ACVR | Equine Diagnostic Imaging

EDI PRELIMINARY EXAM STUDY GUIDE

INTRODUCTION

This study guide is intended to support candidates in their preparation for the ACVR Diagnostic Imaging Preliminary Examination by providing a structured framework of key topics, concepts, and representative examples of the knowledge expected of entry-level veterinary radiologists. It is designed to serve as a companion resource to assist with focused study and self-assessment.

However, this guide is **not an exhaustive source** of all material that may be assessed on the examination. Candidates are expected to demonstrate a working understanding of the **current imaging literature**, including foundational texts and peer-reviewed articles relevant to each topic. Independent review of the broader scientific and clinical body of knowledge remains an essential component of preparation—not only for examination success but also for professional competence in clinical practice.

The **references provided** throughout this guide are **examples** of core and supplemental sources that support understanding of the material. They are included to help direct further reading but do **not represent a complete list** of the literature that candidates should be familiar with.

Acknowledgements

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KEY CONCEPTS

H: ANATOMY, PHYSIOLOGY, AND PATHOPHYSIOLOGY (80%)

Rationale: A variety of imaging modalities are employed to evaluate disease in veterinary patients, including radiography, fluoroscopy, and computed tomography. Consequently, thorough knowledge of normal and abnormal anatomy and physiology is a fundamental component of the veterinary radiologist's daily practice.

The listed diseases are examples to guide study and the exam may not be limited to these topics.

HORSE BREED AND DISCIPLINE SPECIFIC PATHOPHYSIOLOGY

Rationale: A comprehensive understanding of the physiologic adaptations specific to various breeds and athletic disciplines of horses is critical, as is familiarity with the criteria that differentiate adaptive from pathologic responses and knowledge of the prevalence and distribution of common lesions.

Examples:

- Thoroughbred racing
- Standardbred racing
- Western performance
- English performance
- Dressage
- Barrel racing
- Eventing
- Show Jumping
- Driving

MUSCULOSKELETAL SYSTEM

- Anatomy and physiology
  - Bone formation, growth, and fusion
  - Arthrology
- Pathophysiology
  - Fracture predisposition, common sites, and healing
  - Congenital, acquired, degenerative, and metabolic bone and joint diseases.
  - Traumatic, inflammatory, and neoplastic muscle diseases.
  - Subchondral bone injury/repetitive stress injuries
  - Wolff's law

NEUROLOGIC SYSTEM

- Anatomy and physiology
    - Skull
        - Bones
        - Foramina
        - Clinically applicable suture lines/physes
            - e.g. basisphenoid-basioccipital suture
    - Cerebrum
        - Lobes of the brain including function
        - Components of the brain stem including function
        - Cranial nerve location and function
        - Ventricular system
        - Production, flow and resorption of cerebrospinal fluid
        - Vascular supply
        - Meninges
    - Cervical vertebral column
        - Normal anatomy and variances of the cervical vertebral column
        - Physeal closure times
        - Common congenital malformations
        - Criteria for identifying spinal cord compression
    - Spinal cord
        - White and grey matter distribution
        - Cervical and lumbar intumescence location
        - Naming of spinal nerves and relationship to the intervertebral foramina
        - Anatomical relationships between the spinal cord, spinal nerves, meninges, and vertebral canal
    - Appendicular skeleton
        - Distribution of nerves in the limbs
- Pathophysiology
    - Disease processes affecting cranial nerves
        - Temporohyoid osteoarthropathy
        - Petrous temporal bone fracture
        - Neoplasia
    - Neuroanatomical localization and prioritized differential diagnoses based on the localization
    - Myelography (CT, radiographic)
        - Indications
        - Procedure
        - Complications
        - Assessing spinal cord compression
    - Clinical signs and differential diagnoses for forebrain pathology
        - Including possible incidental findings e.g. cholesterinic granulomas
    - Intra-articular and perineural analgesia

        - Structures anaesthetized
        - Mode of action
        - Complications
        - Effects on diagnostic imaging (e.g. nuclear imaging)

CARDIOVASCULAR SYSTEM

- Anatomy and physiology
    - Cardiac cycle
    - Embryology in the context of development of common malformations of the heart and great vessels
    - Differences between fetal and neonatal circulation
    - Major arterial supplies, venous drainage and portal systems
    - Common cardiac developmental anatomy and defects (same as above?)
    - Murmur classification and characteristics
    - EKG analysis
- Pathophysiology
    - The effects of common cardiac diseases including developmental anomalies
    - Hemodynamics, flow, timing, and pressure relationships
    - Congenital and acquired cardiovascular diseases
    - Mechanisms and pathophysiologic effects of congestive heart failure
    - Pericardial disease and effect on cardiac function
    - Portosystemic shunts and AV malformations
    - Thromboembolic disease
    - Incidental echocardiographic abnormalities

OCULAR SYSTEM

- Anatomy
    - Globe
    - Orbit
    - Peri-orbital structures
        - Muscles
        - Nerves
        - Vascular supply
- Pathophysiology
    - Trauma
        - Retinal detachment
        - Intraocular hemorrhage
        - Foreign body
    - Neoplasia
        - Primary ocular

        - Third eyelid
    - Glaucoma
    - Equine Recurrent Uveitis (ERU)
- Imaging techniques
    - Ultrasound
        - Transpalpebral
        - Transcorneal
    - CT
        - Including contrast studies (eg. dacryocystorhinography)
    - MRI

RESPIRATORY SYSTEM

- Anatomy and physiology
    - Nasal passages
    - Paranasal sinuses
    - Pharynx
    - Larynx
    - Trachea
    - Mediastinum
    - Pleural space
    - Pulmonary parenchyma
    - Vascular supply
        - Relationship between lung perfusion and lung health
        - Relationship between the blood gas profile and respiratory health
    - Processes involved in the production and resorption of pleural fluid
- Pathophysiology of common respiratory, mediastinal, and pleural diseases
    - Infectious/inflammatory
    - Neoplasia
    - Edema
    - Trauma
    - Exercise-Induced Pulmonary Hemorrhage (EIPH)

DIGESTIVE SYSTEM

- Anatomy and physiology
    - Pancreas
        - Endocrine vs exocrine
    - Esophagus
    - Gastrointestinal tract
    - Normal anatomic relationships of gastrointestinal tract with all other abdominal organs
- Pathophysiology of common disorders
    - Colic
    - Infectious/inflammatory disease

- Neoplasia
- NSAID toxicity/gastric ulcers
- Delayed gastric emptying
- Megaesophagus, esophageal strictures

ENDOCRINE SYSTEM

- Anatomy and physiology
  - Adrenal glands
  - Thyroid and parathyroid glands, including ectopic locations
  - Pituitary gland
  - Functional relationships between endocrine tissues, electrolytes, and other body systems
- Pathophysiology
  - Expected imaging findings with hyperfunctional or hypofunctional endocrine diseases
  - Recommended imaging modalities and parameters for suspected disease processes
  - Neoplasia

HEPATOBILIARY SYSTEM

- Anatomy and physiology
  - Liver
  - Biliary system
  - Vascular structures
- Pathophysiology of common disorders
  - Infectious/inflammatory
  - Toxicosis
  - Cirrhosis
  - Biliary obstruction
  - Portosystemic shunt

UROGENITAL SYSTEM

- Anatomy and physiology
  - Kidney
  - Ureters
  - Urinary bladder
  - Urethra
  - Primary and accessory sex glands/organs
  - Relationship between urogenital system and other bodily systems
- Pathophysiology
  - E.g., Kidney disease/damage

- Failure
- Glomerular filtration rate
- Pyelonephritis
- Obstruction
- Neoplasia
- Urolithiasis
- Congenital malformations
- Rhabdomyolysis
- Nonsteroidal Anti-Inflammatory Drugs (NSAID) toxicity

I: IMAGING MODALITIES (16%)

It is expected that the minimally competent equine diagnostic imaging candidate has specific knowledge about the following imaging modalities (including the basis of image formation, physics and clinical application) in addition to the more commonly used modalities on the general preliminary examination.

LOW FIELD MAGNETIC RESONANCE IMAGING

- Particular nuances compared to high field
  - Disadvantages vs advantages
  - Limitations of standing vs recumbent examinations
  - Case selection
  - Artifacts
- How technical parameters affect image quality/acquisition
  - Slice thickness
  - Timing
  - Field of view
- Context and Applications
  - Eg. Phase cancellation artifact can be used to identify regions of intra-osseous fluid accumulation, particularly in standing units where motion may limit the use of Short Tau Inversion Recovery (STIR).

BONE SCANS

- The molecular processes involved in radioactive and nuclear decay.
- How to read nuclear decay charts.
- The uses for frame mode acquisition protocols.
- List mode acquisition protocols and the appropriate usages of this protocol type.
- Static acquisition protocols and the appropriate usages of this protocol type.
- Dynamic acquisition protocols and the appropriate usages of this protocol type.

- Gated acquisition protocols and the appropriate usages of this protocol type.
- The diagnostic uses of radiopharmaceuticals in nuclear imaging.
- How image settings influence the quality, frame rate, and digital size of images.
- The impact of different types of artifacts on the quality of nuclear images.
- The functioning of basic components of a Gamma camera.
- The different types of collimators available to use with Gamma cameras.
- The functioning of nuclear medicine generator systems.
- The factors that limit the spatial and temporal resolution of nuclear images.
- The common applications of time activity curves.
- The methods used to correct the background of nuclear images.
- Basic musculoskeletal PET imaging principles and associated physics
- Patient preparation

MYELOGRAPHY

- Appropriate selection of types of contrast media and doses
- Techniques
- Indications

J: RADIATION AND EQUIPMENT SAFETY (4%)

SAFE HANDLING OF RADIOACTIVE MATERIAL

- The handling and proper disposal of radionuclides.
- The radiation protection aspects of handling animals that have been given radionuclides
- The care and handling of the radioisotopes and the radioactive patients

RESOURCE LIST FOR ACVR PRELIMINARY EXAMINATION

This resource list is a guide to help residents prepare for the Preliminary examination. This list is based on the most referenced sources for the Preliminary examination but is not an exhaustive list. There is no required reading so feel free to use other similar references if you prefer.

- Medical Physics
  - Curry, Thomas S., James E. Dowdey, and Robert C. Murry. *Christensen's physics of diagnostic radiology*. Lippincott Williams & Wilkins, 1990.
  - Bushberg, Jerrold T., and John M. Boone. *The essential physics of medical imaging*. Lippincott Williams & Wilkins, 2011.
  - Held, Kathryn D. "Radiobiology for the radiologist, by Eric J. Hall and Amato J. Giaccia." (2006): 816-817.
  - Kremkau, Frederick W. *Sonography principles and instruments*. Elsevier Health Sciences, 2015.
  - Walter, Huda. "Review of Radiologic Physics." (2010).
  - Bushong, Stewart Carlyle, and Frank Goerner. *Radiologic science for technologists*. Elsevier Health Sciences, 2012.
  - Lionhart, Prometheus. "Radiologic Physics War Machine", 3rd Edition.
  - McRobbie, Donald W., et al. *MRI from Picture to Proton*. Cambridge university press, 2017.
  - Westbrook, Catherine, and John Talbot. *MRI in Practice*. John Wiley & Sons, 2018.

- Anatomy
  - Hermanson, John W., and Alexander De Lahunta. *Miller and Evans' anatomy of the dog-E-book*. Elsevier Health Sciences, 2018.
  - Dyce, Keith M., Wolfgang O. Sack, and Cornelis Johannes Gerardus Wensing. *Textbook of veterinary anatomy-E-Book*. Elsevier Health Sciences, 2009.
  - König, Horst Erich, Hans-Georg Liebich, and K. L. Overall. "Veterinary anatomy of domestic animals." *Text Book and Colour Atlas. 3rd ed. New York, NY. Schattauer* (2014): 303-5.

- Physiology
  - Hall, John E., and Michael E. Hall. *Guyton and Hall Textbook of Medical Physiology E-Book: Guyton and Hall Textbook of Medical Physiology E-Book*. Elsevier Health Sciences, 2020.
  - Klein, T. Bradley G. *Cunningham's Textbook of Veterinary Physiology-E-Book: Cunningham's Textbook of Veterinary Physiology-E-Book*. Elsevier Health Sciences, 2012.

- General clinical references
  - Ettinger, Stephen J., and Edward C. Feldman. *Textbook of Veterinary Internal Medicine-eBook: Textbook of Veterinary Internal Medicine-eBook*. Elsevier health sciences, 2010.
  - Morris, Joanna, and Jane Dobson. *Small animal oncology*. John Wiley & Sons, 2008.
  - Lorenz, Michael D., Joan Coates, and Marc Kent. *Handbook of Veterinary Neurology-E-Book: Handbook of Veterinary Neurology-E-Book*. Elsevier Health Sciences, 2010.

    - Fossum TW. Small Animal Surgery. 5th ed. St. Louis, MO: Elsevier; 2020. Selected chapters on orthopedics.

- Imaging references
    - Thrall, Donald E. *Textbook of veterinary diagnostic radiology-E-book*. Elsevier health sciences, 2012.
    - Kidd, Jessica A., Kristina G. Lu, and Michele L. Frazer, eds. *Atlas of equine ultrasonography*. John Wiley & Sons, 2022.
    - Murray, Rachel C., ed. *Equine MRI*. John Wiley & Sons, 2010.
    - Schwarz, Tobias, and Jimmy Saunders, eds. *Veterinary computed tomography*. John Wiley & Sons, 2011.
    - Bertolini, Giovanna. "Body MDCT in small animals." *Cham, Switzerland: Springer International Publishing* (2017).
    - Boon, June A. *Veterinary echocardiography*. John Wiley & Sons, 2011.

- Digital imaging and Image viewing environment
    - Thomas, A. M. K. "PACS A Guide to the Digital Revolution. Edited by KJ Dreyer, A Metha and JH Thrall, pp. x+ 435, 2002 (Springer-Verlag, New York NY),£ 76.50 ISBN 0 387 25291 8." (2003): 82-82.
    - Puchalski, Sarah M. "Image display." *Veterinary radiology & ultrasound* 49 (2008): S9-S13.

- Radiation and Equipment Safety
    - Bushong, Stewart Carlyle, and Frank Goerner. *Radiologic science for technologists*. Elsevier Health Sciences, 2012.
    - IAEA. *Radiation Protection and Safety in Veterinary Medicine*. International Atomic Energy Agency, 2021.
    - Hall, Eric J., and Amato J. Giaccia. "Radiobiology for the Radiologist." *Int J Radiat Oncol Biol Phys* 66.627 (2006): 10-1016.

Residents are encouraged to review other common veterinary journal for articles related to diagnostic imaging. The majority of the relevant journal articles will be found in the last 10-15 years, however, there may be fundamental concepts in imaging that were published prior to this timeframe that are still relevant.

- Veterinary Radiology and Ultrasound
- Journal of the American Veterinary Medical Association
- American Journal of Veterinary Research
- Journal of Veterinary Internal Medicine
- Equine Veterinary Journal
- Equine Veterinary Education
- Veterinary Surgery
- Radiographics
- Veterinary Clinics of North America
- Veterinary Ophthalmology
- The Veterinary Journal

STUDY GUIDE SAMPLE QUESTIONS

E: ANATOMY, PHYSIOLOGY, AND PATHOPHYSIOLOGY

NEUROLOGIC SYSTEM

What is the most common predisposing cause for adverse reactions in horses undergoing general anesthesia and cervical myelography ?

a. Lumbosacral puncture performed at the same time as the myelogram procedure.

b. Their head elevated for a prolonged period of time.

c. Extended general anesthesia times and higher contrast volumes administered.

d. A higher neurologic grade prior to the procedure.

Key: C

Rationale: (Mullen KR, Furness MC, Johnson AL, Normal TE, Hart KA, Burton AJ, Bichalo RC, Ainsworth DM, Thompson MS, Scrivani PV. Adverse Reactions in Horses that Underwent General Anesthesia and Cervical Myelography. J Vet Intern Med. 2015;29:954-960)

OCULAR SYSTEM

The most common neoplasm of the nictitating membrane in horses is:

a. squamous cell carcinoma.

b. melanoma.

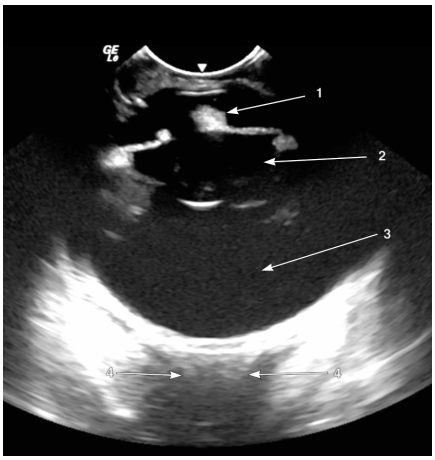
c. chondrosarcoma.

d. adenocarcinoma.

Key: A

Rationale: https://www.merckvetmanual.com/eye-diseases-and-disorders/neoplasia-of-the-eye-and-associated-structures/ocular-neoplasia-in-horses?query=ocular%20neoplasia

What structure is indicated by arrow 1?



a. Anterior chamber

b. Posterior chamber

c. Lens

d. Corpora nigra

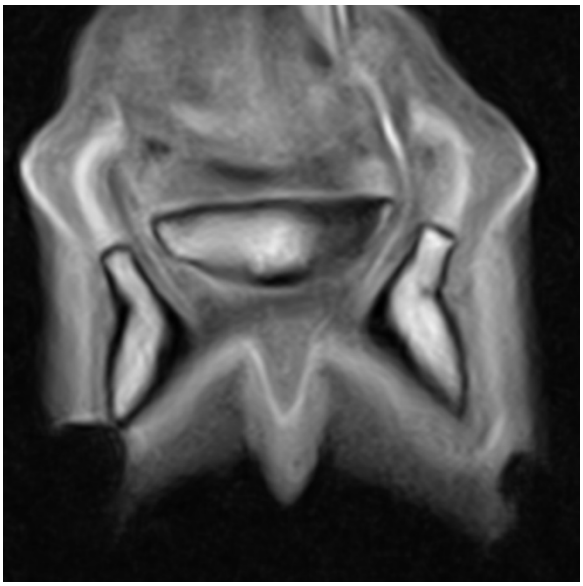
Key: D

Rationale: Gialletti, R. (2022). Equine Ocular Ultrasonography. In Atlas of Equine Ultrasonography (eds J.A. Kidd, K.G. Lu and M.L. Frazer). https://doi.org/10.1002/9781119514671.ch24

F: IMAGING MODALITIES

LOW FIELD MRI

What is the artifact in the image below?



a. Motion artifact

b. Phase cancellation artifact

c. Zipper artifact

d. Susceptibility artifact

Key: D

Rationale: https://radiopaedia.org/articles/magnetic-susceptibility-artifact

What steps can be taken to minimize magic angle artifact in the collateral ligaments of the distal interphalangeal joint in a standing, low-field MRI?

a. Use a FSE sequence

b. Let the horse lean during caudally during acquisition

c. Let the horse lean laterally during the acquisition

d. Use a GRE sequence

Key: A

Rationale: Smith MA, Dyson SJ, Murray RC. Is a magic angle effect observed in the collateral ligaments of the distal interphalangeal joint or the oblique sesamoidean ligaments during standing

magnetic resonance imaging? Vet Radiol Ultrasound. 2008 Nov-Dec;49(6):509-15. doi: 10.1111/j.1740-8261.2008.00432.x. PMID: 19051639.