Introduction:

The ECVDI Study Guide is a guide for ECVDI residents preparing for the theoretical board examination, and is intended to give an indication of topics that may be covered in the examination. Examiners will base their question selection on the Small Animal and Large Animal Exam Content Outlines. 100% adherence to the objectives in this document is not guaranteed.

Anatomy and Physiology:

Imaging-related anatomy, normal imaging features and physiology
For the Large Animal Track, approximately 80% of exam questions will be related to large animal anatomy, with emphasis on the musculoskeletal system.
For the Small Animal Track, approximately 95% of exam questions will be related to canine and feline anatomy and up to 5% may relate to other species (including avian and exotics).

1. **General**

1.1. Current anatomic nomenclature will be used in questions and expected in answers (Nomina Anatomica Veterinaria).
1.2. Current international nomenclature of radiographic projections will be used in questions and expected in answers (Veterinary Radiology 1985;26(1):2-9).

2. **Musculoskeletal system**

2.1. General:
- 2.1.1. Process of bone formation and growth
- 2.1.2. Ages at which ossification centres fuse
- 2.1.3. Gross anatomy and imaging anatomy of muscles and ligaments

2.2. **Axial skeleton**
- 2.2.1. Topographic features of vertebrae in all spinal segments
- 2.2.2. Topographic features of bones of the skull and mandible
- 2.2.3. Dental anatomy and the influence of age on dentition
- 2.2.4. Sinuses, nasal cavities, sinus communications and relationships
- 2.2.5. Topographic features of the pelvis
- 2.2.6. Formulae for the vertebral column, sternum and ribs
- 2.2.7. Anatomical structures in transverse, sagittal, and dorsal planes (head, back and pelvis) as it pertains to CT and MR imaging

2.3. **Appendicular skeleton**
- 2.3.1. Topographic features of the long bones and joints as seen on cross sectional imaging modalities as well as radiographs (including avian and stress radiographs)
- 2.3.2. Proximal and distal attachments of the major muscles, tendons, and ligaments associated with the thoracic and pelvic limbs as it pertains to radiographic and cross-sectional images
- 2.3.3. Transverse and sagittal anatomy of the distal extremity, metacarpus/tarsus (equine), common calcaneal and biceps tendons (canine and equine) as it pertains to ultrasound imaging

2.4. **Arthrology**
- 2.4.1. Topographic features of joints of the head, vertebral column and limbs

2.4.1.1. Relationship, structure and function of ligaments and intervertebral discs of the vertebral column
2.4.1.2. Joints containing menisci and meniscal function
2.4.2. Sesamoid bones and their relationship to the joints
2.4.3. Structures that are accentuated on various radiographic projections (e.g. carpus - lateromedial and “skyline” views)
2.4.4. Comparative arthrology of the bones and joint compartments for the stifle, carpus and tarsus between species
2.4.5. Physiology:
2.4.5.1. Physiology of cartilage growth, development and repair
2.4.5.2. Physiology of normal synovial joints

3. **Cardiovascular and Vascular Systems: Anatomy, Embryological Development, and Congenital Malformations**
3.1. Embryology of the cardiovascular system to explain the development of common malformations of the heart and great vessels
3.2. Differences between foetal and neonatal circulation
3.3. Topographic anatomy of the heart
3.4. Vascular supply to the brain
3.5. Vertebral and paravertebral vascular system
3.6. Branches of the thoracic and abdominal aorta
3.7. Blood supply of the canine and feline thoracic and abdominal organs
3.8. Anatomy of the portal venous system (hepatic) including the appearance on angiographic studies
3.9. Blood supply to thoracic and pelvic limbs including:
3.9.1. Blood supply of long bones
3.9.2. Blood supply and differences between blood supply in immature and mature long bones
3.9.3. Differences in large animal versus small animal immature long bone blood supply
3.9.4. Major arterial blood supply and venous drainage
3.10. Angiocardiographic anatomy of the heart
3.11. Echocardiographic anatomy in standard right and left parasternal short and long-axis planes
3.12. Physiology:
3.12.1. Basic principles of cardiac haemodynamics, including flow, timing, and pressure relationships
3.12.2. Origin, source and significance of heart sounds
3.12.3. Interrelationship and correlation of the above for the normal cardiac cycle and for abnormal cardiac conditions
3.12.4. Normal coronary blood flow
3.12.5. Starling's Law of the Heart and its relevance to cardiac haemodynamics
3.12.6. Normal Doppler patterns for Doppler ultrasound of the heart and major vessels
3.12.7. Physiology of lymphatic production and flow

4. **Nervous system**
4.1. Anatomical relationships of spinal cord, spinal nerves and meninges including:
4.1.1. Brachial and lumbosacral plexus
4.1.2. Major components and innervations of the nerves that originate from these plexus

4.2. Segmental spinal nerve origins, location of exit from the vertebral canal and the function of the spinal nerves
4.3. Ventricular system of the brain and its drainage
    4.3.1. Production and flow of cerebrospinal fluid
4.4. Distribution of nerves in the distal extremity of the thoracic and pelvic equine limbs as related to common nerve blocks performed
4.5. Gross and imaging anatomy of the brain and brain stem, including the cranial nerves and spinal cord
4.6. Principles of neurologic examination and lesion localization
4.7. Origin of cranial nerves and their function
4.8. Anatomy of the organs of special sense

5. **Digestive system**
5.1. Anatomy of the teeth
5.2. Dental formula and Triadan tooth numbering system in the major domestic species
5.3. Comparative gross and imaging anatomy of the liver, gallbladder, pancreas, gastrointestinal tract, salivary glands including:
    5.3.1. Ileo-ceco-colic region
    5.3.2. Bile duct and pancreatic duct
5.4. Physiologic mechanisms of gastro-intestinal tract function (oral, oesophageal, gastric, intestinal, colonic) including:
    5.4.1. Propulsion and bolus formation, oesophageal and intestinal motility
    5.4.2. Normal transit times of the gastrointestinal system
    5.4.3. Hormonal control and alimentary reflexes (e.g., gastrocolic) as they apply to motility and secretion control
5.5. Normal exocrine and endocrine physiology of the pancreas
5.6. Physiology of the hepatobiliary system
5.7. Avian anatomy of the normal digestive system

6. **Respiratory system**
6.1. Gross and imaging anatomy of the oropharynx, nasopharynx, laryngeal cartilages and hyoid apparatus
6.2. Guttural pouches and their anatomic relationships as viewed on routine radiographs and computed tomography or magnetic resonance imaging – equine
6.3. Comparative gross and imaging anatomy of the bronchial tree and lung lobes
6.4. Avian air sac anatomy and connection with primary pulmonary structures (airways, lung, etc.)
6.5. Anatomy and physiology of the pleura including:
    6.5.1. The pleural layers
    6.5.2. Normal pleural fluid formation
6.6. Mediastinal anatomy and degree of development/fenestrations between species
6.7. Physiology
    6.7.1. Mechanics of ventilation, including: Mechanism of air movement, pressure volume relationships and air space divisions
    6.7.2. Lung perfusion and physiologic responses to lung diseases
    6.7.3. Methods of oxygen and carbon dioxide transport
    6.7.4. Basics of the blood gas profile (pH, pO_2, pCO_2, HCO_3, base excess/deficit)

7. **Urogenital system**

7.1. Comparative gross and imaging anatomy of the kidney, ureter, lower urinary tract and reproductive organs including:
    7.1.1. Normal appearance on contrast enhanced radiographic or cross-sectional studies
7.2. Embryology of the urogenital system
    7.2.1. Development of the kidney, ureters, and urinary bladder
    7.2.2. Development of gonadal structures
7.3. Avian normal urogenital anatomy
7.4. Renal function
    7.4.1. Mechanism of urine production
        7.4.1.1. Methods of renal function assessment
        7.4.1.2. Role of the kidney in the maintenance of blood pressure/electrolytes
        7.4.1.3. Renin-angiotensin-aldosterone pathways and their effects on renal function
        7.4.1.4. Erythropoietin and endocrine functions
    7.4.2. Organ, hormonal and mineral inter-relationships including:
        7.4.2.1. Interrelations of kidneys, liver, intestine, bone, parathyroid and thyroid gland on Vitamin D, calcium and phosphate regulation
7.5. Pressure-volume relationship among the ureters, bladder and urethra; neurophysiology of micturition, the detrusor reflex and vesicoureteral reflux
7.6. Radiographically recognizable foetal ossification intervals (canine and feline)
7.7. Physiology of the genital system including, but not limited to:
    7.7.1. Pregnancy and parturition
    7.7.3. Effect of the ovarian cycle on genital organs

8. **Miscellaneous**
8.1. Effects of positioning and postural influences on the radiographic appearance of all body parts, and in particular the thorax and abdomen
8.2. Normal anatomic relationships of all abdominal organs of the different species including their peritoneal or retroperitoneal location
8.2. Effects of inspiration vs. expiration on anatomic relationships and appearances
8.3. Gross anatomy and imaging anatomy of lymph nodes; lymphatic drainage patterns
8.4. Gross anatomy and imaging anatomy of endocrine organs
8.5. Physiology of endocrine organs including:
    8.5.1. Thyroid Gland
        8.5.1.1. Iodide trapping and organification into T3/T4
        8.5.1.2. Pituitary-thyroid axis - homeostasis and negative feedback
        8.5.1.3. Thyroid hormone function and effects on other organ systems
    8.5.2. Pituitary Gland
        8.5.2.1. Homeostasis and regulation of the pituitary gland via portal system and releasing factors/proteins or neurohypophyseal control of posterior pituitary gland
    8.5.3. Adrenal Gland
        8.5.3.1. Epinephrine and norepinephrine production and regulation
        8.5.3.2. Glucocorticoids - control and effects
        8.5.3.3. Mineralocorticoids - control and effects
        8.6.3.4. Physiologic effects of adrenal hormones on CNS, cardiovascular system, respiratory system and metabolic status
8.7. Gross anatomy and imaging anatomy of organs of special sense (eye and ear)

Pathophysiology

Pathophysiology contains both species independent and species-specific topics.
For the Large Animal Track, approximately 80% of exam questions will be related to large animal or species-independent pathophysiology.
For the Small Animal Track, approximately 95% of exam questions will be related to canine and feline or species-independent pathophysiology.

1. Musculoskeletal system

1.1. Pathophysiology of common diseases of the nasal cavity and paranasal sinuses
1.2. Pathophysiology of bone disease including, but not limited to:
- 1.2.1. Metabolic, congenital and developmental diseases
- 1.2.2. Fracture healing (normal and pathological fracture healing)
- 1.2.3. Infection and sequestration of bone
- 1.2.4. Bone infarcts and avascular necrosis
- 1.2.5. Periosteal and periarticular new bone formation
- 1.2.6. Disuse osteopaenia

1.3. Pathophysiology of joint disease including, but not limited to:
- 1.3.1. Immune-mediated and infectious joint disease
- 1.3.2. Degenerative joint disease
- 1.3.3. Traumatic joint disease
- 1.3.4. Metabolic, congenital and developmental disease

1.4. Pathophysiology of common diseases of the musculoskeletal systems in horses, for example:
- 1.4.1. Navicular syndrome
- 1.4.2. Laminitis
- 1.4.3. Osteoarthritis
- 1.4.4. Osteochondrosis of the tarsus, fetlock, stifle joint

2. Cardiovascular system

2.1. Anatomy and haemodynamic consequences of common congenital and acquired cardiovascular diseases including, but not limited to:
- 2.1.1. Patent ductus arteriosus
- 2.1.2. Atrial and ventricular septal defects
- 2.1.3. Valvular stenosis
- 2.1.4. Atrioventricular dysplasias
- 2.1.5. Endocardial cushion defects and conotruncal defects
- 2.1.6. Tetralogy and pentalogy of Fallot
- 2.1.7. Persistent left cranial vena cava
- 2.1.8. Valvular endocardiosis
- 2.1.9. Cardiomyopathy
- 2.1.10. Persistent right aortic arch
- 2.1.11. Aberrant left subclavian artery
- 2.1.12. Double aortic arch
- 2.1.13. Aortic coarctation
- 2.1.14. Cor triatriatum dexter
- 2.1.15. Valvular endocarditis
- 2.1.16. Heartworm disease

2.2. Mechanisms and pathophysiologic effects of congestive heart failure
2.3. Pericardial disease and its effect on cardiac function
2.4. Clinical signs, anatomy, haemodynamic effects and pathophysiology of the following:
- 2.4.1. Arteriovenous malformations
- 2.4.2. Infarction of major vessels and downstream organs
- 2.4.3. Aortic and venous embolism/thrombus

2.5. Calculation of pressure gradients in the diseased cardiovascular system on Doppler ultrasound using a modified Bernoulli equation
2.6. Clinical signs, anatomy, hemodynamic effects and pathophysiology of portosystemic shunts (acquired, single intrahepatic and single extrahepatic)

3. Nervous system
3.1. Pathophysiology of common causes of localised spinal cord disorders in small animals including, but not limited to: intervertebral disc disease, haemorrhage, fibrocartilaginous embolism, neoplasia, developmental disorders, infection and trauma
3.2. Pathophysiology of common causes of localized spinal cord disorders in large animals including, but not limited to: Wobbler, developmental disorders, and trauma

4. Digestive system
4.1. Pathophysiology of common diseases of the oral cavity and associated structures (teeth, tongue, salivary glands, masticatory apparatus…)
4.2. Pathophysiology of oesophageal diseases
    4.2.1. Pathophysiology of oesophageal dysfunction including but not limited to: megaoesophagus, strictures, motility disorders, dysphagia, foreign body, oesophageal perforation
4.3. Pathophysiology of dysphagia
4.4. Difference between vomiting and regurgitation
4.5. Pathophysiology of small and large intestinal disease
4.6. Intestinal transit times in disease states
4.7. Causes and types of mechanical and functional ileus
4.8. Pathophysiology of gastric dilatation/torsion/volvulus complex in dogs:
    4.8.1. Possible etiologic factors
    4.8.2. Systemic and local pathophysiologic alterations resulting from gastric torsion/volvulus
4.9. Applicable pathophysiology of small intestinal versus large intestinal diarrhoea
4.10. Pathophysiology of the hepatobiliary system disorders including, but not limited to:
    4.10.1. Hepatitis
    4.10.2. Hepatic abscessation
    4.10.3. Cholangitis
    4.10.4. Cholecystitis
    4.10.5. Obstructive biliary disorders
    4.10.6. Biliary rupture and peritonitis
    4.10.7. Mucocele
4.10.7. Hepatic lipidosis
4.11. Pathophysiology of pancreatitis and other pancreatic disorders including but not limited to:
    4.11.1. Exocine pancreatic insufficiency
    4.11.2. Classification and biological behavior of pancreatic tumours
4.12. Pathophysiology of splenic disease

5. Respiratory system
5.1. Common causes of respiratory dysfunction including dyspnoea and stridor and their pathophysiologic effects on the thoracic wall, pleural space, upper respiratory system and bronchi, lungs, pulmonary vasculature and diaphragm
5.2. Pathophysiology of the diaphragm and thoracic wall
5.3. Pathophysiology of upper and lower airway obstruction
5.4. Pathophysiology of pulmonary parenchymal disease
5.5. Pathophysiology of pleural disease
5.6. Pathophysiology of pulmonary thromboembolism

6. Urogenital

6.1. Pathophysiology of the upper urinary tract including, but not limited to:
- 6.1.1. Acute vs. chronic renal failure
- 6.1.2. Glomerulonephritis
- 6.1.3. Interstitial nephritis
- 6.1.4. Toxicities
- 6.1.5. Infections
- 6.1.6. Pyelonephritis
- 6.1.7. Ureteral obstructions and rupture
- 6.1.8. Renal and ureteral neoplasia

6.2. Abnormal pressure and volume relationship among the ureters, bladder and urethra including the neuropathophysiology of micturition, the detrusor reflex and vesicoureteral reflux

6.3. Pathophysiology of lower urinary tract disease including, but not limited to:
- 6.3.1. Urolithiasis
- 6.3.2. Cystitis
- 6.3.3. Bladder rupture
- 6.3.4. Feline lower urinary tract disease
- 6.3.5. Neoplasia of the lower urinary tract

6.4. Pathophysiology of the ovaries and uterus including, but not limited to
- 6.4.1. Congenital, neoplastic and functional problems, and systemic effects of ovarian disease

6.5. Pathophysiology of prostate gland diseases

6.6. Pathophysiology of testicular diseases

6.7. Anatomy and developmental mechanism of malformations of the urogenital system including ectopic ureter, pseudohermaphroditism, renal agenesis, uterus masculinus, and cryptorchidism

7. Miscellaneous including endocrine and lymphoid system and organs of special sense

7.1. Pathophysiology of common diseases of the internal, external and middle ear

7.2. Pathophysiology of the thyroid gland

7.3. Pathophysiology of pituitary disease including Cushing's syndrome

7.4. Pathophysiology of endocrine diseases associated with the pancreas

7.6. Pathophysiology of diseases of the lymphatic system

7.7. Pathophysiology of the adrenal gland including:
- 7.7.1. Tumours of the adrenal cortex and medulla
- 7.7.2. Hyperadrenocorticism and hypoadrenocorticism
- 7.7.3. Hyperaldosteronism

7.8. Pathophysiology of diseases of the lymphoid and mononuclear phagocytic systems

7.9. Pathophysiology and causes of peritonitis

Physics, Safety and Instrumentation

Physics and safety of ionising radiation, ultrasound and MR; radiobiology; statistics in diagnostic imaging; image artefacts.

Instrumentation, image formation, and methodology of contrast medium enhanced techniques of imaging modalities.

1. **Basic Principles**

1.1. Basic Atomic and Nuclear Physics
- 1.1.1. Atomic composition and structure and nuclear binding forces
- 1.1.2. Nuclear decay charts and radioactive decay

1.1.3. Line of stability and line of unity
1.1.4. Isotopes, isobars, isomers and isotones
1.1.5. Atomic number and atomic mass; calculation of neutron number

1.2. Modes of Radioactive Decay (particulate and non-particulate emissions including neutrinos and anti-neutrinos)

1.2.1. Negatron decay
1.2.2. Alpha decay
1.2.3. Electron capture
1.2.4. Positron decay (annihilation reaction and photon formation)
1.2.5. Isomeric transition

1.3. Radioactive Decay terminology

1.3.1. Decay constant and relationship with physical half-life
1.3.2. Physical and biological half-life, concept and calculation of the effective half-life
1.3.3. Average half-life
1.3.4. Specific activity

1.4. Physics and Chemistry of Radiation Absorption

1.4.1. Difference between molecular excitation and ionization
1.4.2. Difference between particulate and electromagnetic (nonparticulate) forms of radiation
1.4.3. Difference between the sites of origin of gamma rays and x-rays
1.4.4. Basic forms of particulate radiation and their interactions or potential interactions with matter, including: alpha particles, electrons, protons, and neutrons
1.4.5. Difference between direct and indirect forms of ionizing radiation
1.4.6. Difference between direct and indirect actions of radiation
1.4.7. Role of ionization and free radical formation in creating biological effects

1.5. Molecular reactions and interactions of radiation with matter

1.5.1. “Wave concept” and “particle concept” for understanding electromagnetic radiation. Given two known values of electromagnetic radiation, be able to calculate the wavelength, energy or frequency of the radiation
1.5.2. Photoelectric and Compton interaction, pair production, and photodisintegration. Radiation energy and physical density (subject) ranges for which these types of interactions are likely to occur
1.5.3. Interactions between photons and matter and how and when they occur. Differences between them and their role in diagnostic radiology. This includes the basic interactions related to:
1.5.3.1. Absorption
1.5.3.2. Scattering
1.5.3.3. Transmission
1.5.3.4. Mass and linear attenuation coefficient
1.5.4. Exposure, dose equivalent, absorbed dose, weighting (quality) factor for electromagnetic and particulate radiation

2. **Physics of Diagnostic Radiology**

2.1. Physical properties of x-rays:

2.1.1. Relationship of the speed of light, frequency and wavelength. Relationship of the x-ray wavelength and energy.
2.1.2. Wavelength of diagnostic x-rays compared to other forms of electromagnetic radiation (electromagnetic spectrum)
2.1.3. Electron orbits and energy levels
2.1.4. Bremsstrahlung radiation and polychromatic (energetic) x-ray beam
2.1.5. Characteristic radiation
2.1.6. X-ray beam intensity and quality
2.1.7. Effect on photographic emulsion

2.1.8. Fluorescence and phosphorescence
2.1.9. Inverse square law and calculations for determining new mAs factors when distance changes
2.1.10. Interactions with matter and ionization of atoms and secondary scatter
2.1.11. Half value layer, linear and mass attenuation coefficients

3. **Radiation Biology**

3.1. Basic biology and radiobiology of the cell cycle
3.2. Difference in radiation response between acute and late responding tissues
3.3. Radiation induced cell death
3.3.1. Mechanisms of electromagnetic radiation induced cell killing
3.3.2. Basic mechanisms of acute and late radiation injury and cell killing
3.3.3. Differences between apoptotic and mitotic cell death related to radiation induced cellular injury
3.3.4. Comparison of lethal damage, sub-lethal damage and potentially lethal damage
3.4. Concept of L.E.T. (linear energy transfer) and how L.E.T. relates to R.B.E. (relative biological effectiveness) and the oxygen effect
3.5. R.B.E. and how R.B.E. may be influenced by other factors
3.6. Phases of acute radiation syndrome, including the bone marrow, gastrointestinal and CNS radiation syndromes
3.6.1. Prodromal symptoms, and clinical signs associated with acute radiation syndrome. Whole body dose range that results in acute radiation syndrome.
3.7. Effects of chronic radiation exposure
3.8. Effects of radiation on the developing embryo/foetus in utero
3.9. Difference between “lethal dose” and “tolerance dose”
3.10. Difference between deterministic and stochastic effects related to radiation induced injury

4. **Radiation Protection**

4.1. Various radiation protection devices used for different types of radiation
4.2. A.L.A.R.A. concept and application to standards of radiation protection and safety
4.3. Barrier design, occupancy, workload, filtration, beam limiting devices and personnel shielding for the design of radiology rooms and shielding within the room
4.4. Common patient exposure levels during radiographic and CT procedures
4.5. Radiation protection and safety when handling animals that have been given either diagnostic (99mTc, 111Indium) or therapeutic radiopharmaceuticals (131I) including:
4.5.1. Care and handling of the radioisotopes and the radioactive patients
4.5.2. Monitoring external and internal exposure of personnel
4.5.3. Risks of exposure versus contamination

5. **Radiation Monitoring**

5.1. Equipment and devices used for monitoring radiation and the basic principles involved
5.1.1. Gas-filled detectors, ionization chambers, proportional counters and Geiger-Mueller survey meters
5.2. Appropriate use and limitations of personnel monitoring equipment (TLD monitors, pocket dosimeters and film badges) and interpretation of data obtained
5.3. European regulations and dose limits for occupational, non-occupational, general population, and foetal exposures
5.3.1. Patient versus operator exposure
5.3.2. Effect of radiation safety factors: time, distance, shielding
5.3.3. Lifetime cumulative exposures

6. **Construction and function of the components of a diagnostic x-ray unit** including:

6.1. Construction and function of X-ray tubes
6.1.1. Tungsten usage for anodes and cathodes
6.1.2. Cathode anatomy and function

6.1.3. Characteristics of focal spots including: Actual vs. effective focal spots
6.1.4. Line focus principle, large vs. small focal spots
6.1.5. Requirements for and principle and technique of magnification radiography
6.1.6. Anode anatomy and function
6.1.6.1. Rotation and stationary anodes
6.1.6.2. Target angle
6.1.6.3. Heat dissipation within the tube and tube housing
6.1.7. Inherent and added beam filtration
6.1.8. Milliamperage (mA) regulation
6.1.9. Voltage (kVp) regulation
6.1.10. X-ray tube housing and cooling elements
6.2. Construction (basics) and function of different generator types including:
6.2.1. Alternating and direct current
6.2.2. Transformers – anatomy and function
6.2.2.1. Law of transformers
6.2.3. Filament versus high voltage circuits
6.2.4. Rectification
6.2.4.1. Semiconductors (basics)
6.2.5. Generator types:
6.2.5.1. Three phase generators
6.2.5.2. Capacitor discharge generators
6.2.5.3. Falling load principle in generators
6.2.5.4. High frequency generators
6.2.6. Exposure timers (electronic, phototimers – automatic exposure control)
6.2.7. Kilovoltage (including ripple effect, constant potential and high frequency)
6.2.8. Differences between x- gamma rays, and kilo-, ortho- and megavoltage
6.3. Miscellaneous
6.3.1. Cause and appearance of the Heel effect
6.3.2. Average KW ratings of X-ray tubes and X-ray generators
6.3.3. Different types and uses of collimators
6.3.4. Tube rating charts and anode cooling charts for routine radiology and fluoroscopy units
6.3.5. Principle of calculation of heat units
6.3.6. Normal line voltage and use of line voltage compensators
6.3.7. Principles of energy transfer in the production of a useful x-ray beam including those acting at the anode, cathode, glass envelope, and within the transformer
6.4. Use, limitations, care and construction of the following radiographic equipment:
6.4.1. Callipers
6.4.2. Cones and collimators
6.4.3. Fluoroscopic input screens and output phosphors and their functions
6.4.4. Grids
6.4.4.1. Parallel, cross, focused and Potter-Bucky grids
6.4.4.2. Grid ratio and their common values
6.4.4.3. Composition of grids
6.4.4.4. Effects of grids on exposure settings and image quality
6.5. Principles, mechanics and usefulness of air-gap technique
6.6. Image generation process in cinefluoroscopic devices
6.6.1. Components of the image intensifier and the production of an image
6.7. Digital Radiography
6.7.1. Use of computers in radiology and the concepts of digital image formation, format, resolution and storage, including secure transport
6.7.2. Computer hardware characteristics (RAM, CPU, Graphics card, LAN-Adapter)

6.7.3. Storage media and their capacity and general characteristics:
6.7.3.1. Units of performance and storage (Bits and Bytes)
6.7.3.2. HDD
6.7.3.3. FDD
6.7.3.4. CD/DVD
6.7.3.5. MO-Disks
6.7.3.6. Tape
6.7.3.7. RAID (Redundant Array of Independent Drives)
6.7.4. Pixel, voxel, matrix size and their relationships
6.7.5. Characteristics of common file types (*.jpg, *.tiff, DICOM-standard)
6.7.6. Basic components and characteristics of PACS (picture archiving and communication system), including DICOM connectivity
6.7.7. Voice recognition software for reporting
6.7.8. DR and CR systems
6.7.8.1. Components of a photostimulable phosphor (PSP) detection systems and method of image capture
6.7.8.2. Processing of a PSP imaging plate and mechanism of image production
6.7.8.3. Basic components and function of flat panel digital radiography detection systems including:
6.7.8.3.1. Indirect conversion detectors
6.7.8.3.2. Direct conversion detectors
6.7.8.4. Difference between Thin Film Transistor (TFT) detectors and Charge Coupled Device (CCD) – based detectors
6.7.8.5. Factors contributing to spatial resolution and overall image quality (including image noise) in CR and DR
6.7.8.6. Evaluation of performance of imaging systems including:
6.7.8.6.1. MTF
6.7.8.6.2. DQE
6.7.8.7. Basic methods of digital image processing/postprocessing
6.7.8.8. Advantages and disadvantages of digital systems (CR and DR) as compared to one another
6.7.8.9. Properties of H&D curves and comparison of the relative speed, latitude and contrast of different detector types from their characteristic curves
6.8. Properties of commonly used contrast media: barium sulphate, iopamidol, iohexol, iotrolan,iothalamate, ioxaglate, iobitridol, ioversol and various combinations of methylglucamine (meglumine) and sodium diatrizoate
6.8.1. Chemical names
6.8.2. Relative viscosities
6.8.3. Anionic and cationic composition of the ionic and non-ionic contrast media
6.8.4. Advantages and disadvantages of ionic and non-ionic contrast media
6.8.5. Physiologic effects, including the toxicities, of contrast media
6.8.5.1. Management of adverse effects
6.8.6. Physical and chemical properties of the different barium sulphate suspensions
6.8.6.1. Definition of w/v and w/w formulations
6.9. Radiographic Quality and Artefacts
6.9.1. Characteristics of image quality:
6.9.1.1. Contrast - including the differences between subject contrast, film contrast and radiographic contrast
6.9.1.2. Density (radiographic film optical density, base optical density, film fog)
6.9.1.3. Detail, resolution (including full width half max measurements,

FWHM) and sharpness
6.9.1.4. Latitude
6.9.1.5. Modulation transfer function
6.9.1.6. Effects of the following factors on image quality:
6.9.1.6.1. Geometric factors
6.9.1.6.1.1. Distortion
6.9.1.6.1.2. Magnification
6.9.1.6.1.3. Object position
6.9.1.6.1.4. Object size and shape
6.9.1.6.2. Characteristics of controllable x-ray tube factors
6.9.1.6.2.1. Focal spot size
6.9.1.6.2.2. Object-film distance
6.9.1.6.2.3. Target-film distance

6.10. Technique Chart Formation:
6.10.1. Importance and relationship of the following terms as they relate to technique chart formation:
6.10.1.1. Focal-film distance
6.10.1.2. Grids
6.10.1.3. mA x time = mAs
6.10.1.4. mAs vs. kVp
6.10.1.5. Speed of screens and type of film
6.10.1.6. Subject contrast
6.10.1.7. Thickness of subject

6.11. Relationship between the following terms:
6.11.1. mAs and radiographic density
6.11.2. kVp and radiographic contrast
6.11.3. kVp and radiographic density

7. Physics of Diagnostic Ultrasound:

7.1. Physical characteristics of the ultrasound beam
7.2. Basic interactions of ultrasound with matter, including reflection, refraction, scattering and attenuation
7.3. Factors that affect lateral and axial resolution
7.4. Physical factors influencing the propagation of ultrasound in tissues and factors that influence acoustic impedance
7.5. Relationship between wavelength, frequency, impedance and the velocity of sound in tissues
7.6. Ultrasound beam formation and propagation particularly relative to the near field, focal zone and far field
7.7. Calculation of reflected interfaces within tissue and the pulse echo operation (including pulse repetition frequency, pulse duration and duty factor)
7.8. Underlying principles and use of harmonic imaging including indications, contraindications and modes of action
7.9. Doppler Ultrasound
7.9.1. Doppler principle. Be able to calculate the velocity of blood flow given various parameters related to the Doppler frequency shift.
7.10. Safety: Biological effects and safety concerns of Diagnostic Ultrasound

8. Construction and function of the components of a diagnostic ultrasound unit including:

8.1. Basic components of an Ultrasound unit
8.2. Components of ultrasound transducers and their functions including:
8.2.1. Housing
8.2.2. Backing block
8.3. Piezoelectric effect

8.3.1. Materials used for Piezo-Crystals
8.3.2. Curie temperature and its significance in manufacturing the crystals
8.4. Definition of Q-factor
8.5. Characteristics of various transducer types:
8.5.1. Electronic versus mechanical
8.5.2. Linear, curved, phased array
8.5.3. Multifrequency transducers
8.6. Methods of Image Formation and Display
8.6.1. Various modes of displaying ultrasound data
8.6.2. Real-time imaging systems
8.6.3. Use and functions of the controls for real-time equipment:
8.6.3.1. Gain
8.6.3.2. TGC
8.6.3.3. Frame rate
8.6.3.4. FOV
8.6.3.5. Depth range
8.6.3.6. Acoustic power
8.7. Definition of the following terms and their effect on the displayed image:
8.7.1. Frame rate
8.7.2. Image depth
8.8. Doppler Ultrasound
8.8.1. Transducer characteristics, instrumentation, and controls
8.8.1.1. PRF (pulse repetition frequency)
8.8.1.2. CW (continuous wave) vs. PW (pulsed wave)
8.8.1.3. CD (colour Doppler)
8.8.1.4. Power Doppler
8.8.1.5. Tissue Doppler
8.8.2. Clinical applications of Doppler and basic interpretation principles
8.8.2.1. Analysis of arterial wave forms using pulsatility index, resistive index and A/B ratios
8.8.2.2. Doppler energy and Colour/Power Doppler imaging techniques.
8.9. Composition, properties and uses of the different contrast media used in Ultrasound:
8.9.1. Agitated NaCl
8.9.2. Microbubbles
8.10. Principle of harmonic properties of ultrasound contrast media
8.11. Elastography
8.11.1. Principle, types and technique
8.11.2. Clinical applications of elastography

9. Construction and function of the components of a diagnostic Computed Tomography unit including, but not limited to:

9.1. Principles of cross-sectional image formation including the concept of filtered back projection
9.2. Various types of detectors and orientations used in CT scanners (“generations”)
9.2.1. Underlying principles of detectors (see radiation protection)
9.3. Physical principles and basic mechanics of helical CT scanners and the advantages and disadvantages
9.3.1. Pitch for single and multi-detector-row helical scanners
9.4. Image Reconstruction and Display:
9.4.1. Back-projection
9.4.2. Iterative methods of reconstruction
9.4.3. Analytical methods of reconstruction

9.5. Hounsfield units and their limitations and use
9.6. Window level and window width and their application in image display
9.7. Effect of matrix size, image depth, field of view, slice thickness, mA, and kVp on image quality
9.8. Basic principles of cone-beam CT

10. Physics of Magnetic Resonance Imaging

10.1. Basic Principles:

- 10.1.1. Nuclear structure, angular momentum, magnetism and magnetic dipole moment
- 10.1.2. Basic principles and parameters associated with MRI, including the following terminology:
  - 10.1.2.1. Larmor frequency
  - 10.1.2.2. Magnetisation vectors
  - 10.1.2.3. Radiofrequency pulse
  - 10.1.2.4. Free induction decay
  - 10.1.2.5. Spin-spin relaxation time
  - 10.1.2.6. Spin-lattice relaxation time
  - 10.1.2.7. Pulse sequence
  - 10.1.2.8. Chemical shift and paramagnetic substance
  - 10.1.2.9. Contrast media and magnetic susceptibility

10.2. Safety concerns of MRI.

11. Construction and function of the components of a diagnostic Magnetic Resonance Imaging unit including, but not limited to:

11.1. Instrumentation:

- 11.1.1. Basic mechanics and advantages of the different types of magnets used for MRI (permanent, resistive, superconductive)
- 11.1.2. Basic differences between a horizontal magnet design and a vertical (open) magnet design
- 11.1.3. Basic differences between commonly used receiver coil types (surface, quadrature, array) and their use
- 11.1.4. Function of the various components of the MRI scanner
- 11.1.5. Factors that can create image artefacts, including the effect of commonly used veterinary surgical implants
- 11.1.6. MR terminology and the role these factors play in MR image formation, including but not limited to:
  - 11.1.6.1. TR, repetition time
  - 11.1.6.2. TE, echo time
  - 11.1.6.3. Excitation or flip angle
  - 11.1.6.4. FOV, field of view
  - 11.1.6.5. Slice thickness and slice gap
  - 11.1.6.6. Number of averages or excitations
  - 11.1.6.7. Slice selection, phase and frequency encoding gradients

11.2. Clinical Utility/Indications/Procedures

- 11.2.1. General method for acquiring the following pulse sequences and their common clinical uses:
- 11.2.1.1. T1-weighted pulse sequence
- 11.2.1.2. T2-weighted pulse sequences (including fast spin echo T2 imaging and thin-section isotropic images)
- 11.2.1.3. Proton density pulse sequence
- 11.2.1.4. Gradient echo pulse sequences including but not limited to T2*-weighted and 3D sequences
- 11.2.1.5. Fat suppression/fat saturation techniques
- 11.2.1.6. MR angiography (time of flight, phase contrast)

11.2.1.7. Inversion recovery sequences (FLAIR (fluid attenuated inversion recovery) and STIR (short tau inversion recovery))

11.2.1.8. Myelographic sequences

11.2.1.9. Diffusion weighted sequences

11.2.10. Susceptibility weighted imaging

11.3. MRI contrast media:

11.3.1. Common doses of MR contrast media

11.3.2. Hazards and complications of administering contrast media

11.3.3. Mode of action of MR contrast media

12. Construction and function of the components of instrumentation pertaining to Nuclear Medicine Imaging (SA and LA tracks differ in this section) including, but not limited to**:**

12.1. Small and Large Animal Track: Nuclear medicine generator systems

12.1.1. Production of radionuclides by the parent-daughter decay system (generator systems).

12.2. Small and Large Animal Track: Radiation Detectors:

12.2.1. Scintillation Detectors - Gamma Camera

12.2.2. Gamma camera head and function of its components including the NaI crystal, photocathode, and photomultiplier tubes

12.2.3. Basic mechanics and function of the preamplifier, amplifier, and pulse height analyser

12.2.4. Basic mechanics and function of rate scalers, cathode ray tube, and analogue digital converter (ADC)

12.2.5. Structure and use of collimators including low energy-all purpose, diverging, converging, medium energy, pinhole, high resolution, and high sensitivity

12.3. Small and Large Animal Track: Gamma Cameras – Resolution/QC:

12.3.1. Common procedures used in quality control

12.3.2. Factors that limit spatial and temporal resolution

12.4. Small and Large Animal Tracks: Digital Image Processing:

12.4.1. Types of acquisitions including frame mode, list mode, static, dynamic, and gated (ECG synchronized)

12.4.2. Image depth – bit, byte and word

12.4.3. Effect of matrix size on image quality, frame rate and storage capacity

12.4.4. Types of background correction

12.4.5. Cross talk and its quantitative effect on ROI

12.4.6. Underlying principles and use of regions of interest (ROI), time activity curves and basic filtering operations including smoothing, edge detection, temporal and spatial operations

12.5. Radionuclides – Energy and half-life of the following radionuclides:

12.5.1. Technetium 99-m (**Small and Large Animal Tracks)**

12.5.2. Iodine 123 (**Small Track only)**

12.5.3. Iodine 131 (**Small Track only)**

12.6. Small and Large Animal Tracks: Radiopharmaceuticals - Indication, routes of administration, mechanisms of location and route of excretion for the following radiopharmaceuticals:

12.6.1. Pertechnetate – thyroid imaging, per-rectal portal and trans-splenic scintigraphy

12.6.2. Methylene diphosphonate (MDP), Hydroxymethylene diphosphonate (HDP) and dicarboxypropane diphoshonate (DPD) – bone scans, pulmonary mineralisation studies

12.6.3. 123I, 131I – thyroid scintigraphy (**Small Track only)**

13. Statistics in Diagnostic Imaging

13.1. Methods of comparing various imaging systems or methods to each other in terms

of diagnostic accuracy

13.1.1. The principles of a “gold standard”
13.1.2. Receiver operating characteristic curve analysis
13.1.3. The kappa statistic
13.1.4. Sensitivity, specificity and accuracy
13.1.5. Positive and negative predictive values

14. Artefacts in Diagnostic Imaging

14.1. Origin and appearance of the following CR/DR artefacts, but not limited to:

14.1.1. Quantum mottle
14.1.2. Saturation
14.1.3. Planking
14.1.4. Fading
14.1.5. Light leak (CR plate)
14.1.6. Dirty light guide
14.1.7. Faulty transfer
14.1.8. Misplacement
14.1.9. Border detection
14.1.10. Dead pixels
14.1.11. Moire
14.1.12. Uberschwinger/Halo
14.1.13. Density threshold

14.2. Cause, appearance and correction of the following ultrasound artefacts, but not limited to:

14.2.1. Section/slice thickness
14.2.2. Reverberation
14.2.3. Comet tail
14.2.4. Ring down
14.2.5. Range ambiguity
14.2.6. Refraction
14.2.7. Mirror image
14.2.8. Side and grating lobe
14.2.9. Propagation speed error
14.2.10. Shadowing
14.2.11. (Edge) shadowing
14.2.12. Enhancement (through transmission)
14.2.13. Electronic noise
14.2.14. Aliasing
14.2.15. Anisotropism

14.3. Cause, appearance and correction of the following CT artefacts, but not limited to:

14.3.1. Motion
14.3.2. Artefacts caused by high-density material
14.3.3. Partial volume
14.3.4. Beam hardening
14.3.5. Edge gradient artefact
14.3.6. Aliasing
14.3.7. Detector nonlinearity and detector failure
14.3.8. Truncation
14.3.9. Helical artefacts
14.3.10. Point spread effect & blooming
14.3.11. Edge enhancement and rebound artefact
14.3.12. Photon starvation

14.4. Cause, appearance and correction of the following MRI artefacts:

14.4.1. Signal wraparound (aliasing)

14.4.2. Slice overlap (cross-excitation)
14.4.3. Truncation (ringing / Gibbs-artefact)
14.4.4. Noise and RF-interference (Zipper artefact)
14.4.5. Partial volume averaging
14.4.6. Chemical shift
14.4.7. Motion and Pulsatility
14.4.8. Flow artefact
14.4.9. Susceptibility
14.4.10. Magic angle

14.5. Cause, appearance and correction of the following scintigraphic artefacts:
14.5.1. Motion
14.5.2. Edge packing
14.5.3. Crystal abnormality
14.5.4. Radionuclide contamination (urine, injection site, etc.)
14.5.5. Non-functioning PM tube, defective or uncoupled light pipe
14.5.6. Improper energy calibration
14.5.7. Contaminated gamma camera face
14.5.8. Improper delay from injection to imaging
14.5.9. Inadequate count density
14.5.10. Improper matrix size
14.5.11. Blockage of technetium uptake by drugs and contrast media
14.5.12. Poor technetium-radiopharmaceutical binding improper collimator for isotope used (e.g., low energy all-purpose collimator with Indium)

Imaging features – Basic knowledge

*Topics listed in this section represent knowledge essential for large and small animal imaging tracks. Candidates are expected to know basic imaging features in small and large animals (**dependent on track**). Basic knowledge is defined as what is included in general diagnostic imaging textbooks. For the small animal track, approximately 95% of questions will pertain to canine and feline imaging. For the large animal track, approximately 80% of questions will pertain to large animal imaging.*

1. Musculoskeletal system

1.1. Common diseases of the skull, nasal cavity and paranasal sinuses
1.2.1. Radiographic appearance in small and large animals
1.2.2. CT and MR: Indications, scanning protocol, principles of interpretation and appearance in small and large animals

1.2. Radiographic appearance common diseases of the musculoskeletal system in small animals:
1.2.1. Congenital and developmental
1.2.2. Metabolic
1.2.3. Acquired

1.3. Radiographic imaging features of common diseases of the musculoskeletal system in large animals including:
1.3.1. Navicular syndrome
1.3.2. Laminitis
1.3.3. Osteoarthritis
1.3.4. Osteochondrosis of the tarsus, fetlock, stifle joint

1.4. Ultrasonographic appearance of common diseases of the musculoskeletal system including:
1.4.1. Tendonitis/desmitis

1.5. CT and MR: Indications, scanning protocol, principles of interpretation and appearance of common diseases of the axial and appendicular skeleton in small and large animals

2. Cardiovascular system

2.1. Common diseases of the cardiovascular system
- 2.1.1. Radiographic appearance
- 2.1.2. CT: indications, scanning protocol, principles of interpretation and appearance in small animals
- 2.1.3. Ultrasonographic appearance of:
  - 2.1.3.1. Pericardial effusion
  - 2.1.3.2. Congenital cardiac diseases
  - 2.1.3.3. Thromboembolism

2.2. Abdominal vasculature including splanchnic vascular beds
- 2.2.1. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of common diseases in small animals
- 2.2.2. CT angiography of diseases and malformations of the hepatic vasculature in small animals

3. Nervous system

3.1. Radiographic appearance of common causes of spinal, paraspinal tissue and spinal cord disorders in small and large animals for example developmental, traumatic and degenerative disorders including Wobbler syndrome

3.2. Myelography
- 3.2.1. Indications and contra-indications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for appearance of common diseases of the spine, paraspinal tissues and spinal cord

3.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance of common disease in small animals for:
- 3.3.1. Brain
- 3.3.2. Spine, paraspinal tissues and spinal cord

4. Digestive system

4.1. Common diseases of the oral cavity and associated structures
- 4.1.1. Radiographic appearance in small and large animals
- 4.1.2. CT and MR: indications, scanning protocol, principles of interpretation and appearance in small and large animals

4.2. Common oesophageal diseases
- 4.2.1. Radiographic appearance in small and large animals
- 4.2.2. CT: indications, scanning protocol, principles of interpretation and appearance in small animals

4.3. Common diseases of the gastrointestinal system
- 4.3. Radiographic appearance in small animals
- 4.3.1 Radiographic appearance in large animals (including ileus and meconium impaction in foals, sand impaction and enteroliths in horses, and traumatic reticuloperitonitis in ruminants)

4.4. Indications and contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for upper GI series (contrast radiography)

4.5. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of common disease in the following organ systems in small animals:
- 4.5.1. Peritoneal cavity including diaphragm
- 4.5.2. Hepatobiliary tract
- 4.5.3. GI tract

4.5.4. Pancreas

4.6. CT: Indications, scanning protocol, principles of interpretation and appearance of common diseases of the liver in small animals

5. Respiratory system

5.1. Common diseases of the respiratory system (including larynx)

5.1.1. Radiographic appearance in small and large animals, including technique and positioning

5.1.2. CT: Indications, scanning protocol, principles of interpretation and appearance in small animals

5.1.3. Ultrasonographic appearance

5.2. Common diseases of the mediastinum and pleura

5.2.1. Radiographic appearance in small and large animals, including technique and positioning

5.2.2. CT: Indications, scanning protocol, principles of interpretation and appearance in small animals

5.2.3. Ultrasonographic appearance in small animals

6. Urogenital system

6.1. Common diseases of the urogenital system

6.1.1. Radiographic appearance in small animals

6.1.2. Indications and contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for the following contrast procedures:

6.1.2.1. Excretory urography

6.1.2.2. Cystography (positive, negative and double contrast)

6.1.2.3. Urethrography

6.1.3. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance in small animals

6.1.4. CT: Indications, scanning protocol, principles of interpretation and appearance of common diseases of the urogenital system in small animals

7. Endocrine and lymphoid system and organs of special sense

7.1. Common diseases of the external, middle and inner ear

7.1.1. Radiographic appearance in small animals

7.1.2. CT and MR: Indications, scanning protocol, principles of interpretation and appearance in small animals

7.2. Thyroid gland:

7.2.1. US, CT and MR: Indications, scanning protocol, principles of interpretation and appearance of common disease in small animals

7.2.2. Scintigraphy scanning protocol and principles of interpretation of Technetium pertechnetate imaging of normal and pathological states of the thyroid gland in small animals

7.3. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of common disease in the following organ systems in small animals:

7.3.1 Spleen

7.3.2. Adrenal glands

7.3.3. Lymph nodes

7.4. CT: Indications, scanning protocol, principles of interpretation and appearance of common diseases in small animals:

7.4.1 Spleen

7.4.2. Adrenal glands
7.4.3. Lymphatic system including lymphangiography

8. Miscellaneous
8.3. Indications and contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for:
8.3.1. Positional radiographs of the abdomen in small animals
8.4. Indications, protocol, principles of interpretation, including evaluation of outcome and complications of interventional procedures:
8.4.1. Fine needle aspirates (FNA)
8.4.2. Tissue biopsy
8.4.3. Percutaneous pyelography in small animals
8.4.4. Diagnostic / therapeutic centesis
8.4.5. Diagnostic injection (e.g. splenoportography) in small animals

In-depth knowledge of pathophysiology, clinical and imaging features in small animals (Small Animal Track only)

This section contains topics that are considered essential for the specialist in small animal imaging. Expected depth of knowledge includes knowledge of the current literature pertinent to diagnostic imaging. The following list should be considered as studying guidelines but might not be exhaustive. Questions might be asked on any small animal imaging feature and associated pertinent clinical findings currently published in the literature.

1.Musculoskeletal system
1.1. Biological behaviour of tumours of the musculoskeletal system including local invasiveness, metastatic potential and metastatic appearance
1.2. Diseases of the skull, nasal cavity and paranasal sinuses
1.2.1. Radiographic appearance in small animals
1.2.2. CT and MR: indications, scanning protocol, principles of interpretation and appearance in small animals
1.3. Describe and recognise the radiographic appearance of congenital, developmental and acquired diseases of the musculoskeletal system in small animals
1.4 CT and MR: Indications, scanning protocol, principles of interpretation and appearance of musculoskeletal diseases in small animals, including contrast procedures
1.5. US: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of diseases of the musculoskeletal system in small animals
1.6. Scintigraphy: Procedures, proper radiopharmaceuticals to be used, scanning protocol, and principles of interpretation of the skeletal system in small animals

2. Cardiovascular system
2.1. Pathophysiology and clinical signs:
2.1.1. Common clinical signs of congenital and acquired cardiovascular diseases in small animals.
2.1.2. Pathophysiology of canine and feline heart worm infections
2.1.3. Biological behaviour of tumours of the cardiovascular system including local invasiveness, metastatic potential and metastatic appearance
2.1.4. Expected alterations in cardiac pressure and blood gas evaluation (oximetry) in common diseases and congenital heart defects
2.2. Radiography:

2.2.1. Describe and recognise the radiographic appearance of diseases of the cardiovascular system in small animals
2.2.2. Angiocardiography (selective and non-selective):
2.2.2.1. Indications and contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation
2.2.2.2. Selective and nonselective angiocardiographic studies of common cardiovascular diseases
2.3. CT and MRI: Indications, scanning protocol, principles of interpretation and appearance of cardiovascular diseases in small animals, including angiography (single and multiphase angiographic protocols) for abdominal diseases, including contrast procedures
2.4. US: Indications, selection of equipment, scanning protocol, principles of interpretation, and appearance of diseases of the heart, abdominal vasculature including the splanchnic vascular beds and peripheral vascular beds including abnormal Doppler patterns for Doppler ultrasound

3. Nervous system
3.1. Biological behaviour of tumours of the nervous system including local invasiveness, metastatic potential and metastatic appearance
3.2. Describe and recognise the radiographic appearance of diseases of the nervous system
3.3. Indications, contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for myelography in small animals
3.4. CT and MR: Indications, scanning protocol (imaging planes, desirable slice thickness, and use of contrast including single and multiphase angiographic protocols), principles of interpretation and appearance of diseases of the central and peripheral nervous system in small animals, including contrast procedures
3.5. US: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of diseases in the CNS (ventricular system, brain)

4. Digestive system
4.1. Biological behaviour of tumours of the digestive system (including liver, pancreas and salivary glands) including local invasiveness, metastatic potential and paraneoplastic syndrome
4.2 Radiographic appearance of diseases of the digestive system in small animals
4.3. Contrast procedures in small animals:
4.3.1. Indications, contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation of:
4.3.1.1. Oesophagography (including evaluation of swallowing) in small animals
4.3.1.2. Gastrography (positive, negative and double contrast)
4.3.1.3. Enterography (positive)
4.3.1.4. Colonography (positive and negative)
4.3.2. Diagnostic imaging procedures and differences between various contrast media and methods for evaluation of:
4.3.2.1. Oesophageal function and diseases
4.3.2.2. Gastric or intestinal transit times/function
4.4. CT and MRI: Indications, scanning protocol, principles of interpretation and appearance of digestive diseases in small animals, including contrast procedures
4.5. US: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of diseases

5. Respiratory system
5.1. Biological behaviour of tumours of the respiratory system including local invasiveness, metastatic potential and paraneoplastic syndrome

5.2. Diseases of the respiratory system (including larynx)
    5.2.1. Radiographic appearance in small animals, including technique and positioning.
    5.2.2. CT: Indications, scanning protocol, principles of interpretation and appearance in small animals, including contrast procedures
    5.2.3. US: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of diseases
5.3. Diseases of the mediastinum and pleura
    5.3.1. Radiographic appearance in small animals, including technique and positioning
    5.3.2. CT: Indications, scanning protocol, principles of interpretation and appearance in small animals, including contrast procedures
    5.3.3. US: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of diseases

6. Urogenital system
6.1. Biological behaviour of tumours of the urogenital system including local invasiveness, metastatic potential and paraneoplastic syndrome
6.2. Diseases of the urogenital system
    6.2.1. Radiographic appearance in small animals
    6.2.2. Indications and contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for the following contrast procedures in small animals:
        6.2.2.1. Excretory urography
        6.2.2.2. Cystography (positive, negative and double contrast)
        6.2.2.3. Urethrography and vaginourethrography
        6.2.2.4. Intravenous pyelonephrography
    6.2.3. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance in small animals
    6.2.4. CT and MRI: Indications, scanning protocol, principles of interpretation and appearance of common diseases of the urinary system in small animals
6.3. Radiographic appearance of foetal death and how the signs develop (dog and cat)
6.4. Ultrasonographic findings of the uterus and foetus during normal pregnancy

7. Endocrine and lymphoid system and organs of special sense
7.1. Pathophysiology of thyroid disease:
    7.1.1. Mode of action/duration of antithyroid medications
    7.1.2. Systemic effects of I-131 in cats treated for feline hyperthyroidism
7.2. Biological behaviour of tumours of the endocrine organs including local invasiveness, metastatic potential and paraneoplastic syndrome
7.3. Biological behaviour of tumours of the lymphoid system (including bone marrow) including local invasiveness, metastatic potential and paraneoplastic syndrome
7.4. Biological behaviour of tumours of the organs of special sense including local invasiveness and metastatic potential
7.5. Diseases of the external and middle ear
    7.5.1. Radiographic appearance in small animals
    7.5.2. CT and MR: Indications, scanning protocol, principles of interpretation and appearance in small animals
7.6. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease in the following organ systems in small animals:
    7.6.1. Endocrine organs
    7.6.2. Lymphoid organs
    7.6.3. Organs of special sense

7.7. Indications and contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for lymphangiography
7.8. CT and MR: Indications, scanning protocol, principles of interpretation and appearance of diseases in small animals, including contrast procedures of the following organs:
- 7.8.1. Endocrine organs
- 7.8.2. Lymphoid organs
- 7.8.3. Organs of special sense

7.9. Procedures, proper radiopharmaceuticals to be used, scanning protocol, and principles of interpretation of thyroid scintigraphy in small animals

8. Miscellaneous

8.1. TFAST (Thoracic Focused Assessment with Sonography for Trauma, Triage and Tracking)
8.2. AFAST (Abdominal Focused Assessment with Sonography for Trauma, Triage and Tracking)

In-depth knowledge of pathophysiology, clinical and imaging features in large animals (Large Animal Track only)

This section contains topics that are considered essential for the specialist in large animal imaging. Expected depth of knowledge includes knowledge of the literature pertinent to diagnostic imaging. The following list should be considered as studying guidelines but might not be exhaustive. Questions might be asked on any large animal imaging feature and associated pertinent clinical findings published in the literature.

1. Musculoskeletal system
1.1. Diseases of the nasal cavity and paranasal sinuses of large animals
- 1.1.1. Pathophysiology
- 1.1.2. Radiographic appearance
- 1.1.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance

1.2. Pathophysiology and clinical findings:
- 1.2.1. Principles of locomotion and concept of lameness in the horse
- 1.2.2. Flexion tests and local diagnostic blocks in the horse
- 1.2.3. Clinical signs and response to local, regional and intra-articular anaesthesia in musculoskeletal disorders in horses
  - 1.2.3.1. Predisposition for specific musculoskeletal injuries in relation to activity in horses
- 1.2.4. Pathophysiology of:
  - 1.2.4.1. Overuse bone trauma and stress fractures in horses
  - 1.2.4.2. Angular deformities in foals
  - 1.2.4.3. Diseases of the hoof and lamina
  - 1.2.4.4. Navicular syndrome
  - 1.2.4.5. Acute tendon injuries, chronic tendon overuse and enthesiopathy
  - 1.2.4.6. Joint disease

1.3. Radiography:

1.3.1. Radiographic appearance of diseases of the musculoskeletal system including contrast precedures and stress radiographs
1.3.2. Indications, technique and radiographic appearance of diseases in special oblique and sky-line views in the horse and in the bovine.

1.4. Ultrasonography
1.4.1. Indications, selection of particular equipment, scanning protocol (including examination in flexion and dynamic ultrasonography when applicable), principles of interpretation, and appearance of disease:
1.4.1.1. Limbs including pelvis
1.4.1.2. Axial musculoskeletal structures

1.5. CT and MR:
1.5.1. Indications, scanning protocol (including single and multiphase contrast studies), principles of interpretation and appearance of disease:
1.5.1.1. Limbs including pelvis
1.5.1.2. Axial musculoskeletal structures

1.6. Scintigraphy: Procedures, proper radiopharmaceuticals to be used, scanning protocol, and principles of interpretation of the skeletal system in large animals

2. Cardiovascular system

2.1. Clinical signs, haemodynamic effects and pathophysiology of phlebitis of commonly affected veins in horses

2.2. Radiographic appearance of diseases of the cardiovascular system in large animals

2.3. Indications and contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation of equine angiographic procedures including:
2.3.1. Angiography of the equine distal limb
2.3.2. Angiography of the internal carotid artery in the horse with guttural pouch mycosis

2.4. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease including abnormal Doppler patterns for Doppler ultrasound of:
2.4.1. Jugular vein
2.4.2. Heart
2.4.3. Peripheral vascular beds
2.4.4. Abdominal vasculature including the splanchnic vascular beds

2.5. Principles of interpretation and appearance of aortic and iliac thrombosis on transrectal ultrasound in horses

3. Nervous system

3.1. Clinical signs and diagnostic tests for common equine neurologic infectious diseases

3.2. Indications, contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for myelography in large animals

3.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance of disease in large animals including contrast procedures for regions:
3.3.1. Brain
3.3.2. Spine, paraspinal tissues and spinal cord
3.3.3. Peripheral nerves

4. Respiratory system

4.1. Biological behaviour of common tumours of the respiratory system in large animals including local invasiveness, metastatic potential and common metastatic appearance
4.2. Diseases of the equine guttural pouches
    4.2.1 Pathophysiology
    4.2.2. Radiographic appearance
    4.2.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance
4.3. Equine larynx
    4.3.1. Radiographic appearance of equine laryngeal diseases, including post-surgery changes
    4.3.2. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease
    4.3.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance
4.4. Disease of the hyoid apparatus and temporohyoid joints
    4.4.1. Radiographic appearance
    4.4.2. CT and MR: Indications, scanning protocol, principles of interpretation and appearance
4.5. Trachea, bronchi and pulmonary parenchyma
    4.5.1. Radiographic appearance of diseases
    4.5.2. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease
    4.5.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance
4.6. Mediastinum and pleural space:
    4.6.1. Radiographic appearance of diseases in large animals
    4.6.2. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease
    4.6.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance

5. Digestive system
5.1. Pathophysiology of postoperative ileus in horses
5.2. Oral cavity and associated structures
    5.2.1. Radiographic appearance
    5.2.2. CT and MR: Indications, scanning protocol, principles of interpretation and appearance
5.3. Oesophagus:
    5.3.1. Radiographic appearance of disease
    5.3.2. Indications and contra-indications, technical aspects, complications, standard imaging protocols and principles of interpretation of oesophagography in large animals
    5.3.3. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease
    5.3.4. CT and MR: Indications, scanning protocol, principles of interpretation and appearance (normal and disease)
5.4. Gastrointestinal tract
    5.4.1. Indication for abdominal radiography and radiographic appearance of gastrointestinal diseases in large animals
    5.4.2. Indications, contraindications, technical aspects, complications, standard imaging protocols (including positioning) and principles of interpretation for colonography in foals

5.4.3. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease in large animals
5.4.4. CT and MR: Indications, scanning protocol, principles of interpretation and appearance (normal and disease), including contrast studies

5.5. Liver
5.5.1. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease
5.5.2. CT and MR: Indications, scanning protocol, principles of interpretation and appearance (normal and disease)

6. Urogenital system
6.1. Urogenital tract of large animals
6.1.1. Indication for abdominal radiography and radiographic appearance of urogenital diseases including contrast studies
6.1.2. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance (normal and disease)
6.1.3. CT and MR: Indications, scanning protocol, principles of interpretation and appearance (normal and disease) including contrast studies
6.2. Pregnancy in large animals:
6.2.1. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation

7. Endocrine and lymphoid system and organs of special sense
7.1. Disease of the inner, external and middle ear in large animals
7.1.1. Radiographic appearance
7.1.2. CT and MR: Indications, scanning protocol, principles of interpretation and appearance
7.2. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease in the following organ systems:
7.2.1. Eye and orbit
7.2.2. Lymphoid system

8. Miscellaneous
8.2. Pathophysiology of umbilical infections in foals and ruminants
8.3. Ultrasonography: Indications, selection of particular equipment, scanning protocol, principles of interpretation, and appearance of disease of the abdomen (including the diaphragm) in large animals
8.4. FLASH (Fast Localised Abdominal Sonography for Horses)
8.4. Indications, material and technique for imaging-guided injections, aspirations and biopsies in horses (including all systems)