
		There are 13 categories of specific points that have special properties. When combining these points, an acupuncturist is able to decide on what drug to use.
		• *Mu or alarm points:* On the abdomen and chest; may become tender when specific organs are effected by disease
		• *Terminal points:* Found on the beginning and end of each meridian
		• *Tonification points and sedation points:* Increase and decrease energy in the meridian
		• *Source points:* In the knees and hocks; increase the effects of sedation points
		• *Connecting points:* Connect the coupled meridians and equalize the chi between them
		• *Shu and association points:* Parallel to the spin, bladder meridian; become tender when a pathological issue occurs in a specific organ
		• *Command points:* Below the elbow and stifle
		• *Special action points:* Special effects on certain conditions
		• *Horary points:* Used when energy flow is greatest in the meridian
		• *Trigger points:* Specific points that show up when there is disease and trauma
		• *Auricular points:* Located in the ear and represent all areas of the body
		• *Accumulation points:* On each of the twelve meridians where the energy level is the highest
		• *Master points:* Face, chest, abdomen, digestive tract, and the back and lumbar spine	

	5 elements: Nature of the Zang-Fu organs and the relationship between them • Wood • Fire • Earth • Metal • Water		
Techniques	*Needles:* • Handle and pointed shaft • The design is different depending on the country. • Gentle pressure on the handle while turning a needle handle can be used. • *Tonify:* Needle is rotated clockwise. • *Sedation:* Counterclockwise • **Note:** Should only be done by someone who is thoroughly trained	*Aquapuncture* • Difference between on dry needling • Inject a small amount of fluid using a small-gauge hypodermic needle. • Stimulates the area with pressure • Disadvantage is a sharper needle than acupuncture; breaks under stress • *Solution that can be used:* Vitamin B-12, DMSO, serapin, iodine blister, homeopathic remedies	*Electroacupuncture:* • Helps treat pain and physical ailments and helps to induce acupuncture analgesia before surgery • The electronic devices are used to increase stimulation of acupuncture points. • Attached to a needle or damp sponges surrounding the area of interest
	Moxibustion and heat therapy: • Heating of acupuncture points by burning the herb (moxa) on or above the skin over the acupuncture points • Uses a hot needle to treat abscesses, skin conditions, and severe arthritis	*Hemoacupuncture (bloodletting):* • Needles are used to cut or pierce the skin and blood vessels to cause controlled bleeding. • The amount of blood and specific puncture points are used based on specific diseases. • *Laminitis or founders:* Where bleeding points are stimulated around the coronary band	*Acupressure:* • Finger pressure applied to the body surface • Used to relieve muscle spasms and pain
Therapeutic Indications in the Horse	*Musculoskeletal problems:* • Arthritis, osteoarthritis of the knee, hock, ankle, or pastern	*Respiratory conditions:* • Heaves, allergic bronchitis, chronic bronchitis	*Reproductive disorders:* • Direct stimulation of the anterior pituitary gland
	Gastrointestinal Problems: • Gaseous colic with increased or decreased motility, impaction, diarrhea, colitis, and ulcers	*Neurological Problems:* • Peripheral nerve paralysis, wobblers syndrome, cervical ataxia	*Behavioral problems:* • Aggressive and nervous horses

Glossary

Abomasum	Fourth compartment of a ruminant's stomach
Accelerators	Chemicals that increase the pH of the developer and quicken the rate of development
Acidifiers	Compounds that accelerate the fixing process and neutralize the alkaline developer
Acidosis	An abnormal condition of low PH
Adaptogen	Adapts its effect to what the body needs
Adjustment	An attempt to correct the misalignment
Agglutination	The clumping of red blood cells
Agonist	A substance that produces an effect by binding to an appropriate receptor
Alopecia	Hair loss resulting in hairless patches or a complete lack of hair
Alterative	A type of medicine that increases overall health and tissue renewal
Analgesic	Pain reliever
Anemia	Blood condition of abnormal values of red blood cells and or hemoglobin
Anisocytosis	A condition with unequal cell size and excessive variation in red blood size
Anodye	Pain reliever
Anorexia	Loss of appetite
Antacid	Medication that reduces acid in the stomach and gut
Antagonist	A substance that inhibits a specific action by binding with a particular receptor instead of allowing the agonist to bind to the receptor
Anthelmintic	Removes worms and parasites
Antibiotic	Kills infection
Anticoagulant	Substance that prevents blood clotting
Antiemetic	Substance that stops vomiting
Antifungal	Kills fungal infections
Antiinflammatory	Decreases inflammation
Antimicrobial	Destroys microorganisms, such as bacteria
Antioxidant	Scavenges free radicals to limit cellular damage
Antipruritic	Substance that reduces itching
Antirheumatic	Relieves arthritis
Antiseptic	Cleans wounds and helps prevent infection by preventing the growth of bacteria
Antispasmodic	Relieves spasms
Antitussive	Relieves coughing
Anuria	Complete suppression of urine production

Aperient	Gently removes the contents of the bowels, an easy laxative
Aromatic	Distinctively fragrant smell
Arthrogryposis	A rare congenital disorder that is characterized by multiple joint contractures and can include muscle weakness and fibrosis. It is a nonprogressive disease.
Ascites	Accumulation of fluid in the abdomen
Astringent	A substance that contracts the tissues or canals of the body and diminishes discharge of mucus or blood
Ataxia	Lack of voluntary movement of the muscles
Auscultation	Using a stethoscope to listen to sounds in the body
Azotemia	Presence of urea or other nitrogenous elements in the blood
Bactericidal	Killing bacteria
Bacteriostatic	Controlling bacterial growth
Basophilic	Stained readily with basic or blue dyes in many commonly used stains such as Giemsa and Wright
Bronchoalveolar lavage	Collection of mucus or fluid from the bronchi and/or alveoli through an endoscope
Bruxism	Gnashing of teeth, characterized by the grinding of the teeth and typically accompanied by the clenching of the jaw
Buffers	Compounds in the fixer that continue the correct solution pH
Buffy coat	Layer that appears at the interface of the erythrocytes and plasma
Cachexia	General ill health and malnutrition, used in describing the condition of cancer patients
Calmative	Sedative and calming
Carminative	Helps expel gas to relieve colic
Carrier oils	Carrier oils dilute the essential oils. Most essential oils are too strong to be applied to the skin alone.
Caudal	Toward the tail
Coalescence	The process by which two or more droplets or particles merge during contact to form a single daughter droplet or bubble.
Cranial	Toward the head
Demulcent	Soothes inflammation
Detoxification	Eliminates impurities from the blood and supports the liver
Diaphoretic	Increases perspiration
Diestrus	Period after metestrus
Distal	Away from the origin or attachment
Diuretic	Increases the flow of urine

Dorsal	The aspect of the limbs distal to and including the carpus and tarsus and facing toward the head
Dyschezia	Trouble defecating
Dyspnea	Labored breathing
Dystocia	Difficult birth
Electrolytes	Natural body salts, sodium bicarbonate, sodium chloride, and potassium chloride
Emaciation	Wasting away of the body
Emetic	Causes vomiting
Emmenagogue	Promotes menstruation
Emollient	Softens the skin and mucous membranes
Encephalopathy	Any disease of the brain
Endometritis	Inflammation of the endometrium, which is the inner lining of the uterus
Enzyme	Substances that chemically change another substance
Epistaxis	Nosebleed
Epithelial	Skin that covers the external surface of the body
Estrogen	Hormone that regulates ovulation in females and helps produce secondary sex characteristics
Estrus	The state when the female is receptive to the male. FSH levels are decreased and the egg is about to be released.
Everted	Turned outward
Excipient	A pharmacologically inactive substance that is used as a carrier for the active ingredients of a medication
Expectorant	Expels mucus from the respiratory tract
Febrifuge	Reduces fever
Fetotomy	Cutting apart a fetus to remove it from the uterus
Fibrinogen	Clotting proteins
Fibroblasts	Fiber-producing cells
Flavonoid	Plant constituents that effect healing
Follicle stimulating hormone (FSH)	Augments the secretions of estrogen and development of eggs and sperm
Fu (Yang)	Large intestines, stomach, small intestine, bladder, gallbladder, which receive and digest food and excrete waste
Galactagogue	Increases the production of milk
Gastroenteritis	Inflammation of the stomach and small intestine
Glossalgia	Painful sensations in the tongue
Glucosuria	Glucose in the urine
Goitrogens	Substances that suppress the function of the thyroid gland by interfering with iodine uptake, possibly resulting in an enlargement of the thyroid
Hematoma	Mass collection of blood
Hemorrhage	Loss of blood

Hemostasis	Stoppage of blood flow
Hyperfibrinogenemia	Excessive fibrinogen in the blood
Hyperflexion	A condition in which a joint is flexed or extended too far; palmar or plantar movement of the joint angles
Hyperglycemia	Elevated blood sugar levels
Hyperkalemia	Excessive levels of blood potassium
Hyperparathyroidism	Abnormal condition of excessive parathyroid secretions causing hypercalcemia
Hyperplasia	Abnormal increase in the number of normal cells in normal arrangement in an organ or tissue
Hypersalivation	Overproduction of saliva
Hypoglycemia	Decreased blood sugar levels
Hyponatremia	Deficiency of blood sodium
Hypoplasia	Incomplete or less-than-normal development of an organ, tissue, or cell
Immuno-	Stimulates and supports the immune system
Inapparent	Not apparent clinically
Indurated	Hardened, such as a soft tissue that becomes extremely firm
Infundibulum	Funnel-shaped passage
Ischemia	Deficiency in the blood supply to an area
Isotonic fluids	Solution with equal particles to the cell to which it is being compared
Lateral	The aspect of the limbs that is toward the outside of the sagittal plane of that limb (away from the midline)
Laxative	Relieves constipation
Lead feeding	Feeding an animal more feed than their present production or growth justifies in an attempt to elicit higher production rates
Lethargic	Drowsiness or indifference
Leukopenia	Deficiency of white blood cells, also called leukocytopenia
Lipemic	Excessive amount of fats in the blood
Meconium	First stool passed by the newborn that consists of material from the intestine of the fetus
Medial	The aspect of the limb that is toward the inside of the sagittal plane of that limb (toward the midline)
Meglumine	An amino sugar derived from sorbitol. It is often used as an excipient in pharmaceuticals and in conjunction with iodinated compounds in contrast media.
Meridians	Pathways in the body where Chi and blood circulate
Metritis	Inflammation of the uterus
Midges	Many kinds of very small, two-winged flies

Moxibustion	Heating of an acupuncture point by burning an herb (moxa) on or above the skin over the acupuncture point
Mucilage	Demulcent that soothes mucous membranes
Nasogastric tube	A tube that passes through the nose, down the esophagus, and into the stomach
Necropsy	Postmortem examination to determine the cause of death
Neoplasia	Any abnormal new growth of tissue that involves an uncontrolled multiplication of cells. The cells grow faster than normal and progressively.
Obstipation	Intractable constipation
Oliguria	Little urine production
Omasum	Third compartment of the ruminant's stomach
Opisthotonus	A state of a severe hyperextension and spasticity in which an individual's head, neck, and spinal column enter into a complete "bridging" or "arching" position. This abnormal posturing is an extrapyramidal effect and is caused by spasm of the axial muscles along the spinal column.
Orogastric tube	A tube that is passed from the mouth, down the esophagus, and into the stomach
Oxytocin	Stimulates contractions of the uterus and allows milk letdown from the mammary glands
Palmar	The aspect of the forelimbs distal to and including the carpus and facing toward the tail
Paracentesis	A procedure during which fluid from the abdomen is removed through a needle
Parakeratosis	A lesion that has thick scales, cracking, and a red raw surface, caused by constant keratinocyte nuclei in the horny layer of the skin
Paralysis	Loss of voluntary movement
Parturition	The act of giving birth
Phagocytosis	Eating of cells
Pheochromocytoma	A neuroendocrine tumor of the medulla of the adrenal glands (originating in the chromaffin cells) or extra-adrenal chromaffin tissue that failed to involute after birth and secretes excessive amounts of catecholamines, usually adrenaline (epinephrine), if in the adrenal gland, and noradrenaline
Phytotherapy	Therapeutic plant remedies in medicines
Piloerection	Hair that stands up straight due to action of the arrectores pilorum muscles
Plantar	The aspect of the hind limbs distal to and including the tarsus that faces toward the tail

Plasma	Straw-colored fluid portion of blood that transports nutrients, hormones, and waste products
Polyuria	Increased urination
Poultice	Semisolid mixture of clay in cotton cloth that is placed on the body and is cold
Progesterone	Hormone that helps maintain pregnancy
Proximal	Toward the origin or attachment
Reticulum	Most-cranial compartment of the ruminant, also called the honeycomb
Rhinarium	The moist, naked surface around the nostrils in most mammals. In actual scientific usage, it is typically called a “wet snout” or “wet nose” due to its moist and shiny appearance. The groove in the center of it, which reaches the mouth, is called the philtrum.
Rhythm	Frequency in which movement is applied
Rostral	Any point on the head toward the nose
Rouleaux	Red blood cells that arrange like stacks
Rumen	The largest compartment of the ruminant stomach that serves as a fermentation vat, also called the paunch
Rumen fistula	A passage surgically made from the rumen to the outside of the abdominal wall. This can be used to relieve bloat or to facilitate rumen liquor donation for other ruminants.
Santes' Rule	Calculation for approximately how much kilovoltage (KVP) is needed for a specific anatomical part of the body, based on measurement and the grid used (2X thickness) + source image distance + grid factor = KVP
Septicemia	Condition in the blood where toxins and bacteria are present
Serum	The liquid portion of blood with the clotting proteins removed
Stenosis	The narrowing of an opening
Styptic	Controls bleeding
Subluxation	Specific problems or disease of the spinal column, misalignment of the vertebrae
Technique chart	A settings chart used to set the specific kVp and mAs settings on an x-ray machine
Tendon	Connective tissue that connects muscle to bone
Testosterone	Male hormone that aids in the development of secondary sex characteristics
Thrombosis	Abnormal condition in which a blood clot develops in a blood vessel
Tonic	A solution that cleanses and promotes healthy bodily functions
Tracheal wash	Collection from the trachea of either fluid or mucus

Tread	To step, walk, or trample so as to press, crush, or injure something
Vasoconstriction	Narrowing of the vessel's diameter
Vasodilation	A widening of a vessel's diameter
Ventral	Toward the abdomen
Vermifuge	Expels worms
Vertebrae	Small bones that make up the spinal column, excluding the tail. Most species usually have 32 vertebrae.
Volatile fatty acids	Fatty acids with a carbon chain of six or fewer carbons. They can be created through fermentation in the intestine. Examples include acetate, propionate, and butyrate.
Volatile oils	Plant oils easily vaporized with heat or pressure
Vulnerary	Heals wounds
Zang (Yin)	Lungs, spleen, heart, kidneys, pericardium, and liver, which make and store essential substances (Chi—blood and body fluids)

Bibliography

Chapter 1

localriding.com. *Horse Head Conformation—Horse Health*. Accessed March, 2010, at http://www.localriding.com/horse-head-conformation.html

localriding.com. *Horse Shoulder Conformation—The Conformation of Your Horse*. Accessed March, 2010, at http://www.localriding.com/horse-shoulder-conformation.html

Thomas, H. (2005) *The Horse Conformation Handbook*. Storey Publishing, North Adams, MA.

Washington State University Extension. *Horse Conformation Analysis*. Accessed February, 2010, at http://cru.cahe.wsu.edu/CEPublications/eb1613/eb1613.pdf

Chapter 2

American Association of Equine Practitioners. (2008) *Vaccination Guidelines*. Accessed August 30, 2010, at http://www.aaep.org/index.php

Floyd, J.G., Jr. *Vaccinations for the Swine Herd*. Alabama Cooperative Extension System ANR-902 Alabama A&M and Auburn Universities. Accessed October, 2010, at http://www.aces.edu/pubs/docs/A/ANR-0902/ANR-0902.pdf

McCurnin, D.M., and Bassert, J.M. (2010) *McCurnin's Clinical Textbook for Veterinary Technicians*, 7th Edition. Saunders Elsevier, St. Louis, MO.

Merkvetmanual.com. (2008) Merck & Co., Inc. Accessed December, 2010, at http://www.merkvetmanual.com/

Powell, J. *Dairy Herd Vaccination Program*. University of Arkansas Division of Agriculture Research and Extension. Accessed October, 2010, at http://www.uaex.edu/Other_Areas/publications/PDF/FSA-4012.pdf

Schoenian, S. *Small Ruminant Info Sheet: Vaccinations for Sheep and Goats*. University of Maryland Extension. Accessed October, 2010, at http://www.sheepandgoat.com/articles/flockvaccinations.html

The Merck Veterinary Manual, 9th Edition. (2005) Edited by C.M. Kahn and S. Line. Merck & Co., Inc., Whitehouse Station, NJ.

Chapter 3

Blood, D.C., Studdert, V.P., and Gay, C.C. (2006) *Saunders Comprehensive Veterinary Dictionary*, 3rd Edition. Saunders, Philadelphia, PA.

Buechner-Maxwell, V.A. (2005) Nutritional Support for the Neonatal Foal. *Veterinary Clinics of North America: Equine Practice*, 21: 487–510.

Car, E.A., and Holcombe, S.J. (2009) Nutrition of the Critically Ill Horse. *Veterinary Clinics of North America: Equine Practice*, 25: 93–108.

Haynes, N.B. (1994) *Keeping Livestock Healthy: A Veterinary Guide to Horses, Cattle, Pigs, Goats & Sheep*, 3rd Edition. Storey Publishing, LLC., North Adams, MA.

McCurnin, D.M., and Bassert, J.M. (2010) *McCurnin's Clinical Textbook for Veterinary Technicians*, 7th Edition. Saunders Elsevier, St. Louis, MO.

Merkvetmanual.com. Merck & Co., Inc. Accessed in 2008 at http://www.merkvetmanual.com/

The Merck Veterinary Manual, 9th Edition. (2005) Edited by C.M. Kahn and S. Line. Merck & Co., Inc., Whitehouse Station, NJ.

Chapter 4

Amundson, J.R. *An Illustrated Guide to Veterinary Medical Terminology*, 3rd Edition. (2008) Delmar, Cengage Learning, Clifton Park, NY.

McCurnin, D.M., and Bassert, J.M. (2010) *McCurnin's Clinical Textbook for Veterinary Technicians*, 7th Edition. Saunders Elsevier, St. Louis, MO.

Merkvetmanual.com. 2008. Merck & Co., Inc. Accessed April, 2011, at http://www.merkvetmanual.com/

The Merck Veterinary Manual, 9th Edition. (2005) Edited by C.M. Kahn and S. Line. Merck & Co., Inc., Whitehouse Station, NJ.

Chapter 5

American Association of Equine Practitioners Infectious Disease Committee. (2012) *Vaccinations for Adult Horses*. Accessed April, 2012, at http://www.aaep.org/images/files/AdultVaccinationChartFinal022412.pdf

BayerEquineConnection.com. *Cooled Semen Transport.* Bayer HealthCare LLC, Animal Health Division. Accessed May, 2012, at http://www.bayerequineconnection.com/show.aspx/conditions-and-diseases/breeding-foaling/semen-transport

Coffey, L., and Hale, M. *An Illustrated Guide to Sheep and Goat Production*. University of New Hampsire Extension. Accessed May, 2012, at http://www.slideshare.net/ElisaMendelsohn/sheep-sustainable-and-organic-production

Deutscher, G.H. (2012) *Beef Cattle Handbook: Pelvic Measurements For Reducing Calving Difficulty*. Extension Beef Cattle Resource Committee. Accessed April, 2012, at http://www.iowabeefcenter.org/Beef%20Cattle%20Handbook/Pelvic_Measurements.pdf

Dyer, R.M. (2012) *Vaccination of Sheep and Goats: A 4-H Primer*. University of Delaware Department of Animal and Food Science and College of Agriculture and Natural Resources, Newark, NJ. Accessed April, 2012, at http://extension.udel.edu/4h/files/2012/02/VaccinationprogramsShowSheepandGoats.pdf

Friedman Veterinary Service & The Oregon Equine Reproduction Center. (2009) *Breeding with Frozen Semen*. Accessed May, 2012, at http://www.oregonequine.com/ORRepro/Mares/breed_frozen.html

Ginther, O.J. (1992) *Reproductive Biology of the Mare: Basic and Applied Aspects*, 2nd Edition. Equiservices, Cross Plains, WI.

Houghton, P. *Making Cows Out of Heifers*. Heartland Cattle Company. Accessed April, 2012, at http://media.agricharts.com/sites/54/Workshop%20Materials/02Houghton

Kane, E. (2010) *Keys to Successful Equine Embryo Transfer*. dvm360, Advanstar Communications. Accessed April, 2012, at http://veterinarynews.dvm360.com/dvm/Veterinary+Equine/Keys-to-successful-equine-embryo-transfer/ArticleStandard/Article/detail/653161

Lawhorn, B. *Isolation Procedures for Farrowing Operations*. *Agri*LIFE EXTENSION, Texas A&M University System. Accessed April, 2012, at http://animalscience.tamu.edu/files/2012/04/L2263-isolationswine2.pdf

Patterson, David J., and Herring, William O. The Beef Site. *Pelvic Measurements and Calving Difficulty*. University of Missouri Extension. Accessed May, 2012, at www.thebeefsite.com/articles/903/pelvic-measurements-and-calving-difficulty

Powell, J., Jones, S., Gadberry, S., and Troxel, T. (2006) *Beef Cattle Herd Health Vaccination Schedule*. University of Arkansas, Division of Agriculture. Accessed April, 2012, at http://www.uaex.edu/Other_Areas/publications/PDF/FSA-3009.pdf

Rutherford, B. (2012) Breeding Soundness Exam For Heifers Encouraged. *Beef Magazine*. Accessed April 2012 at http://beefmagazine.com/genetics/breeding-soundness-exam-heifers-encouraged

Scharko, P., and Burris, R. *Section 6: Health and Management Techniques*. University of Kentucky College of Agriculture. Accessed April, 2012, at www.ca.uky.edu/agc/pubs/id/id108/06.pdf

Senger, P.L. (2003) *Pathways to Pregnancy and Parturition*, 2nd Edition. Cadmus Professional Communications Science Press Division, Ephrata, PA.

Suwannee River Fair, Inc. (2010) *Viewing Swine Conformations*. Accessed May, 2012, at http://mysrf.org/pdf/pdf_swine/s19.pdf

Youngquist, R.S., and Threlfall, W.R. (2007) *Current Therapy in Large Animal Theriogenology*, 2nd Edition. Saunders Elsevier, St. Louis, MO.

Chapter 6

Hanie, E.A. (2006) Physical Restraint of Horses. In: *Large Animal Clinical Procedures for Veterinary Technicians*. Elsevier Mosby, St. Louis, MO. pp. 47–65.

Higgins, A.J., and Snyder, J.R. (2005) *The Equine Manual*, 2nd Edition. Elsevier Health Sciences, Amsterdam, Netherlands.

Holtgrew-Bohling, K.J. (2011) *Large Animal Clinical Procedures for Veterinary Technicians*, 2nd Edition. Elsevier Mosby, St. Louis, MO.

Marlborough, L.C., and Knottenbelt, D.C. (2001) Basic Management. In: Coumbe, K., Editor, *Equine Veterinary Nursing Manual*. Blackwell Science, Ltd., London. pp. 1–24.

McCurnin, D.M., and Bassert, J.M. (2010) *McCurnin's Clinical Textbook for Veterinary Technicians*, 7th Edition. Saunders Elsevier, St. Louis, MO.

Orsini J.A., and Divers, T.J. (2008) *Equine Emergencies Treatment and Procedures*, 3rd Edition. Saunders Elsevier, St. Louis, MO.

Reeder, D., Miller, S., Wilfong, D., Leitch, M., and Zimmel, D. (2009) *AAEVT's Equine Manual for Veterinary Technicians*. Wiley-Blackwell, Ames, IA.

Rockett, J., and Bosted, S. (2006) *Veterinary Clinical Procedures in Large Animal Practice*. Thomson Delmar Learning, Independence, KY.

Smith, B.P. (2002) *Large Animal Internal Medicine*, 3rd Edition. C.V. Mosby Co, St. Louis, MO.

Chapter 7

de Hoog, G.S., Cuarro, G.J., and Figueras, M.J. (2001) *Atlas of Clinical Fungi*, 2nd Edition. ASM Press, Washington, D.C. pp. 150, 228, 925.

Feldman, B.F., Zinkl, J.G., and Jain, N.C. *Schalm's Veterinary Hematology*, 5th Edition. Lippincott Williams & Wilkins, Baltimore, MD.

Fowler, M.E. (1998) *Medicine and Surgery of South American Camelids: Llama, Alpaca, Vicuña, Guanaco*. Iowa State University Press, Ames, IA. p. 364.

French, T.W., Blue, J.T., and Stokol, T. Cornell University College of Veterinary Medicine. Accessed May, 2012, at https://ahdc.vet.cornell.edu/clinpath/modules/chem/chempanl.htm

Jack, C.M., Watson, P.M., Donovan, M.S. (2008) *Veterinary Technician's Daily Reference Guide: Canine and Feline*, 2nd Edition. Blackwell Publishing, Ames, IA.

Jain, N.C. (1993) *Essentials of Veterinary Hematology*. Wiley-Blackwell, Ames, IA. p. 51.

McCurnin, D.M., and Bassert, J.M. (2010) *McCurnin's Clinical Textbook for Veterinary Technicians*, 7th Edition. Saunders Elsevier, St. Louis, MO.

The Merck Veterinary Manual, 9th Edition. (2005) Edited by C.M. Kahn and S. Line. Merck & Co., Inc., Whitehouse Station, NJ.

Ogilvie, T.H. (2005) *Large Animal Internal Medicine*. Blackwell Publishing, Ames, IA. pp. 95–96.

Radostits, O.M., Gay, C.C., Blood, D.C. Hinchcliff, K.W. (2000)*Veterinary Medicine: A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses*, 9th Edition. WB Saunders, Philadelphia, PA.

Reagan, W.J., Sanders, T.G., DeNicola, D.B. (1998) *Veterinary Hematology: Atlas of Common Domestic Species*. Wiley-Blackwell, Ames, IA.

Sirois, M., and Hendrix, C.M. (2007) *Laboratory Procedures for Veterinary Technicians*, 5th Edition. Mosby Elsevier Health Science, St. Louis, MO.

Thrall, M.A., Baker, D.C., and Lassen, E.D. (2003) *Veterinary Hematology and Clinical Chemistry*. Lippincott Williams & Wilkins, Philadelphia, PA. p. 476.

Chapter 8

Butler, J.A., Colles, C.M., Dyson, S.J., Kold, S.E., and Poulos, P.W. (2000) *Clinical Radiology of the Horse*, 2nd Edition. Blackwell Science Ltd., Oxford, UK.

Farrow, C.S. (2006) *Veterinary Diagnostic Imaging the Horse*. Mosby Elsevier, St. Louis, MO.

Miller, S., and Bramlage, L., (2004) Proper Positioning for Diagnostic Radiography of the Equine Distal Limb. In: *AAEP Technician Proceedings*. Denver, CO.

Redden, R.F. (2002) *Equine Podiatry Monograph Series Radiography of the Equine Foot*. Nanric, Inc., Versailles, KY.

Reeder, D., Miller, S., Wilfong, D., Leitch, M., and Zimmel, D. (2009) *AAEVT's Equine Manual for Veterinary Technicians*. Wiley-Blackwell, Ames, IA.

Chapter 9

Plumb, D.C., *Plumb's Veterinary Drug Handbook*, 6th Edition. Blackwell Publishing, Ames, IA.

Chapter 10

Colahan, P.T., Merritt, A.M., Moore, J.N., Mayhew, I.G., and King, C. (2013) *Manual of Equine Medicine and Surgery*. Mosby, St. Louis, MO.

Landolt, G.A. (2007) Management of Equine Poisoning and Envenomation. *Veterinary Clinics of North America Equine Practice*. 23: 31–47.

Mueller, P.O., and Moore, J. (2003) Gastrointestinal Emergencies and Other Causes of Colic: A Classification and Pathophysiology of Colic. In: Editors J.A. Orsini and T.J. Divers, *Manual of Equine Emergencies Treatment and Procedures*, 2nd Edition. Saunders by Elsevier Science, Philadelphia, PA. pp. 188–199.

Orsini, J.A., and Divers, T.J., (2002) *Manual of Equine Emergencies: Treatment and Procedures*, 2nd Edition. Saunders by Elsevier Science, Philadelphia, PA.

The Merck Veterinary Manual, 9th Edition. (2005) Edited by C.M. Kahn and S. Line. Merck & Co., Inc., Whitehouse Station, NJ.

West, C. (2010) *EPM Diagnosis and Treatment Recommendations*. Blood-Horse Publications. http://www.bloodhorse.com/horse-racing/articles/55565/epm-diagnosis-and-treatment-recommendations.%20From%20Bloodhorse.com

Chapter 11

Basko, I., Denege, C., Khalsa, D., Snader, M., and Willoughby, S. (1993) *Healing Your Horse: Alternative Therapies*. Howell Bookhouse, New York.

Cointreau, M., Kavasch, B., and Cointreau, S. (2005) *Equine Herbs & Healing: An Earth Lodge Guide to Horse Wellness*. Earth Lodge, Gaylordsville, CT.

Hourdebaigt, Jean-Pierre. (2007) *Equine Massage: A Practical Guide*, 2nd Edition. Wiley Publishing, Inc., Hoboken, NJ.

Hooper, P. (2005) *Sports Massage for Horses*. Trafalgar Square Books, North Pomfret, VT.

Index

choke

cleft palate

Clostridium perfringens

coccidiosis

colic

emergencies

gastric ulcers

grain overload

hepatic amyloidosis

hepatic lipidosis

intestinal chlamydial infection

left displaced abomasum (LDA)

neoplasia

nonsteroidal antiinflammatory drug toxicosis

physical examination

prognathia

rectal prolapse

right displaced abomasum (RDA)

rotavirus enteritis

ruminant acidosis

salmonellosis

sand entercolopathy

stomatitis

Tyzzer’s disease

rickets

selenium toxicity

urinary calculi

vitamin A (retinol) deficiency

vitamin E deficiency

vitamin K deficiency

white muscle disease (WMD), nutritional myodegeneration (NMD)

zinc deficiency (ruminal parakeratosis)

minerals

chromium

cobalt

copper

fluorine

iodine

iron

manganese

molybdenum

selenium

silicon

zinc

vitamins

biotin

cobalamin (vitamin B12)

folic acid

acanthocytes (spur cell)

agglutination

anisocytosis

basophilic stippling

blister cells (prekeratocytes)

codocyte cell (target cell)

dacrocytes

eccentrocytes

echinocytes (crenation)

Heinz bodies

Howell-Jolly bodies

hypochromasia

keratocytes

macrocytosis

microcytosis

nucleated RBCs (metarubricytes, normoblasts)

poikilocytosis

polychromasia

Rouleaux formation

schistocytes

spherocytes

stomatocytes

torocytes

inclusions

clinical parameters of parturition

complete blood count (CBC)

dystocia signs

estrous detection

female reproductive anatomy

female reproductive physiology

gestation

heart rate normal values

hoof care

intravenous blood withdrawal

male reproductive anatomy

medication administration techniques

intradermal

intramuscular (IM)

intravenous (IV)

oral

subcutaneous

minimum acceptable semen quality in satisfactory potential breeders

minimum acceptable testicular size for breeders

nutritional requirements

packed cell volume (PCV) normal values

pregnancy diagnosis

respiratory rate

respiratory rate normal values