Chapter

1

General Introduction

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"Until one has loved an animal, a part of one's soul remains unawakened" —**Anatole France**

GENERAL TERMINOLOGY

Radiology (roentgenology): It is that branch of medical science which deals with the diagnostic and therapeutic applications of radiant energy. Radiant energy for this purpose includes X-rays, and beta and gamma radiations.

Veterinary radiology: It is that branch of science which uses radiant energy principally for diagnostic and therapeutic purposes in domestic, zoo and laboratory animals.

Computed radiography (CR): It is like conventional radiography except that in place of a film to create the image, an imaging plate (IP) made of photostimulable phosphor is used which stores the received radiation dose as latent image and is read out through a scanner to produce a visible digital image on the monitor.

Direct digital radiography (DDR/DR): The film screen cassette of conventional or IP of CR is replaced by electronic detector (like charged couple device i.e. CCD) to capture the X-ray image and transmit directly to display screen.

Science of radiology: It covers all of the uses of radiant energy in medical and veterinary sciences such as in diagnosis, monitoring and treatment of diseases, and in research program.

Interventional radiology: It is an image [X-ray, fluoroscopy, ultrasound, computed tomography (CT) or magnetic resonance imaging MRI] guided medical procedure to treat and diagnose diseases using minimal invasive process and treat target specific repair.

Radiologist: Any person qualified in medical or veterinary sciences and radiological physics to use radiant energy in the diagnostic, therapeutic and research fields of medicine.

Radiographer: A technically trained person who can obtain quality radiographs for use by a radiologist.

X-rays: A special type of electromagnetic radiation which has high energy, extremely short wavelength, no mass or charge and travels at the speed of light.

Medical X-rays: These X-rays are generated within a vacuum tube consisting of a source of electron and a target. The electrons are accelerated in the tube to travel through the tube at tremendous speed to strike at the target. This electron–target interaction generates medical X-rays.

Radiograph: X-rays interact with body tissues with some degree of absorption in the exposed tissues. This photographic record of the extent of penetrability of X-rays through

the exposed tissue parts is called a radiograph or roentgenogram or skiagram or simply an X-ray picture.

HISTORICAL PERSPECTIVES

The discovery of X-rays was an accidental product of the work on Crookes-type tubes. Due to the nature and importance of the discovery, rapid progress took place in the production and uses of X-rays in medical science. Veterinarians also made significant contributions in this regard. Some of the main events only are listed here:

November 8, 1895:
- Wilhem Conrad Roentgen discovered X-rays.

1896:
- Lindenthal made first contrast picture of a hand.
- First oil immersed X-ray tube developed by Trowbridge.
- Roentgen and colleagues made the first metal-target X-ray tube.
- First intensifying screen made by Pupin.
- First photographic paper developed for recording of X-ray image by Wright.
- First dental radiograph made by Konig and Morten.
- First veterinary radiograph of an equine foot, published by Paton and Duncan in the March issue of The Veterinary Journal.
- Papers describing the use of X-rays in veterinary practice published by R Eberlein and C Troester of Germany; FTG Hobday.
- VE Jhonson and JAW Dollar (of Dollar's Surgery) of England and V Lemoine of France.

1897:
- AM Becquerel discovered radioactivity of uranium.
- JJ Thomson discovered electron (a negatively charged particle much smaller than atom).
- X-rays were used to locate bullets in the bodies of soldiers in Greco–Turkish and Sudan–Boer wars.

1898:
- Cannon used X-rays in the form of contrast studies (using bismuth meals) to investigate physiology of the gastrointestinal tract.

1900:
- The Roentgen Society of the United States formed.

1901:
- On December 10, WC Roentgen received first Noble prize in physics for discovery of X-rays.

1902:
- G Holz Knecht developed first dosimeter for radiation therapy.

1903:
- Noble prize in Physics awarded to Becquerel (for discovery of radioactivity of uranium), Marie Curie and Pierre Curie (for discovery of radioactivity of radium and polonium).

1905:
- Kienbock used strips of silver bromide photographic paper to estimate dosage in radiation therapy.
- First Roentgenological Congress held at Berlin with veterinarian R Eberlein being the chairman.

1913:
- Gustav Bucky invented grid to remove scatter radiation.

1914:
- WH Bragg and WL Bragg discovered that X-rays could be reflected.

1917:	• Self-rectifying generators developed for use in X-ray machine.
1918:	• Line focus principle was discovered for small focal area to obtain good radiographic detail. (In the early years that followed discovery of X-rays, use of a fluoroscopic screen was preferred to visualize an X-ray image because of long exposure time required to obtain a photographic image, poor film emulsions and unpredictable tube performance. The safety precautions were largely ignored and even hands were left unprotected during exposures. This caused permanent radiation injuries to an extent that in some cases grafts or amputation of fingers became necessary. In veterinary practice, X-ray machines were not considered productive because of high costs involved.)
1919:	• HF Waite constructed oil immersed shock-proof high voltage generators with enclosed collidge tube.
Early 1920s:	• Double coated film replaced old glass plate for recording X-ray image. • Moving grid invented by Dr Hollis Potter. • Iodine compounds introduced for use as contrast agents. • Total reflection, refraction and diffraction of X-rays by ruled grating was shown by Compton and Doan.
1926:	• High voltage transformers with valve tube rectification came into general use.
1928:	• International recommendations on radiation safety precautions were published.
1930:	• Super voltage single section X-ray tube developed by CC Launston.
1935:	• Subtraction technique introduced in radiography by Ziedes de Plantes (a Dutch radiologist).
1937:	• Xeroradiography invented by a physicist Chester F Carlson.
1945:	• Gray Schnelle wrote first American book on veterinary radiology.
1950:	• Cadmium sulphide crystals were used to detect X-rays by self amplification. It produced 107-fold increase in photoconducting currents. • SF_6 gas replaced oil, etc. as an insulating medium in transformers of portable X-ray machines.
Early 1950s:	• X-ray image intensifiers and clinically safe cinfluorography developed. • Medical application of ultrasound.
1954:	• First meeting of The American Veterinary Radiological Society was held (during this period, WD Carlson was a moving force in developing veterinary radiology in the USA).
1957:	• The organization of Educators in Veterinary Radiology (EVRS) formed in the USA.
1958:	• Alois Pommer of Australia published exhaustive treatise on veterinary radiotherapy.

1960:	• First medical radiographic film with a polyester based used. • American Board of Veterinary Radiologists (ABVR) formed. • American Veterinary Radiological Society issued its first printed proceedings (now it is a leading world journal "Veterinary Radiology and Ultrasound").
1969:	• American Board of Veterinary Radiologists (ABVR) renamed as American College of Veterinary Radiologists (ACVR).
1972:	• Rare earth intensifying screens invented. • Computerized axial tomography (CT scan) developed by GN Hounsfield in England. • The first human tomographic images with positron emitting isotopes (PET) were presented.
1973–74:	• Single photon emission tomography (SPECT) was demonstrated.
1977:	• The first human medical resonance imaging (MRI) was done.
1980:	• MRI use in veterinary medicine started.
1996:	• Blankespoor and co-workers presented a combined SPECT/CT design comprising a clinical SPECT gamma camera in tandem with a clinical single-slice CT.
2000:	• FDA approved handling of new drug applications; ^{18}F, ^{13}N, and ^{18}F-FDG were approved for PET in the areas of bone scintigraphy, cardiac perfusion, and oncology/neurology, respectively.
2004:	• The first combined clinical SPECT/CT system, the Symbia T2 (Siemens Medical Solutions), was launched comprising a dual-slice Emotion CT and a dual-head Symbia S scintillation camera.

In comparison to medical radiology, veterinary radiology in India has made slow progress. First 500 mA machine suitable for large animal radiography was installed at the College of Veterinary Sciences, Hisar, in 1972. The First ultrasound facility was available at College of Veterinary Sciences, Ludhiana. Now, most of the veterinary teaching institutes and many of the polyclinics do have facilities for both small and large animal radiography, ultrasonography and endoscopy. X-ray units in most of the facilities have been updated with high frequency X-ray generators, CR system and PACS (picture archiving and communication system). However, CT scan (RAJUVAS, Bikaner) and Nuclear scintigraphy (Veterinary college, Mumbai) are still rare. MRI studies on animals are being reported but with the help of human MRI facilities. Hybrid imaging techniques (PET/CT or SPECT/CT) are still a dream for animals in India.

Improvements in X-ray based imaging in the next decade will result in reductions of radiation doses to the point where the issue will no longer be of discussion or concern. Current calculations projecting excess cancers and cancer deaths from CT seriously inflate the risks, because they are derived from 10-year-old data that do not take into account new reconstruction methods and scanning systems developed in the last decade that have reduced radiation doses substantially. Phase contrast X-ray imaging is likely to be the next new imaging method to be explored clinically. Compared to attenuation based X-ray imaging, phase contrast has the theoretical potential to reduce doses by 10- to 100-fold or more due to the inherently high contrast it affords.

SCOPE AND USES OF VETERINARY RADIOLOGY

Radiology in veterinary practice may not always be used to arrive at a final diagnosis. Nevertheless, radiography remains a good aid in diagnosis. Some 65–70% of all imaging exams rely on radiography. Judicious use of conventional/high frequency machines, proper positioning of the part to be examined, careful interpretation and genuity of the radiologist, all help to arrive at a reasonable radiographic diagnosis. In practice, radiography should be used only when it is expected to provide more significant information. Following are the possible uses of radiography in veterinary practice:

i. As a diagnostic aid.
ii. To select methods or techniques of treatment, e.g. for fracture repair.
iii. To detect previously unrecognized lesions.
iv. To monitor efficacy of a treatment schedule or disease progression.
v. To screen normal animals for morphological evaluation in an attempt to eradicate inherited diseases by selective breeding.
vi. To determine the age of animals.
vii. To examine postmortem material.
viii. For non-destructive examination of archaeological specimens of animal origin.
ix. As a teaching aid in the subject of anatomy.

According to Webbon, three approaches are possible for the continued development of radiology without acquiring equipments of prohibitive cost:

i. Establishment and maintenance of a close contact with radiologists working in human medicine so that expensive equipment can be made available for use in animals.
ii. Consolidation of knowledge on the natural history of diseases and significance of minor variations from the normal.
iii. Application and expansion of diverse uses of radiography in veterinary science, especially for purposes other than diagnosis of diseases in clinical, cases e.g. in disease eradication programmes by selective breeding.

DIRECTIONAL TERMS (RADIOGRAPHIC VIEWS)

The nomenclature committee of the American College of Veterinary Radiologists recommended a system of standard nomenclature for radiographic views and these recommendations were accepted by American College of Veterinary Radiologists in 1983. The recommended directional terms are easy to understand and avoid confusion. Standard journals and textbooks have mostly shifted to this new terminology. Therefore, the new terminology is being used in the present text and reader should be familiar with this terminology. **These directional terms are based on the principle that each view should be able to indicate the direction that the central ray of the primary beam of X-rays penetrates the body part being examined, i.e. from the point of entrance to the point of exit.**

These terms replace the previously used terms of anterior, posterior, superior and inferior. These directional terms are described in Fig. 1.1.

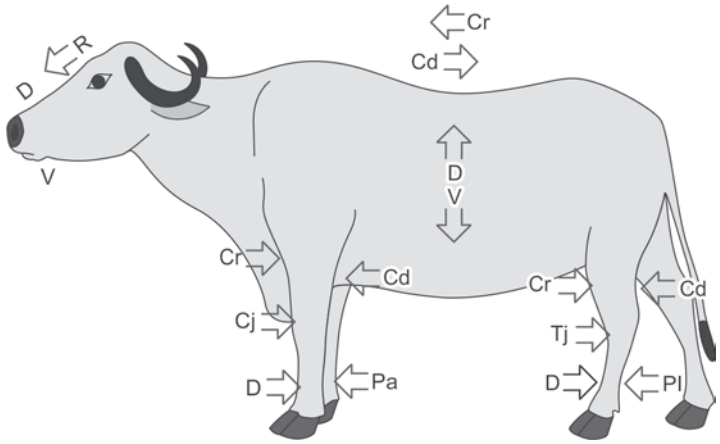

Fig. 1.1: Directional terms. D = Dorsal, R = Rostral, Cr = Cranial, Cd = Caudal, V = Ventral, Pa = Palmar, PI = Plantar, Cj= Carpal joint, Tj = Tarsal joint.

Cranial: It describes the part of the neck, trunk and tail positioned towards the head from any given point. It also describes aspects of the limb facing the head and above the carpal and tarsal joints.

Rostral: It describes the parts of the head positioned towards nares from any given point on the head, e.g. nostrils are rostral to the eyes.

Caudal: Parts of the head, neck and trunk positioned towards the tail from any given point, and aspects of the limbs facing tail but proximal to the carpal and tarsal joints.

Palmar: It replaces caudal in the forelimb from the carpal joint distally.

Plantar: It replaces caudal in the hindlimb from the tarsal joint distally.

Dorsal: It describes the following:

i. *Upper aspects of the head, neck, trunk and tail, also meaning towards the vertebrae or back.*
ii. *Upper aspe*cts *of the limb from the carpal or the tarsal joint distally.*

Ventral: Lower aspects of the head, neck, trunk and tail, also means towards lower aspects of the animal.

Proximal: Describes **nearness to the point of origin** of a structure, e.g. the scapula is proximal to the humerus.

Distal: Describes a point farther away from the point of origin of a structure, e.g. the radius is distal to the humerus.

The term volar is no longer used. Superior and inferior are still used to describe the upper and lower dental arches. In anatomical terms, anterior and posterior are still used for certain locations such as for parts of the eye, ear and brain.

The nomenclature committee also recommended the use of standard abbreviations which are listed in Table 1.1.

In a view when only two-directional terms are used, standard listing is done, e.g. ventrodorsal, dorsopalmar, etc. In ventrodorsal term, it is clear that central ray enters from the ventral side to exit from the dorsal side; and so on. For complex terms, as in case of oblique views, a hyphen is added to indicate the point of entrance and exit of the central ray, e.g. dorsolateral-palmaromedial oblique. Angles of obliquity can also be

designated by inserting number of degrees of obliquity between the directional terms involved. If the dorsomedial-palmerolateral oblique (DMPaLO) projection is to be made by positioning the X-ray tube 50° medially to dorsal, the designation would be D50MPaLO. When a special position, other than the routinely used is employed, appropriate term should be used for the same, e.g. a dorsopalmar view of the flexed carpal joint would be written as dorsopalmar (flexed).

Table 1.1: Abbreviations of directional terms to describe radiographic views (recommended by the nomenclature committee of the American College of Veterinary Radiologists)

Directional term	*Abbreviation*
Left	Le
Right	Rt
Dorsal	D
Ventral	V
Cranial	Cr
Rostral	R
Caudal	Cd
Medial	M
Lateral	L
Proximal	Pr
Distal	Di
Palmar	Pa
Plantar	Pl
Oblique	O

For most oblique views, combinations of basic directional terms would be required. To standardise nomenclature for such views, the nomenclature committee recommended as follows:

i. 'Right and left' should precede other terms, e.g. right cranioventral.
ii. 'Medial' and 'lateral' should be subservient when used in combination with other terms, e.g. dorsomedial, ventrolateral, etc.
iii. On the head, neck, trunk and tail, the terms 'rostral', 'cranial' and 'caudal' should take precedence when used in combination with other terms, e.g. rostromedial, craniodorsal, etc.
iv. On the limbs, the terms 'dorsal', 'palmar', 'plantar', 'cranial' and 'caudal' should take precedence when used in combination with other terms, e.g. dorsoproximal, palmarodistal, etc.

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SELECTED QUESTIONS

1. Define the following terms:
   i. Veterinary radiology
   ii. X-rays
   iii. Roentgenogram
   iv. Rostral
   v. Palmar
   vi. Plantar
2. List the possible uses of radiography in veterinary practice.
3. Name the persons credited with the following achievements:
   i. Discovery of X-rays
   ii. Production of first veterinary radiograph
   iii. Discovery of electron
   iv. First noble prize in physics
   v. Invention of moving grid
   vi. CAT scan
4. Who is considered father of veterinary radiology and why?