**AUSTRALIAN AND NEW ZEALAND
COLLEGE OF VETERINARY SCIENTISTS**

MEMBERSHIP GUIDELINES

Veterinary Radiology (Small Animal)

INTRODUCTION

These Membership Guidelines should be read in conjunction with the *Membership Candidate Handbook.*

ELIGIBILITY

Refer to the *Membership Candidate Handbook.*

OBJECTIVES

To demonstrate that the candidate has sufficient knowledge and experience to give professional advice to veterinary colleagues not similarly qualified on problems or procedures often encountered or used in general practice in the area of small animal veterinary radiology. For these guidelines small animal refers to canine and feline species.

LEARNING OUTCOMES

1. Radiation physics as it applies to veterinary radiology

The candidate should have a **basic[1]** knowledge of:

1.1. Electromagnetic spectrum:

1.1.1. elementary general physics as it pertains to radiology

1.1.2. the electro-magnetic spectrum: definition, wave and particle theories

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[1]**Knowledge levels:**
  Detailed knowledge - candidates must have an in-depth understanding of the topic, including differing points of view and the published literature. The highest level of knowledge.
  Sound knowledge – candidate must know the principles and some of the finer detail of the topic, including differing points of view and the core literature. A middle level of knowledge.
  Basic knowledge – candidate must know the principles of the topic and the core literature.

1.2. Generation of x-ray photons:

    1.2.1. components of the x-ray tube, types of anodes: rotation and stationary, cathode

    1.2.2. thermionic emission, line focus principle, heel effect, heat dissipation, structure of the atom, binding forces

    1.2.3. basic generator circuits, rectification, transformers, capacitor discharge equipment

1.3. Production of the x-ray photon:

    1.3.1. interactions at the anode: general radiation / Bremsstrahlung and characteristic radiation

    1.3.2. the effect of kV, mA and time on x-ray photon production

1.4. The interaction of x-ray photons with matter:

    1.4.1. coherent scatter, the photoelectric effect, Compton and the relative frequencies of these interactions

    1.4.2. factors affecting attenuation/ the inverse square law

    1.4.3. scatter radiation – factors affecting the production of and methods to reduce the effects of scatter - grids (types, cut-off), air gap techniques, beam collimation

1.5. Formation of the radiographic image for film-screen radiography:

    1.5.1. formation of an image due to differential absorption

    1.5.2. film construction, types and speeds

    1.5.3. photographic density and contrast

    1.5.4. intensifying screens, phosphors, construction, rare earth vs Ca tungstate, speeds

    1.5.5. cassettes

1.6. The principles and practice of film processing:

    1.6.1. development, wash, fixation, wash, dry

    1.6.2. darkroom design and requirements

    1.6.3. film identification

1.7. Factors affecting image quality:

   1.7.1. density, contrast, sharpness

   1.7.2. the origin and control of scatter – grids/collimators

   1.7.3. film and screen speed

   1.7.4. unsharpness – geometric (magnification, distortion, penumbra effect) and motion.

2. Practice of veterinary radiography

The candidate should have a **basic** knowledge of:

2.1. Practical radiography:

   2.1.1. exposure assessment

   2.1.2. factors influencing the choice of kV, mA, time, films and grids

   2.1.3. formation of a technique chart

   2.1.4. patient positioning and problems in veterinary practice/limitations

   2.1.5. the need for restraint and suitable methods/advantages and disadvantages of anaesthesia

2.2. Radiographic faults and artefacts (film-screen radiography):

   2.2.1. identification and explanation of radiographic faults / artefacts

   2.2.2. recognition of faults due to inadequate radiographic procedure

   2.2.3. identification of darkroom artefacts

   2.2.4. identification of processing artefacts.

3. Digital Radiography

The candidate should have a **basic** knowledge of:

3.1. differences in image formation between film-screen and digital systems (both computed radiography and direct digital radiography)

3.2. advantages and disadvantages of digital radiography

3.3. principles of computed radiography vs direct digital radiography, digital imaging and communication in medicine (DICOM), picture archiving and communications systems (PACS)

3.4. common artefacts associated with digital radiography

3.5. factors affecting image quality specific to digital imaging (including system resolution, exposure index, use of grids, algorithms, look-up-table)

4. Diagnostic ultrasound

The candidate should have a **basic** knowledge of:

4.1. principles of ultrasound image formation including frequency, acoustic impedance, resolution, artefacts and transducers

4.2. indications for use of diagnostic ultrasound in practice

4.3. functions of the ultrasound machine used in image optimization: depth, focal zone, gain. Time Gain Control (TGC), dynamic range, persistence/frame averaging

5. Radiation safety

The candidate should have a **sound** knowledge of:

5.1. radiation monitoring and safety equipment and regulations, and should be able to convey this information in a coherent matter to other veterinarians

5.2. relevant Australian and New Zealand laws and Codes of Practice as they apply to the use of ionising radiation

5.3. principles of radiation protection: risks involved in the use of radiographic procedures/methods to minimise this risk

5.4. basic radiation protection rules for a small animal practice

5.5. stochastic and non-stochastic effects

5.6. MPD, ALARA

5.7. somatic and genetic effects

5.8. units: Gray, Sievert.

6. Other imaging

The candidate should have a **basic** knowledge of:

6.1. computed tomography (CT), magnetic resonance imaging (MRI) and nuclear medicine and its application to veterinary practice.

7. Contrast agents and radiographic contrast procedures (contrast studies)

The candidate will be able to with **sound**[2] expertise:

    7.1.   perform common radiographic contrast procedures in dogs and cats of the gastrointestinal system

    7.2.   perform common radiographic contrast procedures on dogs and cats of the urinary system: excretory urogram, retrograde cystogram (positive, negative, double contrast), retrograde urethrogram and vaginourethrogram.

The candidate should have a **sound** knowledge of:

    7.3.   Barium sulphate in its different formulations

    7.4.   Iodinated contrast agents and its formations including the difference between ionic and non-ionic formations.

The candidate should have a **basic** knowledge of:

    7.5.   the pharmacology of radiographic contrast agents including: mechanism of action, indications, contraindication, common side effects and dose rates

    7.6.   the myelographic procedure.

8. General radiological interpretation of dogs and cats

The candidate will have a **sound** knowledge of:

    8.1.   radiographic appearance of the normal structure and function of the various organ systems investigated in small animal practice

    8.2.   radiographic pathology, and associated pathophysiology, of the various organ systems commonly investigated in small animal practice

The candidate will be able to with **sound** expertise:

    8.3.   recognise, describe and list differential diagnoses for the changes in structure and function of the various body systems as related to disease which occurs in dogs and cats

    8.4.   select and interpret an appropriate imaging modality (radiography or ultrasound)

    8.5.   determine which radiographic projection is presented from the radiographic anatomy.

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[2] **Skill levels**:
  Detailed expertise – the candidate must be able to perform the technique with a high degree of skill, and have extensive experience in its application. The highest level of proficiency.
  Sound expertise – the candidate must be able to perform the technique with a moderate degree of skill, and have moderate experience in its application. A middle level of proficiency.
  Basic expertise – the candidate must be able to perform the technique competently in uncomplicated circumstances.

The candidate will have a **basic** knowledge of:

8.6. indications for advanced imaging (including nuclear medicine, MRI and CT).

The candidate should have a **sound** knowledge of:

8.7. normal sonographic appearance of the following structures in the dog and cat:

8.7.1. Abdomen - liver, spleen, kidneys, adrenals, urinary bladder, gastrointestinal tract, pancreas, peritoneal cavity, male and female reproductive tract

9. Radiographic features of disease in dogs and cats

9.1. Skeleton:

The candidate will have a **sound** knowledge of:

9.1.1. reaction of bone to disease

9.1.2. radiographic anatomy of the appendicular and axial skeleton of both dogs and cats

9.1.3. radiographic projections of the different regions of the axial and appendicular skeleton

9.1.4. radiographic features that differentiate bony neoplasia from infection

9.1.5. classification of fractures, including descriptors of the fracture type (e.g. spiral, transverse, incomplete/complete etc), location, Salter-Harris types, comminution, delayed unions (including mal-unions)

9.1.6. radiographic signs of bone healing

9.1.7. radiographic signs of septic and degenerative arthritis.

The candidate will be able to, with **sound** expertise:

9.1.8. position patients to obtain the views

9.1.9. categorise lysis (e.g. geographic, moth-eaten, permeative) and periosteal new bone reaction (solid vs. interrupted categories)

9.1.10. classify bony lesions in the spectrum of benign or aggressive

9.1.11. recognise changes in the soft tissues adjacent to bony lesions; for example the signs of joint effusion or a soft tissue mass in a bony neoplasm

9.2. Hip dysplasia

The candidate will have a **basic** knowledge of:

9.2.1. hip dysplasia schemes available in Australia and New Zealand

The candidate will have **sound** knowledge of:

> 9.2.2. the method of obtaining studies for each scheme, and the advantages and disadvantages of each scheme (AVA and PennHIP)

9.3. Osteoarthritis:

The candidate will have a **sound** knowledge of:

> 9.3.1. radiographic signs of osteoarthritis, in all joints, but in particular, the shoulder, elbow, carpus, coxofemoral, stifle and hock joints.

9.4. Osteochondrosis

The candidate will have a **sound** knowledge of:

> 9.4.1. radiographic signs and the common locations of this disease.

The candidate will have a **basic** knowledge of:

> 9.4.2. pathophysiology of osteochondrosis, including the breed incidence

9.5. Elbow dysplasia (ED)

The candidate will have a **sound** knowledge of:

> 9.5.1. types of elbow dysplasia in the dog (osteochondrosis, un-united anconeal process, fragmented medial coronoid process) and of the radiographic signs of these diseases.
>
> 9.5.2. radiographic signs of osteoarthritis in the elbow.

The candidate will have a **basic** knowledge of:

> 9.5.3. pathophysiology of ED in the dog, including the breed incidence and heritability.
>
> 9.5.4. application of other diagnostic tools (including CT scanning, arthroscopy).
>
> 9.5.5. Elbow dysplasia schemes available in Australia and New Zealand

9.6. Juvenile bone disease

The candidate will have a **basic** knowledge of:

> 9.6.1. pathophysiology of panosteitis, hypertrophic osteodystrophy (syn. metaphyseal osteopathy).

The candidate will have a **sound** knowledge of:

> 9.6.2. radiographic signs of these diseases.

9.7. Vertebrae

The candidate will have a **sound** knowledge of:

9.7.1. pathophysiology of intervertebral disc disease, the radiographic signs of this disease

9.7.2. indications for advanced imaging (including myelography, CT and MRI)

9.7.3. radiographic signs of discospondylitis and spondylosis deformans, and the clinical significance of these two pathologies.

The candidate will have a **basic** knowledge of

9.7.4. congenital anomalies, and appreciation of the breed incidence;

9.7.5. use of myelography in the investigation of spinal disease in dogs and cats.

9.8. Head

The candidate will have a **sound** knowledge of the radiographic signs of:

9.8.1. nasal cavity disease, include neoplasia and rhinitis (fungal)

9.8.2. bony neoplasia of the head, including being able to list differential diagnoses

9.8.3. otitis media.

The candidate will have a **basic** knowledge of the radiographic signs of:

9.8.4. periodontal disease

9.8.5. temporomandibular joint disease

9.8.6. hyperparathyroid disease.

The candidate will have a **basic** knowledge of:

9.8.7. the indications for advanced imaging (include CT or MRI).

9.9. Thorax

9.9.1. The candidate will be able to demonstrate a systematic approach to interpretation of the thorax.

9.10. Heart and pulmonary vessels

The candidate will have a **sound** knowledge of:

9.10.1. radiographic cardiac anatomy (for example, using cardiac clock-face analogy), including the anatomy of the pulmonary lobar vessels and differentiation of arteries and veins

9.10.2. radiographic signs of cardiomegaly, including means to quantify these signs (e.g. the vertebral heart score, or other scoring systems)

9.10.3. radiographic signs of left and right chamber enlargement and right and left sided heart failure

9.10.4. differentials for cardiomegaly, especially as they apply to different species and breeds.

The candidate will have a **basic** knowledge of:

9.10.5. pathophysiology of heart failure.

9.11. Lungs:

The candidate will have a **sound** knowledge of:

9.11.1. radiographic anatomy of the canine and feline lung

9.11.2. radiographic classification of pulmonary disease via traditional paradigms of lung pattern (alveolar, bronchial and interstitial patterns) and also be able to identify and describe the radiographic signs that constitute these patterns with **sound** expertise

9.11.3. the radiographic differential diagnoses for pulmonary disease based on the distribution of the disease (eg cranioventral, caudodorsal locations, diffuse, focal or multifocal locations) and type of lung pattern.

The candidate will be able to with **sound** expertise:

9.11.4. provide differential diagnoses for pulmonary disease which are ranked in order based on the age, signalment and clinical history of the patient.

9.12. Pleural space

The candidate will have a **basic** knowledge of:

9.12.1. pathophysiology of the conditions affecting the pleural space.

The candidate will have a **sound** knowledge of:

9.12.2. radiographic anatomy of the pleural space

9.12.3. radiographic signs of pleural space disease, including differential diagnoses for this disease.

9.13. Mediastinum/body wall/diaphragm

The candidate will have a **sound** knowledge of:

9.13.1. radiographic anatomy of the mediastinum, including the organs located in each region (cranial, mid, caudal mediastinum).

9.13.2. radiographic signs of abnormalities of the mediastinum; particularly diseases of the trachea, oesophagus, lymph nodes, thymus.

9.13.3. indications for an oesophagram and the methods of performing such a contrast study, including the contrast agents

9.13.4. radiographic anatomy of the body wall, and radiographic signs of diseases of ribs.

9.13.5. radiographic features of conditions affecting the diaphragm.

10.   Abdomen:

10.1   The candidate will be able to demonstrate a systematic approach to the radiographic interpretation of the abdomen

The candidate will have a **sound** knowledge of:

10.1.1. radiographic anatomy of the abdomen.

The candidate will be able to with **sound** expertise:

10.1.2. create differential diagnoses for mass effects, based on the displacement of normal anatomy.

10.2. Gastrointestinal tract

The candidate will have a **sound** knowledge of:

10.2.1. radiographic signs of hepatic disease, and differential diagnoses for these signs.

The candidate will have a **basic** knowledge of:

10.2.2. sonographic signs of hepatic disease including nodular hyperplasia, Cushing's disease, diabetes mellitus, diffuse and focal neoplasia, hepatitis and cirrhosis, and differential diagnoses for these signs

The candidate will have a **sound** knowledge of:

10.2.3. radiographic signs of diseases of the GIT, including GDV and small intestinal obstruction. The candidate will have an appreciation for the variable appearance of intestine, and understand the differing location of small and large bowel.

10.2.4. indications for gastrointestinal contrast studies.

10.2.5. indications for gastrointestinal ultrasound.

The candidate will have a **basic** knowledge of:

10.2.6. radiographic and sonographic signs of pancreatitis.

10.2.7. sonographic signs of small intestinal obstruction

10.3. Urogenital tract and retroperitoneal space

The candidate will have a **sound** knowledge of:

10.3.1. normal size/anatomy for urogenital structures, and retroperitoneal anatomy, including kidneys, ureters, urinary bladder, urethra, prostate, testes, ovaries, uterus, vagina.

The candidate will have a **sound** knowledge of:

10.3.2. radiographic signs of urogenital disease, and differential diagnoses for abnormalities

10.3.3. indications and techniques for urogenital contrast studies.

The candidate will have a **basic** knowledge of:

10.3.4. sonographic appearance of pyometra, benign cystic prostatic hyperplasia, cystitis, cystolithiasis and neoplasia of the bladder.

10.3.5. contraindications for urogenital contrast studies.

10.3.6. radiographic detection of pregnancy and the use of ultrasound in pregnancy diagnosis.

10.4. Peritoneal cavity, spleen

The candidate will have a **sound** knowledge of:

10.4.1. normal radiographic anatomy of the spleen, variations between the species and the effects of sedatives/anaesthetic agents

10.4.2. normal radiographic anatomy of the peritoneal and retroperitoneal cavities

10.4.3. radiographic signs of peritoneal disease, including pneumoperitoneum and peritoneal effusion, and means of detecting these diseases.

10.4.4. radiographic signs of splenic disease

The candidate will have a **basic** knowledge of:

10.4.5. sonographic signs of splenic disease, including focal and diffuse neoplasia and nodular hyperplasia

10.4.6. sonographic signs of peritonitis and peritoneal effusion

EXAMINATIONS

For information on both the standard and format of the Written and Practical/Oral examinations, candidates are referred to the *Membership Candidate Handbook*. The Member examination has **two separate, components**:

1. **Written Papers** *(Component 1)*
   Written paper 1: Principles of Small Animal Imaging (two hours)
   Written paper 2: Applied Aspects of Small Animal Imaging (two hours)

2. **Practical and Oral Examination** *(Component 2)*
   Practical (two hours forty minutes)
   Oral (one hour)

The written examination will comprise two separate two-hour written papers taken on the same day. There will be an additional 15 minutes perusal time for each paper, during which no writing on the examination paper is permitted. There is no choice of questions. Marks allocated to each question and to each subsection of questions will be clearly indicated on the written paper.

Each two hour written examination will comprise:

Two (2) essay-type questions of 30 marks each. Questions may be broken into multiple sub-parts. TOTAL SUGGESTED TIME: 60 minutes

Four (4) short-answer questions 10 marks each TOTAL SUGGESTED TIME: 40 minutes

Ten (10) multiple choice questions 2 marks each TOTAL SUGGESTED TIME: 20 minutes

Written Paper 1:
This paper is designed to test the Candidate's knowledge of the principles of Veterinary Radiology as described in the Learning Outcomes. Answers may cite specific examples where general principles apply, but should primarily address the theoretical bases underlying each example. Written Paper 1 will mainly cover the Learning Outcomes 1-7, however material from any learning outcome may be examined. The species examined will be canine and feline.

Written Paper 2:
This paper is designed to (a) test the Candidate's ability to apply the principles of Veterinary Radiology to particular cases/problems or tasks and (b) test the Candidate's familiarity with the current practices and current issues that arise from activities within the discipline of Veterinary Radiology in Australia and New Zealand. Written Paper 2 will mainly cover the Learning Outcomes 8-10, however material from any Learning Outcome may be examined. The species examined will be canine and feline.

Practical Examination:
The practical examination will be 160 minutes in duration and will require written reports on the radiographic digital images of ten (10) cases. Images will be provided in Power Point; no image manipulation will be required. Ultrasound images or clips may be included. Total suggested time for each case is fifteen (15) minutes allowing ten (10) minutes at the end for review, however candidates are free to move through the cases at their own pace. Each case is of equal value equating to a total of 200 marks. The species examined will be canine and feline.

Each answer might include the following:
- Patient signalment, views included, any techniques used (i.e. contrast studies)
- Comment on radiographic technique/quality (positioning/exposure/collimation)
- Radiographic description
- Conclusions, differential diagnosis list, recommendation of further imaging techniques if appropriate

The practical examination may not necessarily be limited to these types of questions.

Examiners are looking for a systematic evaluation of the study.
Marks will be awarded for the following areas:
- correct identification of radiographic views
- assessment of radiographic quality
- description of imaging abnormalities
- radiographic conclusions and differential diagnoses
- recommendations for further imaging procedures

The candidates must demonstrate to the examiners their thought processes, prioritization and conclusions.

Normal findings need not be described.

Candidates should not comment on artefacts unless they are pertinent to interpretation of the study (i.e. they affect the study outcome).

Both descriptive sentences and dot points may be used for the observation of imaging abnormalities or conclusions.

Candidates must use correct radiographic terminology and avoid colloquial language.

Oral Examination:
This examination further tests the candidate's achievement of the above-mentioned Learning Outcomes. It will be approximately one (1) hour duration and will include further description and interpretation of digital images (both radiograph and ultrasound). Six (6) cases are presented with supporting questions asked verbally in a face-to-face setting. The oral examination has a total of 120 marks with each case allocated 20 marks.

Questions will be provided in Power Point format.

These questions aim to test how the candidate arrives at their radiographic conclusions.

Candidates will be provided with information about the study such as signalment and limited history.

Candidates may request additional imaging studies, these may or may not be available.

The candidates must demonstrate to the examiners their thought processes, prioritisation and conclusions.

Marks will be awarded for:

- demonstration of a systematic approach
- the candidate's description of imaging abnormalities
- the candidate's ability to draw logical conclusions from the imaging findings
- the candidate's ability to make appropriate patient management recommendations, including both imaging-related diagnostics and other pertinent diagnostic testing.

Candidates should not comment on artefacts unless they are pertinent to interpretation of the study.

Normal findings may be described, but avoid spending excessive time on describing normal findings.

Examples of questions:

"Describe the artefact you see and discuss how this occurred"

An image depicting a brand of contrast medium. "What is this chemical? What are the indications and contraindications for its use?"

A lateral and ventrodorsal projection of a young dog's abdomen depicting a small intestinal obstruction. The candidate must be able to identify and describe all of the radiographic features present that are consistent with a small intestinal obstruction. The candidate must be able to draw a logical conclusion (eg. mechanical small intestinal ileus), formulate a differential diagnosis list appropriate to the history and signalment of the patient (eg. foreign body, intussusception etc.), and make appropriate patient management recommendations (eg. exploratory laparotomy).

An ultrasound clip of a urinary bladder of a cat with haematuria. The clip shows a cystolith. The candidate must be able to describe the sonographic findings that would lead to this conclusion (eg. a dependent shadowing intraluminal object). The candidate should make appropriate recommendations (eg. cyctocentesis and urinalysis).

RECOMMENDED READING LIST

The candidate is expected to read widely within the discipline, paying particular attention to areas not part of their normal work experiences. This list of books and journals is intended to guide the candidate to some core references, including comparative texts, and other source material. Candidates also should be guided by their mentor / supervisor. The list is not comprehensive and is not intended as an indicator of the content of the examination.

Recommended textbooks:

Bushong, SC (2012) 10th ed. "Radiologic Science for Technologists: Physics, Biology, and Protection" Elsevier

Thrall, DE (2012) 6th ed. "Textbook of Veterinary Radiology", Saunders Elsevier, Missouri.

Nyland, TG and Mattoon, JS, (2002), 2nd ed. "Small Animal Diagnostic Ultrasound", Saunders Elsevier, Philadelphia

Penninck, D and d'Anjou, MA (2008) "Atlas of Small Animal Ultrasonography", Blackwell Pulishing

Additional reading materials:

Barr, F.J and Kirberger, RM (2006) "BSAVA Manual of Canine and Feline Musculoskeletal Imaging" BSAVA

O'Brien, R and Barr, FJ (2009) "BSAVA Manual of Canine and Feline Abdominal Imaging" BSAVA

Schwarz, T and Johnson, V (2008) "BSAVA Manual of Canine and Feline Thoracic Imaging" BSAVA

Coulson, A and Lewis N, (2006), "An Atlas of Interpretative Radiographic Anatomy of the Dog & Cat", 2nd Ed, Blackwell Science, Oxford

Lavin, LM, (2014), "Radiography in Veterinary Technology", 5th Ed. Saunders Elsevier, Philadelphia.

Wallack, ST, (2003), "The Handbook of Veterinary Contrast Radiography" San Diego Imaging Inc. CA, USA

Dennis, R Kirberger , RM Barr FB Wrigley, RH (2010) "Handbook of Small Animal Radiological Differential Diagnoses"

Veterinary Radiology and Ultrasound : V49 Issue 1supplement – digital radiography.

Mattoon JS. "Digital Radiography" Vet Comp Orthop Traumatol. 2006;19(3):123-32.

FURTHER INFORMATION

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