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Veterinary Radiology

Introduction

- **Radiology (Roentgenology):** Radiology is that branch of medical science which deals with the diagnostic and therapeutic application of radiant energy.
- Radiography is an art and science acquired by study and practice in the use of x-rays to produce images.

General Terminology

- **Radiant energy** for the purpose includes x-rays, and beta and gamma radiations. It is used in diagnosis, monitoring, treatment of diseases and in research programs.
- **Veterinary Radiology:** Veterinary radiology is a branch of science which uses radiant energy principally for the diagnostic and therapeutic purposes in domestic, zoo and laboratory animals.
- **Radiologist:** Radiologist is a person qualified in medical or veterinary sciences and radiological physics to use radiant energy in the diagnostic, therapeutic and research fields of medicine.

- **Radiographer:** Radiographer is a technically trained professional responsible for producing quality radiographs for the use of radiologist.
- **X-Ray** is 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:** The x-rays that 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 a tremendous speed to strike at the target. The electron- target interaction generates medical x-rays.

- **Radiograph:** The photographic record of the extent of penetrability of x-rays through the exposed tissue is called **Radiograph or Roentgenograph or skiogram or** simply x-ray picture.
- **Photons:** X-rays are often called photons; it is a Greek word which means “a bundle of energy”.
- X-ray photons are invisible to the human eye.

PROPERTIES OF X-RAY

X-rays are electromagnetic radiations of high energy and low wavelength produced by the conversion of kinetic energy of electrons.

The important properties of x-ray are;

- X-rays behave as waves and have short wave length and high frequency.
- X-rays can penetrate materials which readily absorb and reflect visible light.
- X-rays travel in straight line with the speed of light and cannot be focused by lens.
- X-rays interact with matter, are absorbed or scattered and liberate minute heat on passing.
- X-rays affect photographic film, similar to that by visible light.
- X-rays produce fluorescence in certain crystalline material e.g. calcium tungstate.

Uses of Radiography

- A diagnostic aid.
- To select methods of treatment e.g. for fracture repair
- To detect previously unrecognized lesions
- To monitor efficacy of treatment schedule
- As a teaching aid in the subject of Anatomy
- To determine the age of the animals
- To select normal animals for morphological evaluation in selective breeding.
- To examine archeological specimens of animal origin safely.
- In veterinary science research e.g. Osteomedullography to evaluate bone healing.
- To examine post-mortem materials

Basic Interaction of X-ray with Matter

For an x-ray examination the part to be examined is kept between the x-ray source and the x-ray film. The x-ray beam emitted by the machine will traverse through the part to be examined to reach the film carrying useful information which will be recorded as an image on the film.

The outcome of the x-ray beam that passes through the patient:

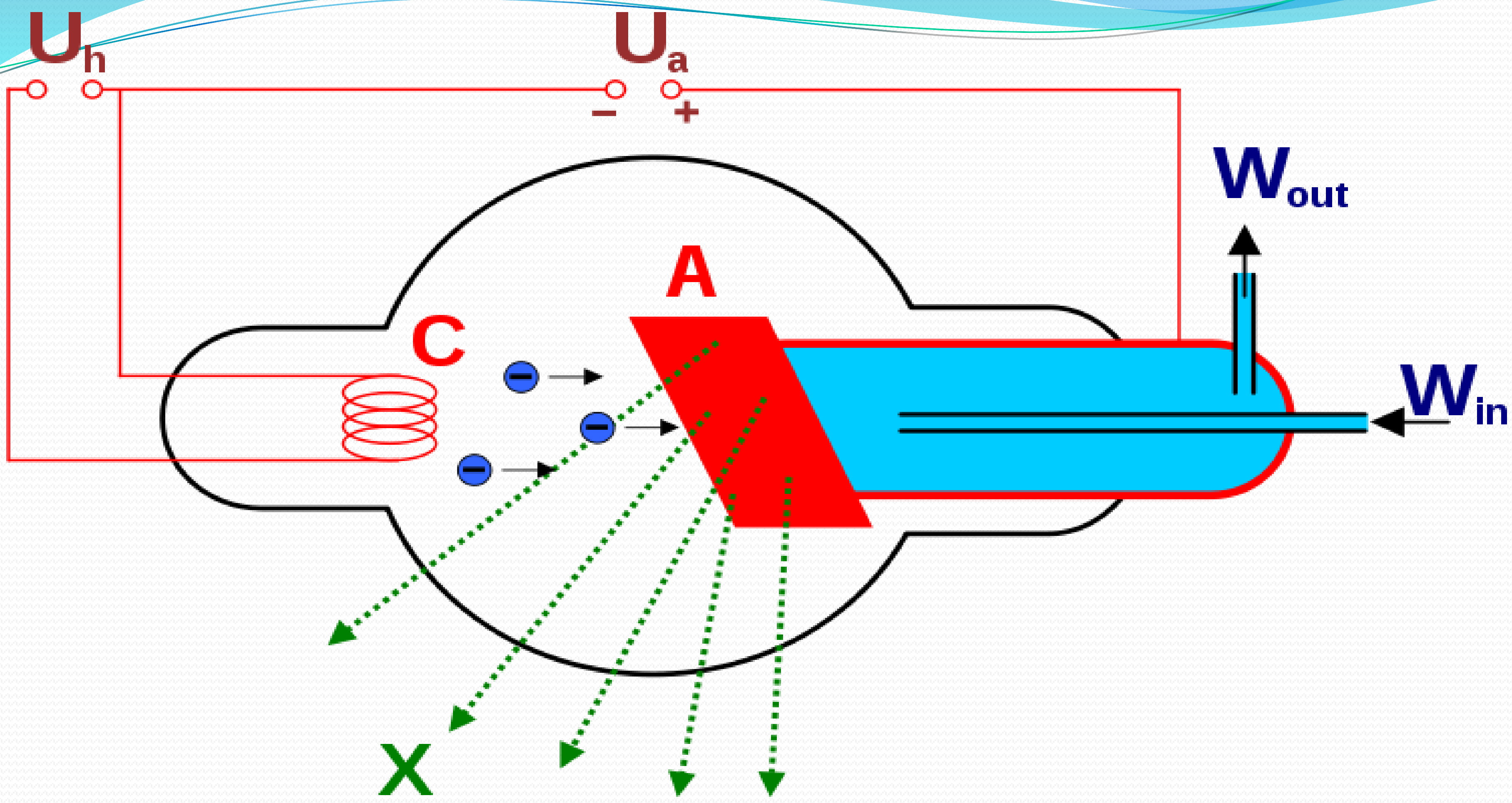
- Some x-rays are differentially **transmitted through the patient** carrying useful information.
- Some photons are **absorbed** and cease to exist.
- Some are **deflected from the course as scatter radiation** which carries no useful information and rather decreases the quality of a radiograph by causing fog on the film.

Ionizing Radiation:

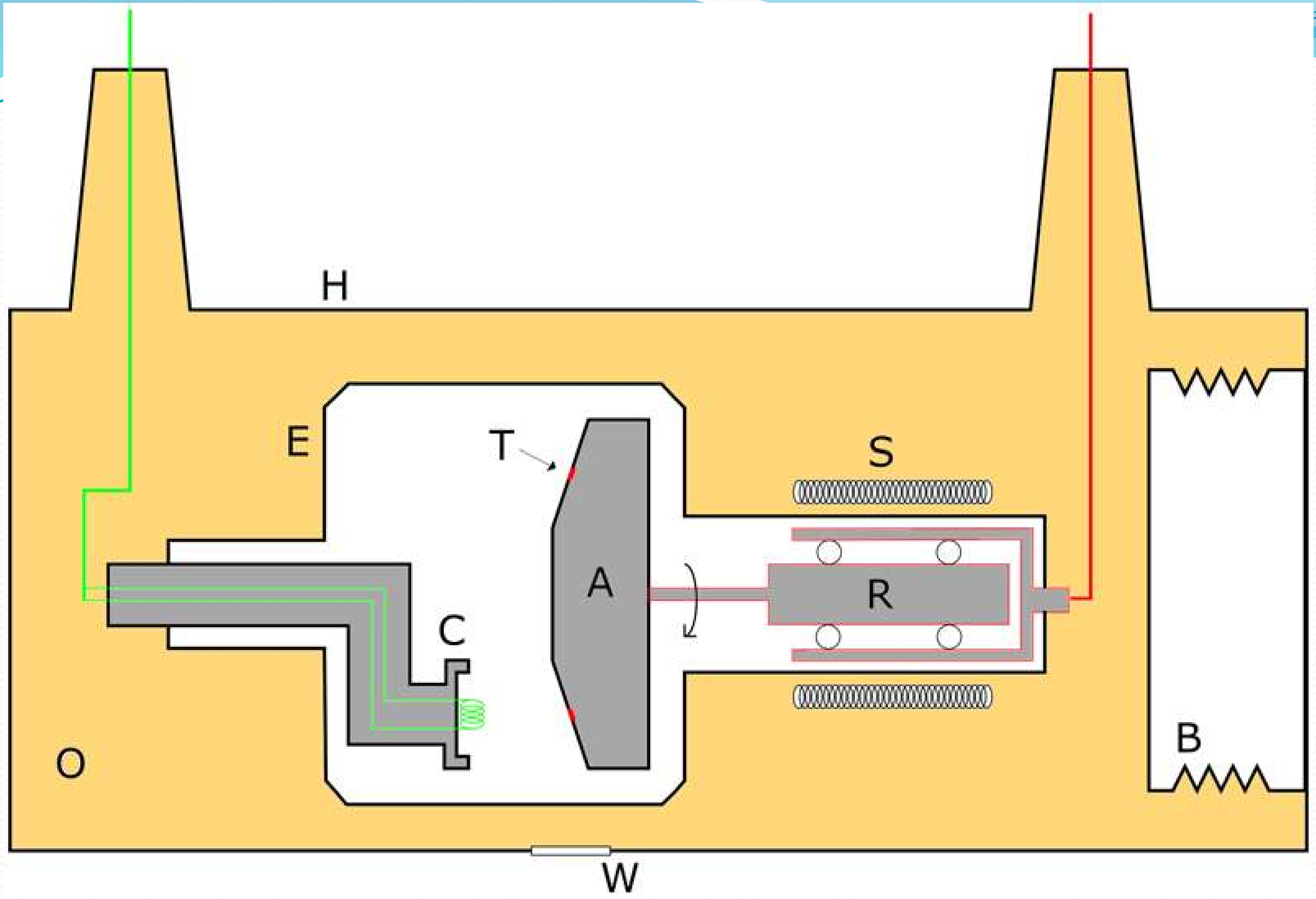
Any type of energy or matter-energy combination, capable of removing one or more orbital electrons from the atom, after interaction is known as ionizing radiation. The process is called ionization. The ionizing radiation caused by x-rays and gamma rays is potentially harmful and can cause serious injury to the living beings, if used indiscriminately.

PRODUCTION OF X-RAY

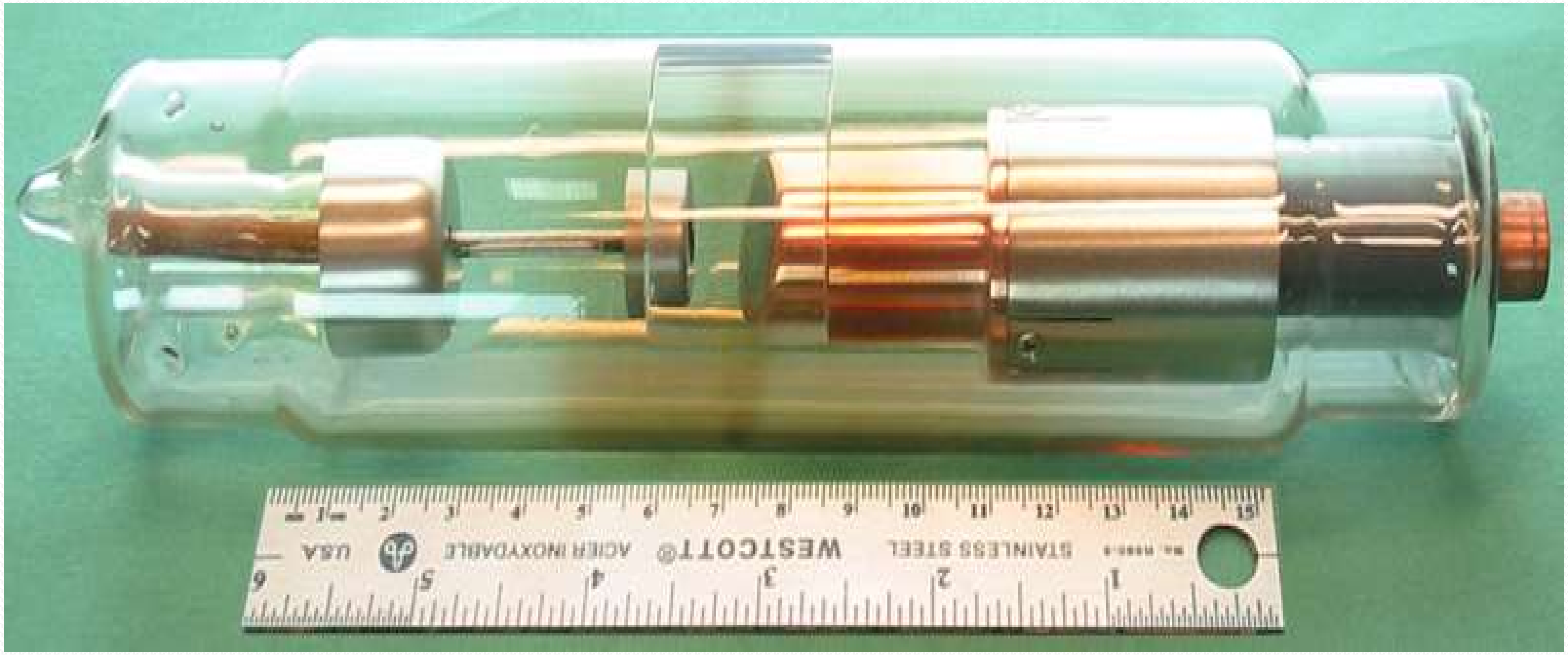
The production of x-rays occurs as a result of a sequence of events. The evacuated x-ray tube is a device for producing free electrons from heated tungsten filament; the process is called thermionic emission. The electrons remain in a constant agitated motion and their number increases as the temperature of the filament increased. Now, the filament or the cathode is given a very high negative electric potential and the target or the anode is given an equally high positive electric potential.



- Coolidge side-window tube (scheme) C: filament/cathode (-) A: anode (+) Win and Wout: water inlet and outlet of the cooling device



- Simplified rotating anode tube schematic A: Anode C: cathode T: Anode target W: X-ray window



- typical fixed-anode X-ray tube

- Two high Voltage rectifier tubes capable of producing X-rays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The resulting strong electrical field causes the cloud of electrons near the filament to rush up at a high speed through the vacuum tube and bombard the target at the focal spot. This results in several types of interactions with the target material in the x-ray tube. More than 99% of the kinetic energy of electrons is converted into thermal energy. Approximately less than 1% of the remaining kinetic energy is irradiated as **X-RAYS.**

When the exposure is terminated, x-rays are no longer present in the room or in the patient since, the x-rays travel at the speed of light. X-rays produced are traveling in all directions. The lead housing surrounding the x-ray tube will absorb most of the x-radiation. The useful x-rays are those x-rays that pass through the tube window and help to produce the radiograph. The useful x-rays that leave the tube housing are called the **‘primary x-ray beam’.**

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Factors Influencing Production of Radiograph

- **1. Kilovoltage (kVp)** is the force that accelerates the electrons from the cathode to the anode. kVp means the **kilovoltage peak** or the crest of waveform representing x-ray photon energy.
- The kVp is the force behind the stream of electrons that determines the speed at which the electrons ‘slam’ or ‘bombard’ into the focal spot. It is the most significant factor in the production of x-rays and radiographs. The stream of electrons is called the **Tube current or Cathode rays.**

2. **Milliampere (mA)** is defined as the current that flow through the cathode filament at the time of exposure. It is the second important technical factor.

An increase in milliampere will increase the number of x-ray photons in the x-ray beam. A doubling of the milliampere will double the amount of blackening in the film.

3. Exposure time(S) is the technical factor that controls the *time of exposure*. It is also a quantitative factor (s), when combined with milliampere (mA) it determines the exposure rate (mAs).

An increase in the mAs increases the x-ray photons exposing the film.

4. Focal Spot

The focal spot on the target surface of the anode is the area which is bombarded, by the electrons from the cathode during an exposure. The rotating target produces a focal track that runs the circumference of the rotating disk. **Umbra** is the true object recorded on the film. **Penumbra** is the thin blurred area around the umbra. Penumbra is unsharpness.

5. Focal – Film Distance (FFD) is measured from the focal spot to the recording medium (x-ray film in the cassette). In veterinary radiography, 90-100cm FFD is considered a good compromise between the distance and exposure factors.

Increase in FFD decreases the total number of x-rays available to expose the film.

RADIOGRAPHIC QUALITY

Radiographic quality refers to the accuracy with which anatomical structures of the part being radiographed are represented on a radiograph. In other words, if visibility and sharpens of the structures are good, the radiograph is of good quality.

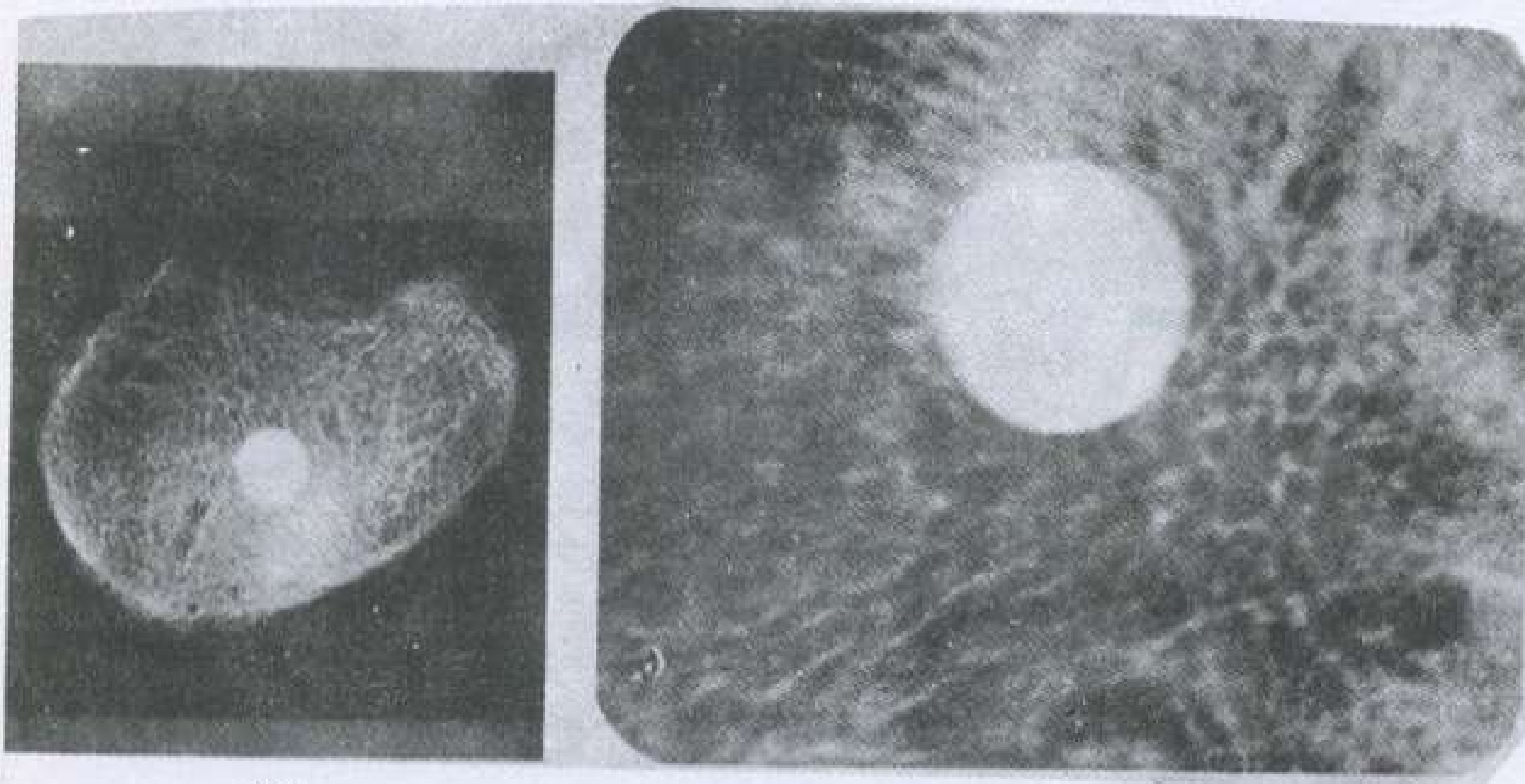
Three main visual requirements of a good quality radiograph are:

- Excellent **Detail**
- Correct **Density**
- Proper scale of **Contrast**

The factors affecting the main visual requirements of good quality radiograph are detailed below.

1. Detail (Definition) :- describes the **clarity and sharpness of the image** on the radiograph.

- The following factors influence the detail:
  Geometric factors
- Intensifying screens
- Motion of the patient
- X-ray tube
- Differential absorption of x-rays
- Double emulsion of the film(Gelatin, potassium bromide, potassium iodide, and silver nitrate)
- Radiographic mottle(statistical fluctuation of the number of photons absorbed by the intensifying screens)
- Exposure factors used
- Film processing
- Scatter radiation



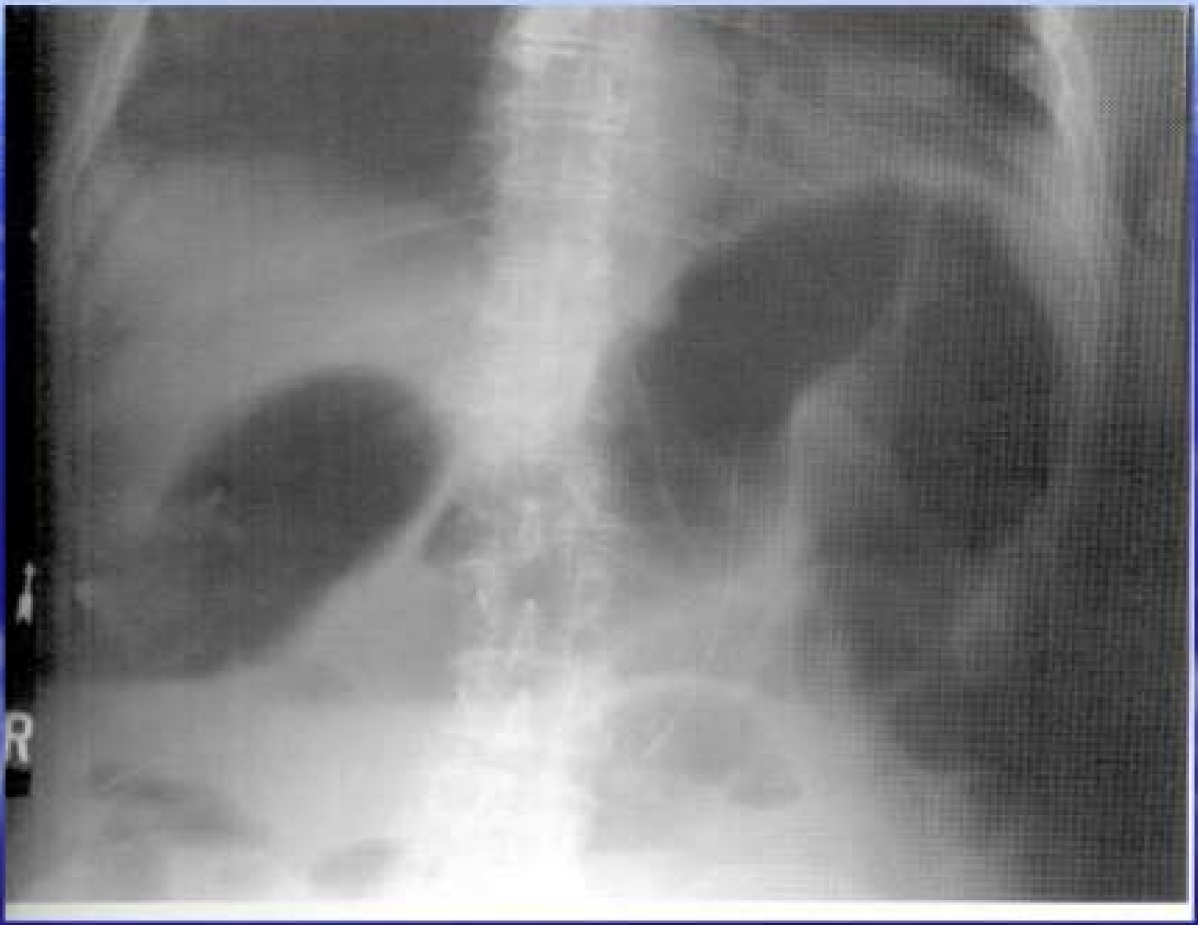
(a) (b)

Sharp edges image

Unsharp edges image

Radiographs small bone with shot embedded in it

Motion blur (unsharpness)



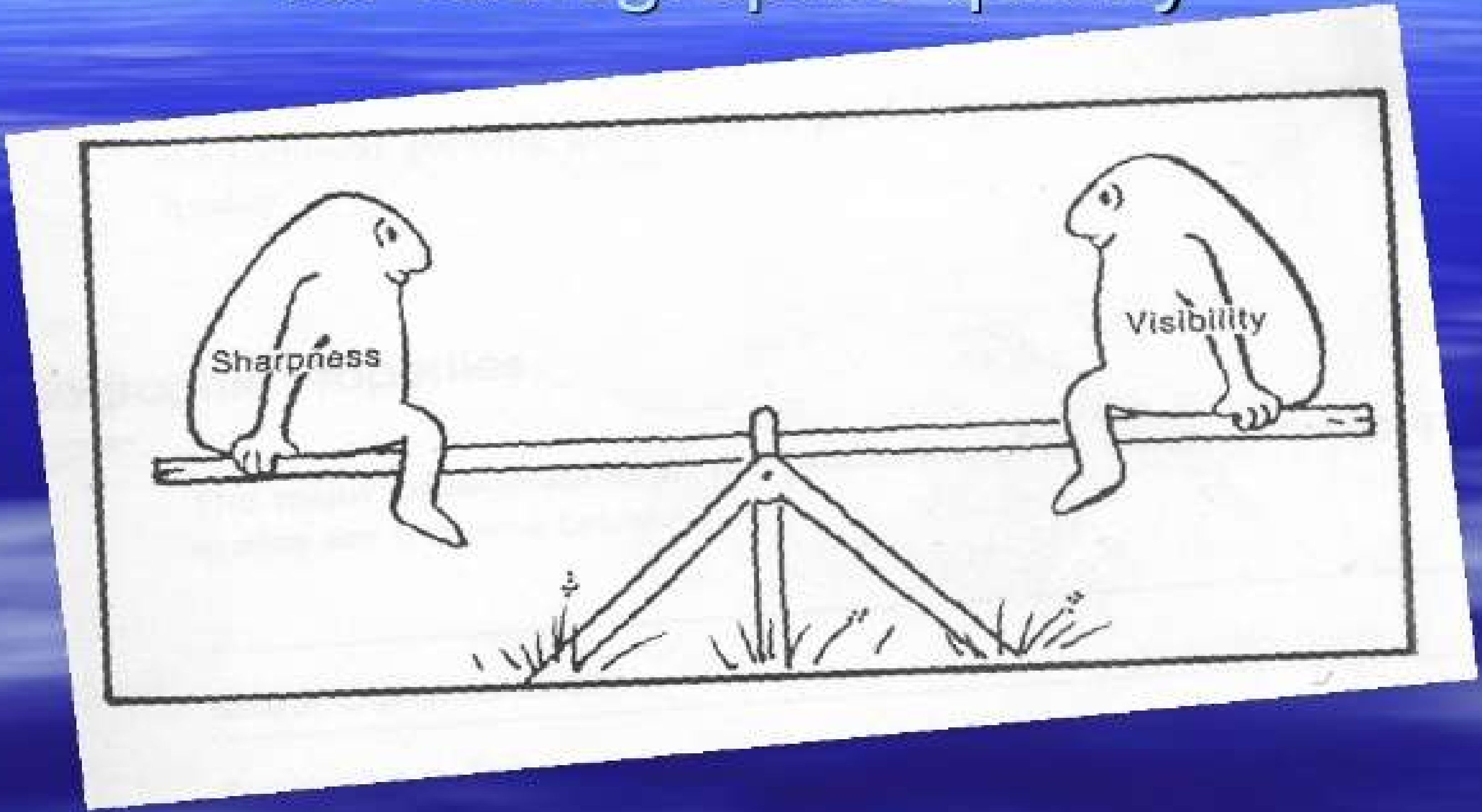
Involuntary patient motion during radiography


R
Good Visibility
Poor Visibility
X-ray Sinuses

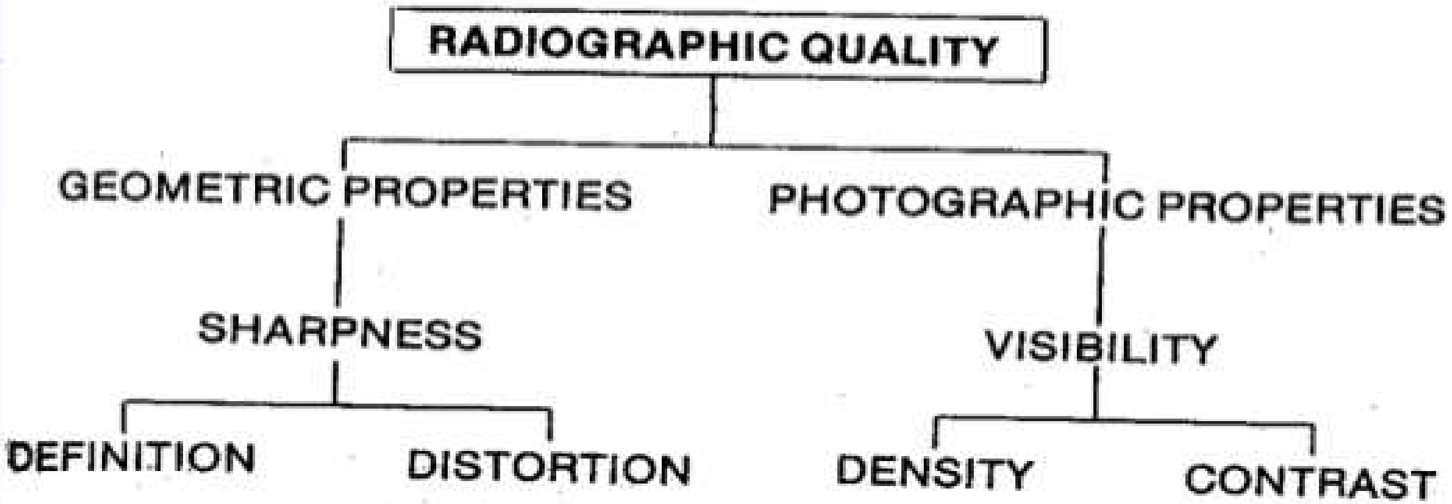

R


R

Balance of sharpness and visibility for radiographic quality



Radiographic Quality

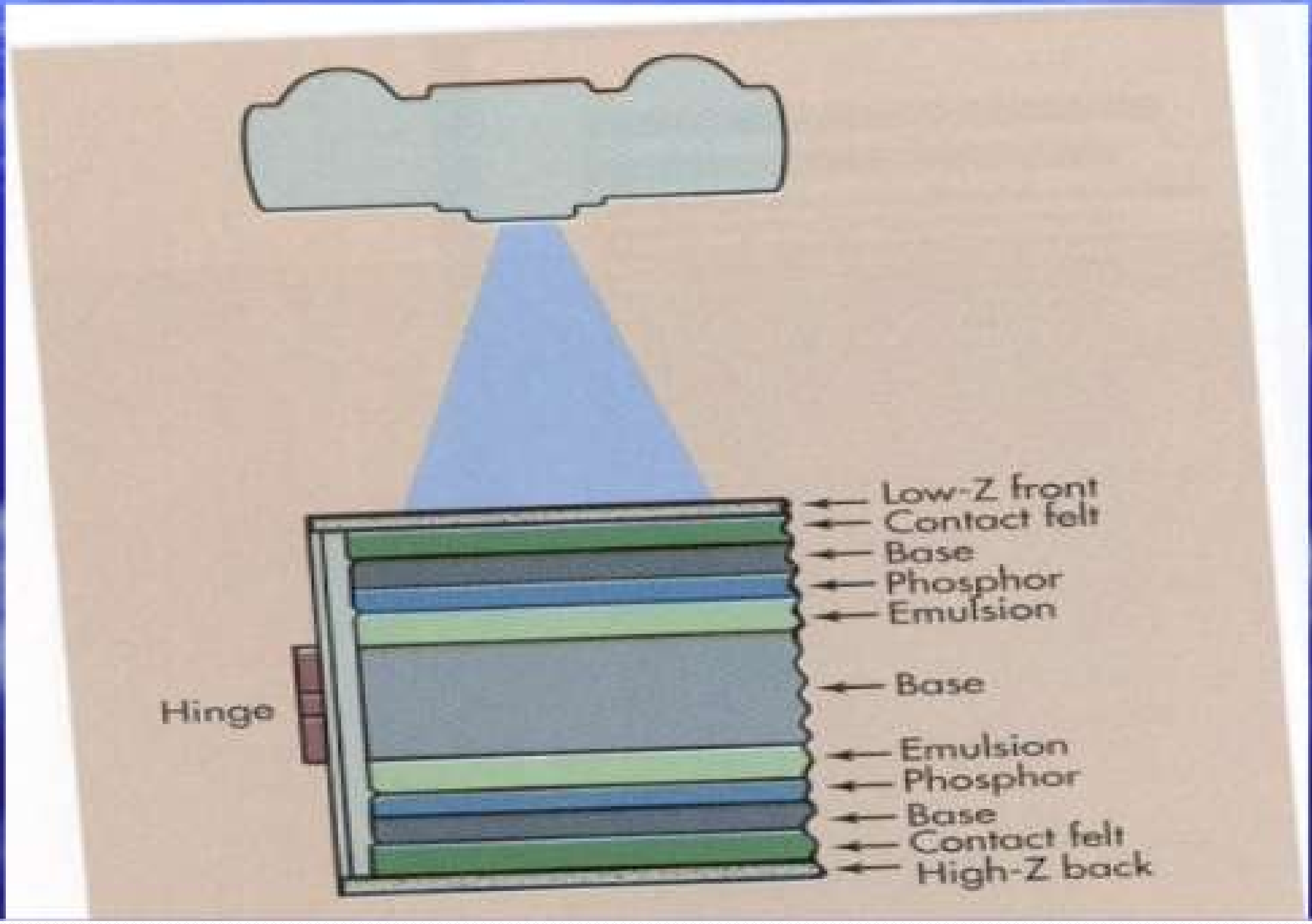


A basic outline of the radiographic quality relationship.

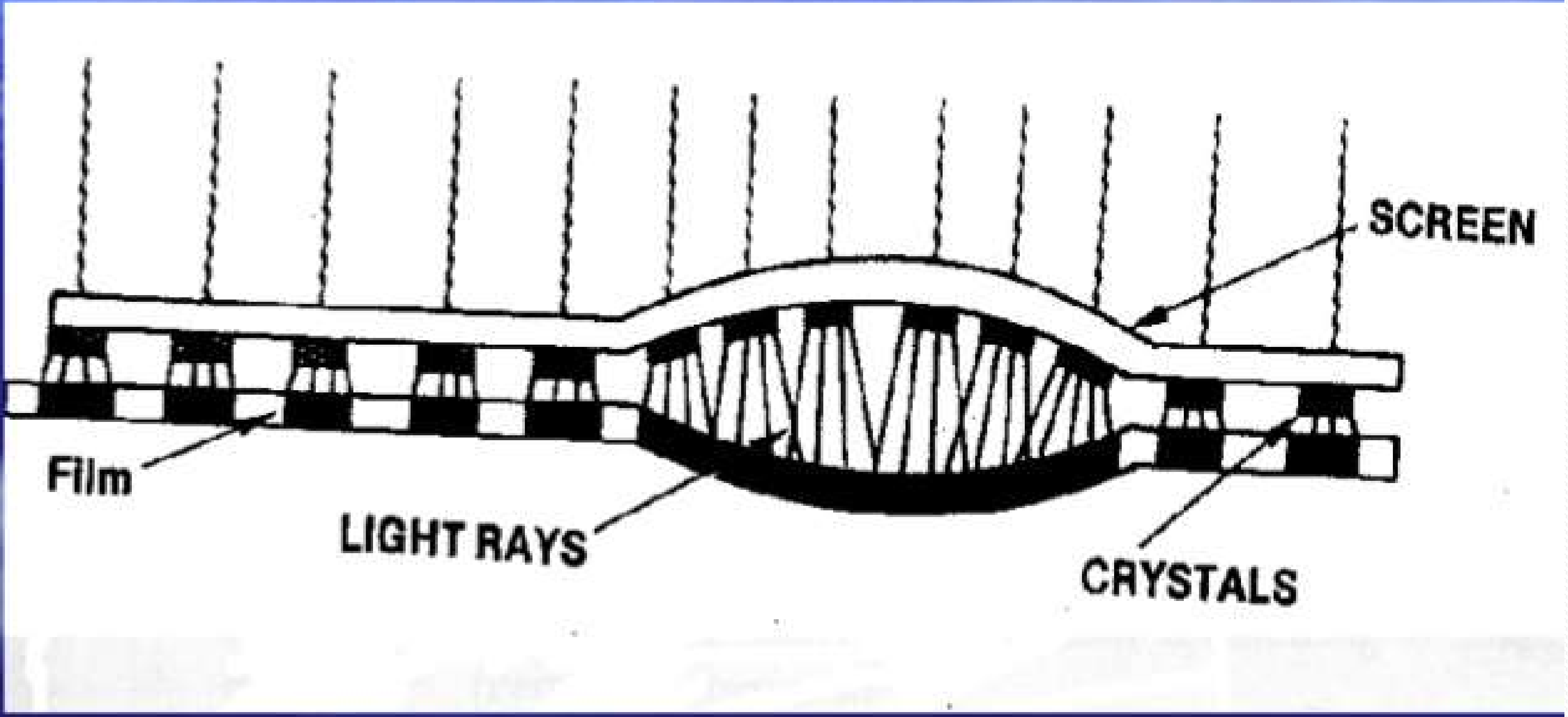
(A) demonstrates quantum mottle

(B) demonstrates recorded details

The three major factors influencing material unsharpness



Poor film screen contact




Poor film-screen contact


Good film-screen contact

2. Radiographic Density:- is the measure of the degree of blackness on a processed film and is directly related to the number of x-rays reaching the film.

More the number of x-rays that are reached the film, higher the radiographic density and blacker the film. Those objects which allow x-rays to readily pass through them appear blacker on the film and are radiolucent, while those which inhibit most x-rays appear white and are radiopaque.

Main densities that can be appreciated on the radiograph are; i) metal: ii) mineral, and bone iii) fluid and soft tissue iv) fat and v) gas.

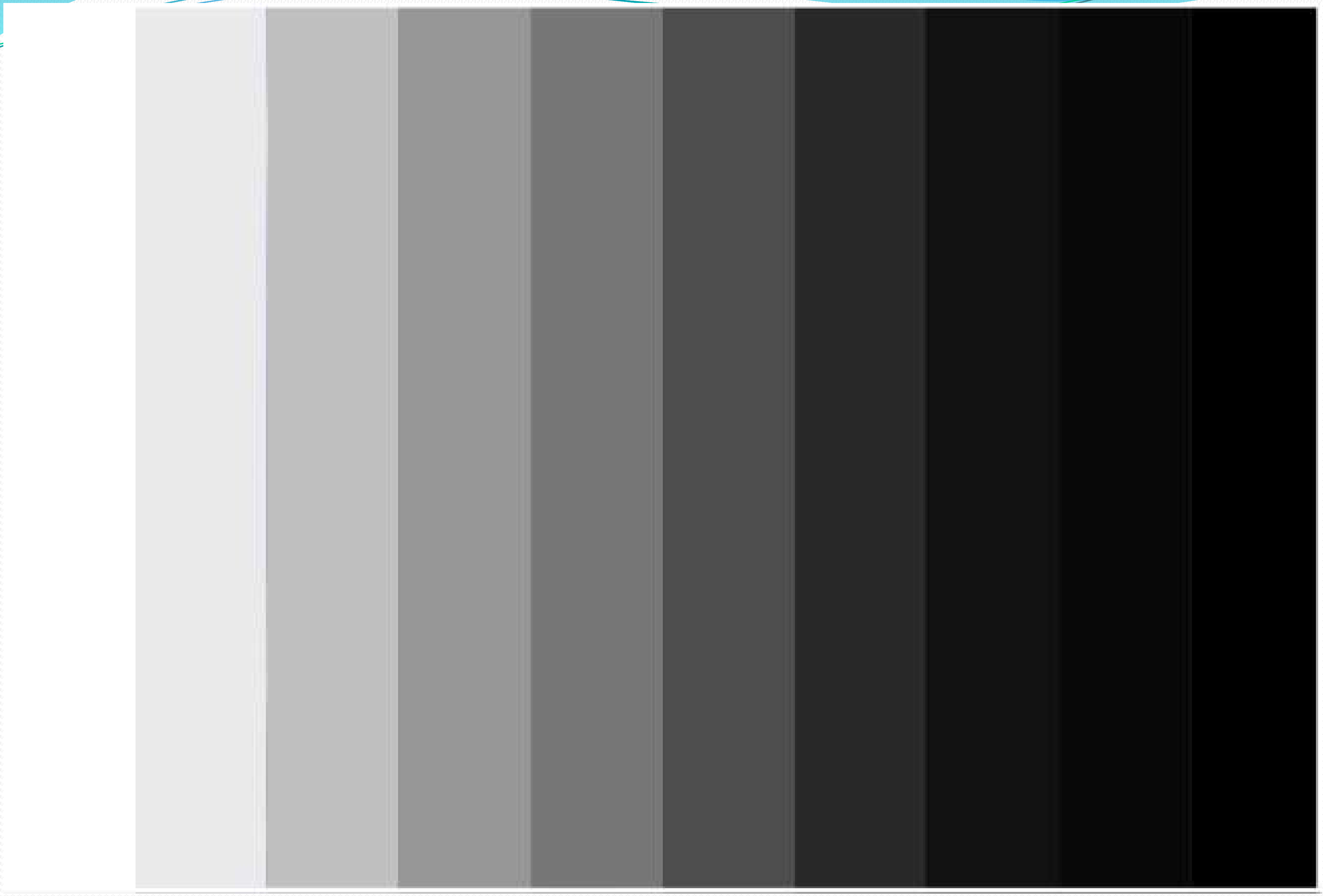
Factors affecting the radiographic density are;

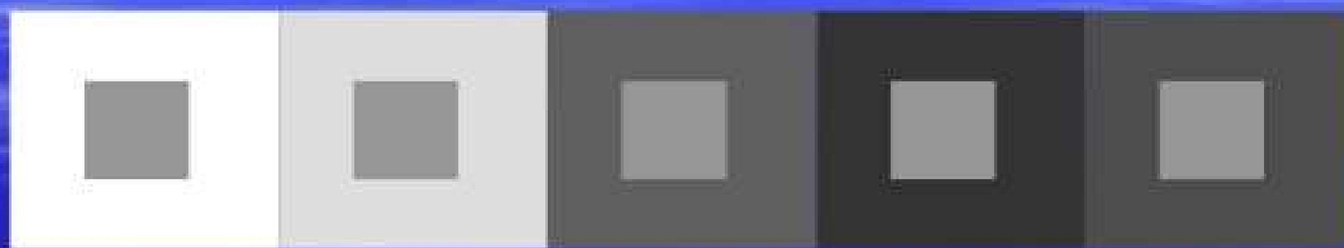
- Milliamperage
- Exposure time
- Kilovoltage
- Focal- film distance
- Speed of the film
- Intensifying screens
- Developing time & temperature
- Grid ratio

3. Radiographic Contrast: Difference in various densities of adjacent areas on a radiograph is radiographic contrast. Density must be present in order to visualize contrast.

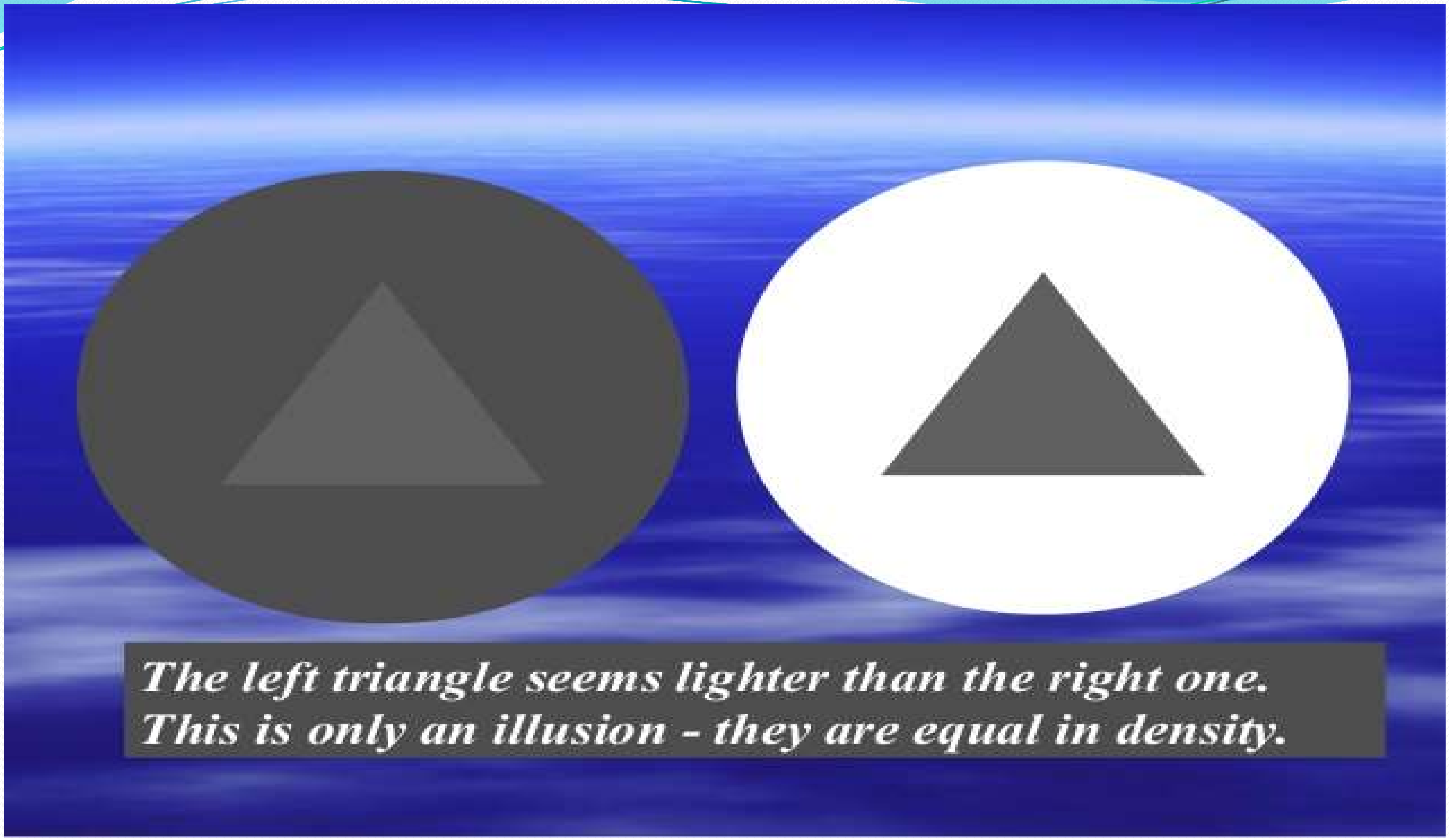
Factors that affect contrast are:

- Thickness of the part
- Density of the part
- Effective atomic number of tissue
- Kilovoltage
- Fog and scatter radiation



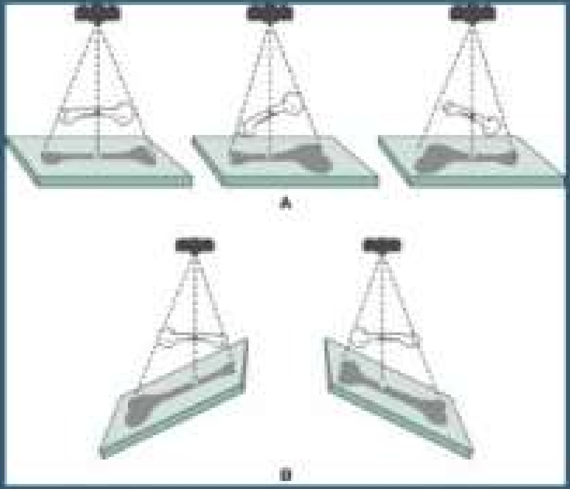


Radiopacity and radiolucency are relative terms. The central gray squares are all of the same density.


The left triangle seems lighter than the right one.
This is only an illusion - they are equal in density.

Assessing Radiographic Distortion

- Radiographic misrepresentation of either the size or shape of the anatomic part is called distortion
- 2 Types of Distortion

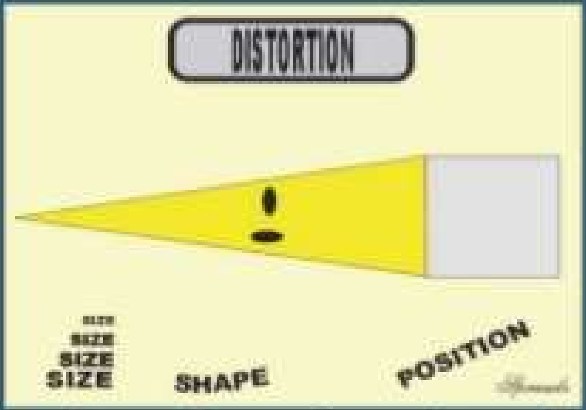


DISTORTION

SIZE SHAPE

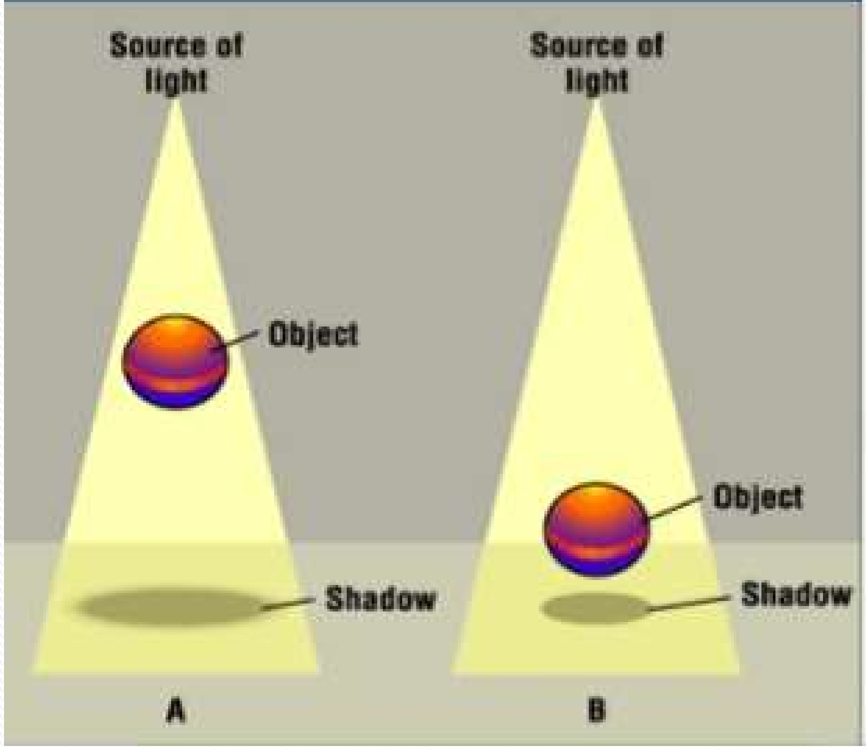
Size Distortion - Magnification

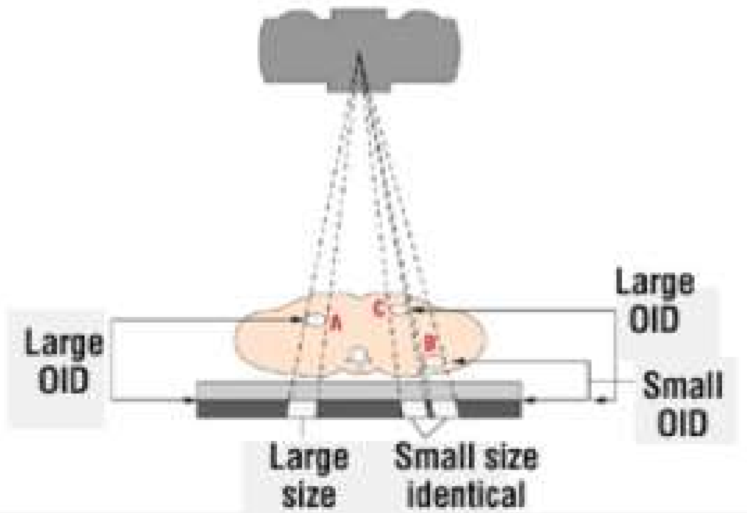
- An increase in the object's image size compared with its true, or actual size
- There is a percentage of **magnification** in every radiographic image
- *As the percentage of* ***magnification increases****, the level of geometric* ***unsharpness*** *also* ***increases***



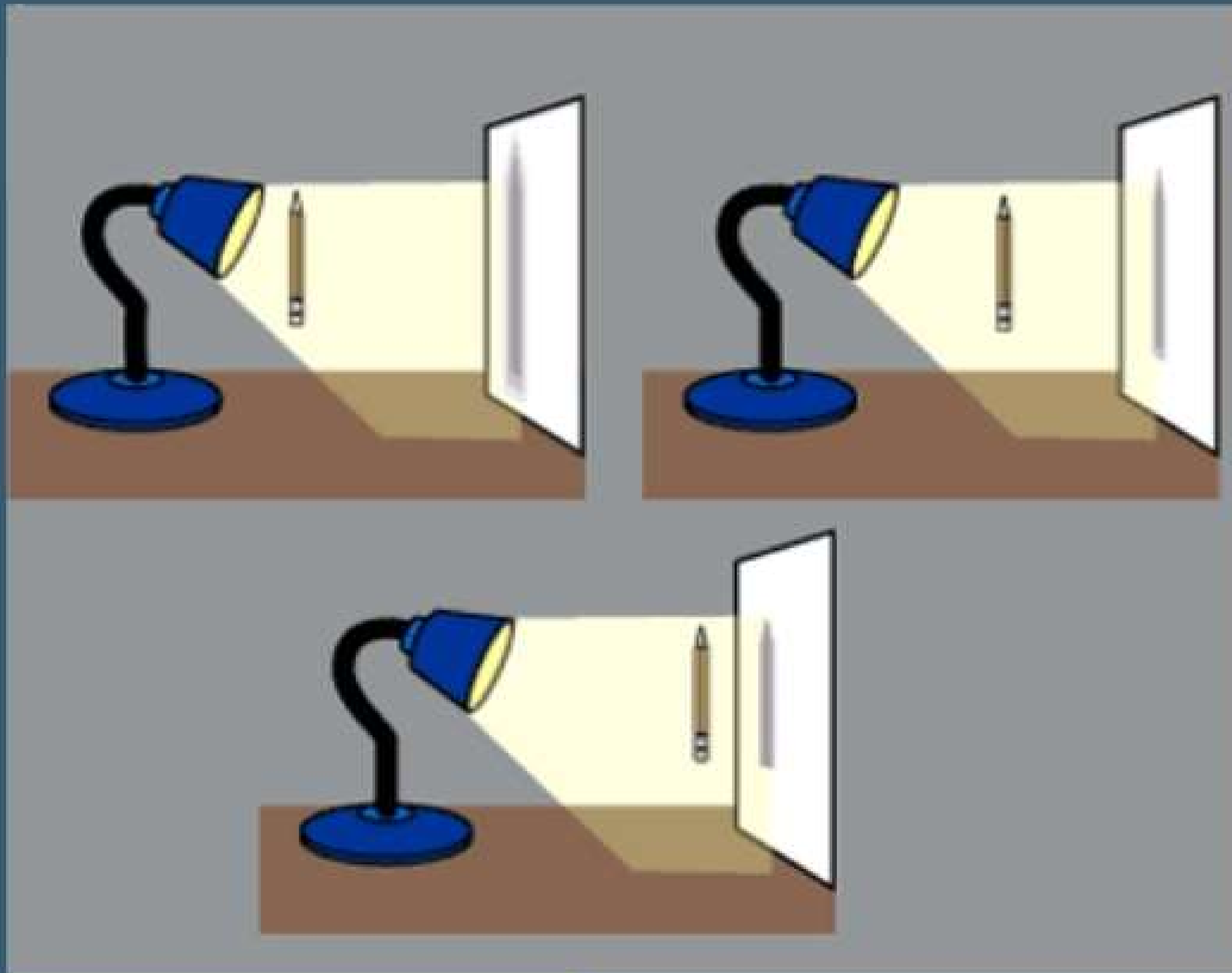
OID

OID has a <u>direct relationship</u> with size distortion
As OID increases, size distortion/magnification increases
As OID decreases, size distortion/magnification decreases





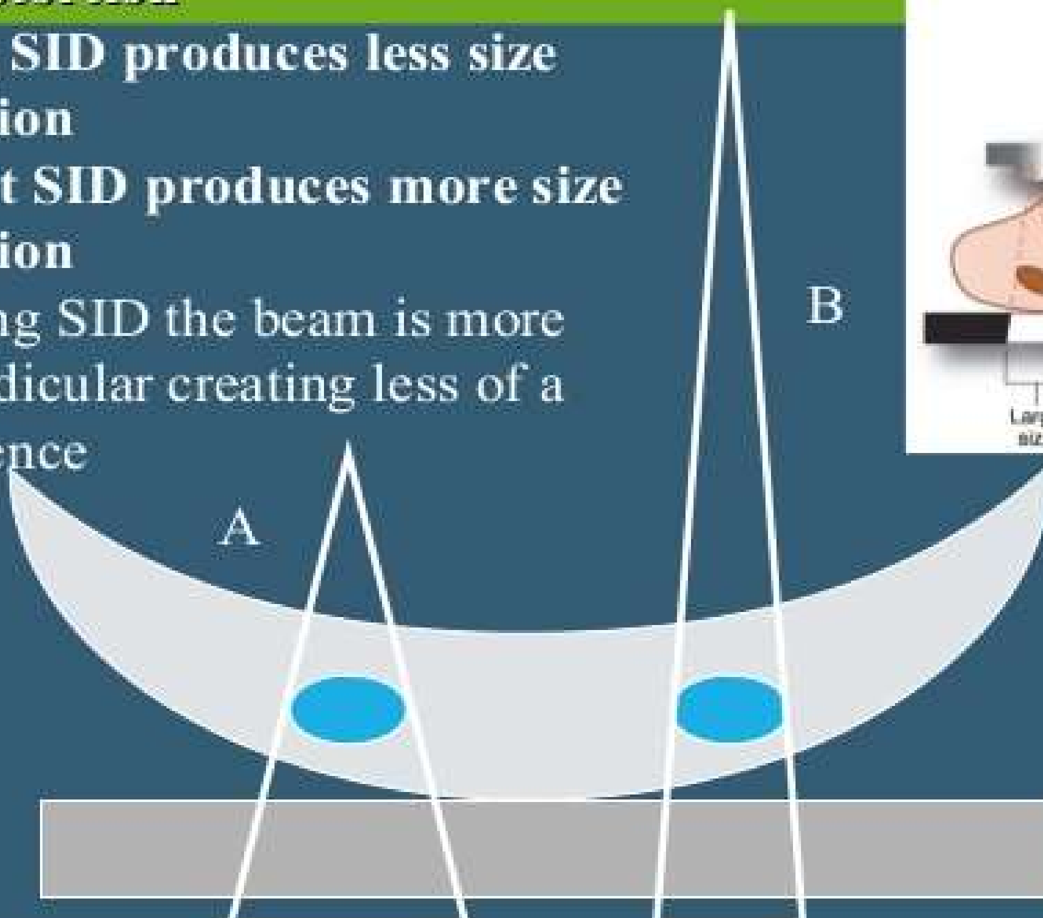
Even though objects A and B are identical, their projected images are different. Object C is smaller than B, but because C's OID is greater, their image sizes are identical.

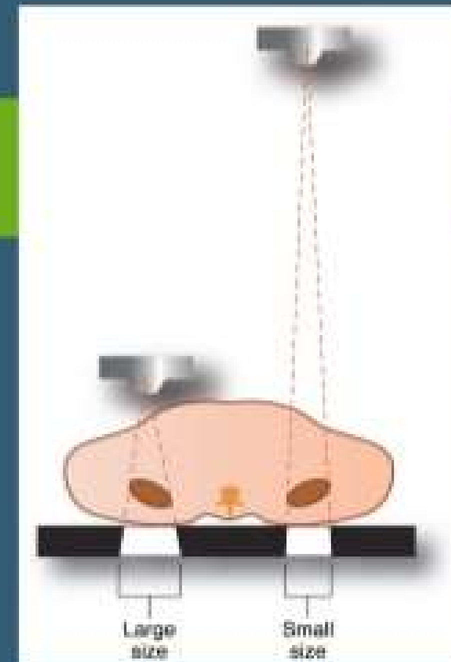


SID

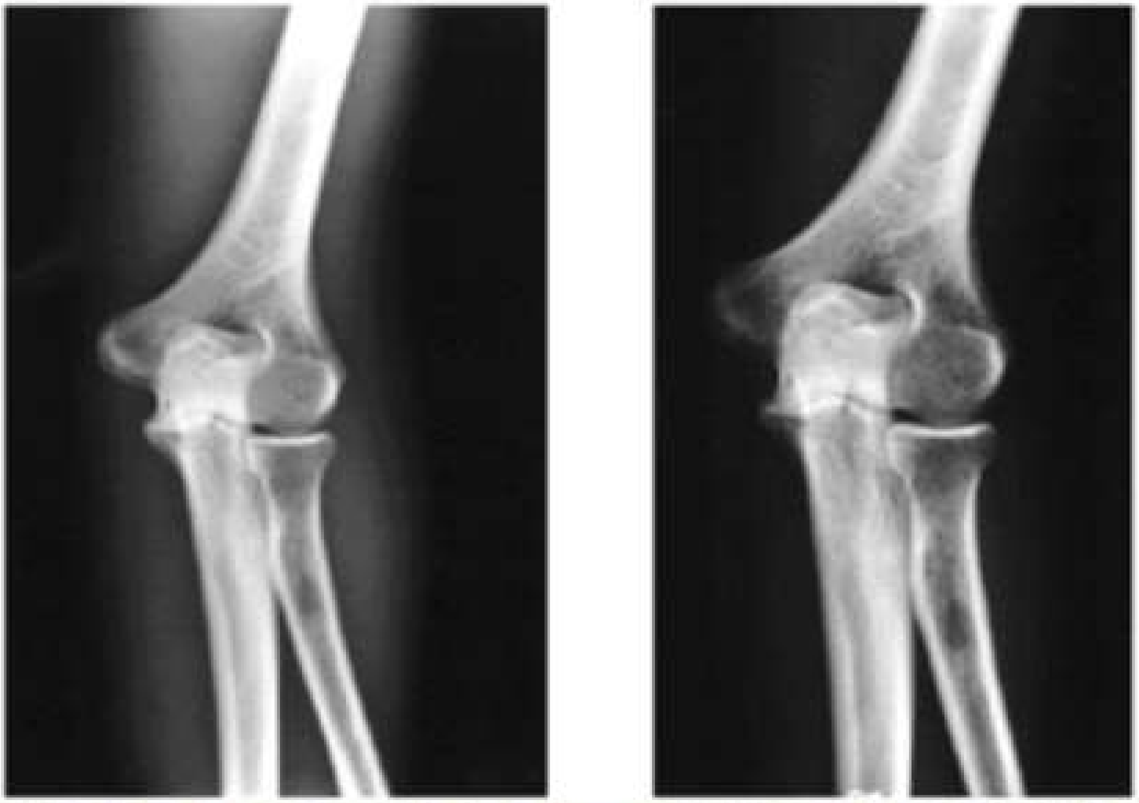
- **SID has an <u>inverse relationship</u> with size distortion**
- **A long SID produces less size distortion**
- **A short SID produces more size distortion**

With a long SID the beam is more perpendicular creating less of a divergence





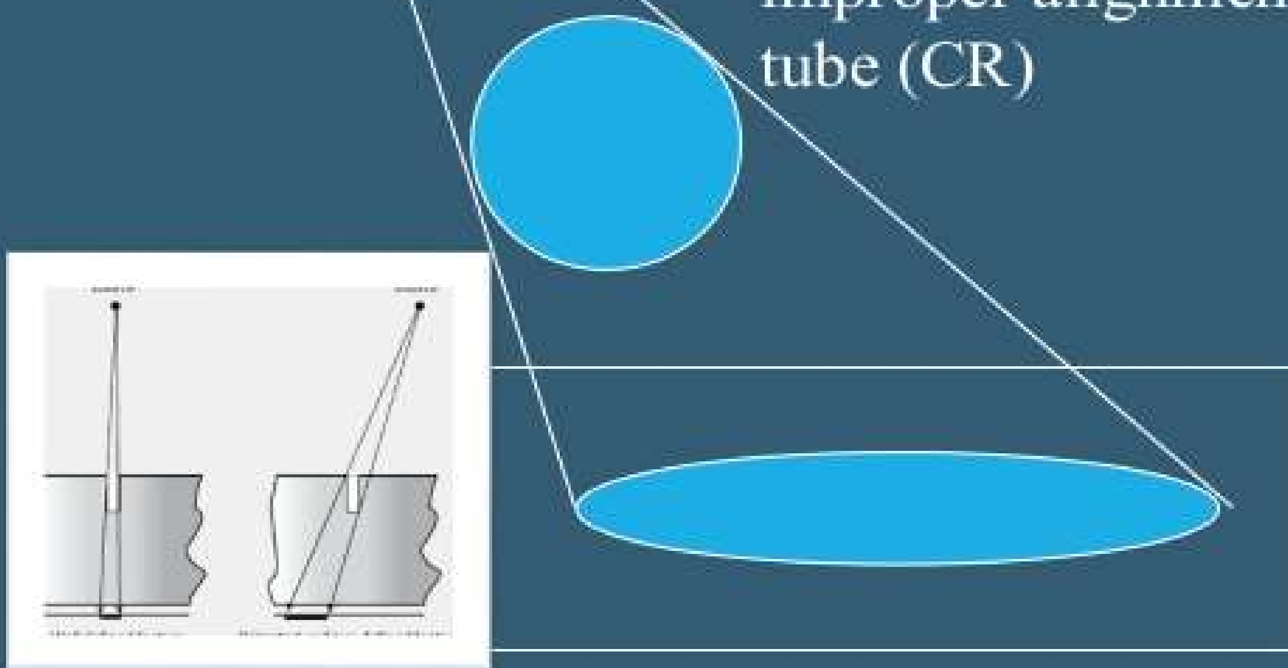
Lab Demonstrations



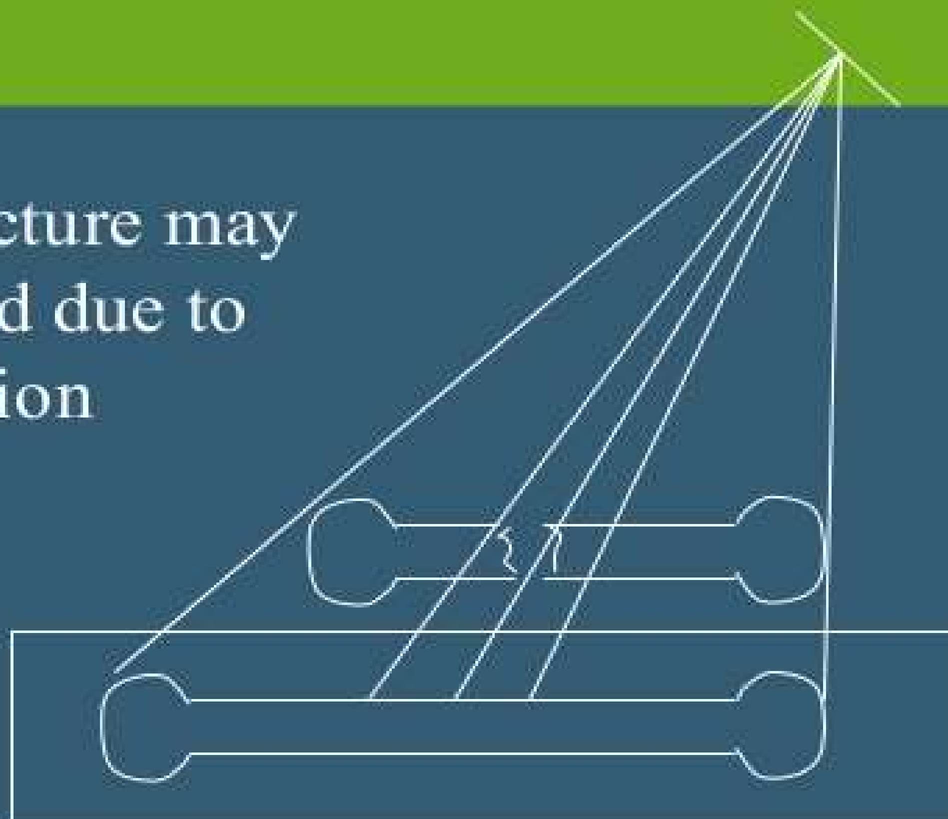
VERY LITTLE MAGNIFICATION SIGNIFICANT MAGNIFICATION

Elongation

Shape distortion resulting from improper alignment of the x-ray tube (CR)



A simple fracture may go undetected due to shape distortion



Minimizing Shape Distortion

- **X-ray tube alignment (CR)**
  - Perpendicular to Part and IR
  - ***Elongation**
- **Image Receptor alignment**
  - Parallel to Part
  - *If the **IR** is the piece un-aligned
  - (CR and part still perpendicular)
  - ***Elongation**

SHAPE DISTORTION CAUSED WHEN PART AND FILM AREN'T PARALLEL

- **Part alignment**
  - Parallel to IR
  - *If the **Part** is the piece un-aligned
  - (CR and IR still perpendicular)
  - ***Foreshortening**

SHAPE DISTORTION CAUSED WHEN PART AND FILM AREN'T PARALLEL

Conclusion

Radiographic variables	Density	Contrast
Increase MAS	increase	no change
Decrease MAS	decrease	no change
increase KVP	increase	decrease
decrease KVP	decrease	increase
increase FFD	decrease	no change
decrease FFD	increase	no change
increase OID	decrease	increase
decrease OID	increase	decrease

SCATTER RADIATION

- Scatter radiation refers to radiation which deviates from the primary beam both in direction and wavelength after interacting with a medium or a patient being exposed to x-rays.
- If no device is used to check, the scatter radiation 50% blackening of a processed film may be entirely due to scatter radiation. Apart from affecting the quality of a radiograph, it is also hazardous to personnel working in radiology section.

The relative intensity of scatter radiation is directly proportional to the following factors

- Kilovoltage
- Body part thickness
- Field size.

The main scatter deviation control devices are grid, beam collimators, and filters

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- Double emulsion of the film
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Main densities that can be appreciated on the radiograph are; i) metal: ii) mineral, and bone iii) fluid and soft tissue iv) fat and v) gas.

The X-ray image is black and white. Dense body parts that block the passage of the X-ray beam through the body, such as the heart and bones, appear white on the X-ray image. Hollow body parts, such as the lungs, allow X-ray beams to pass through them and appear black.

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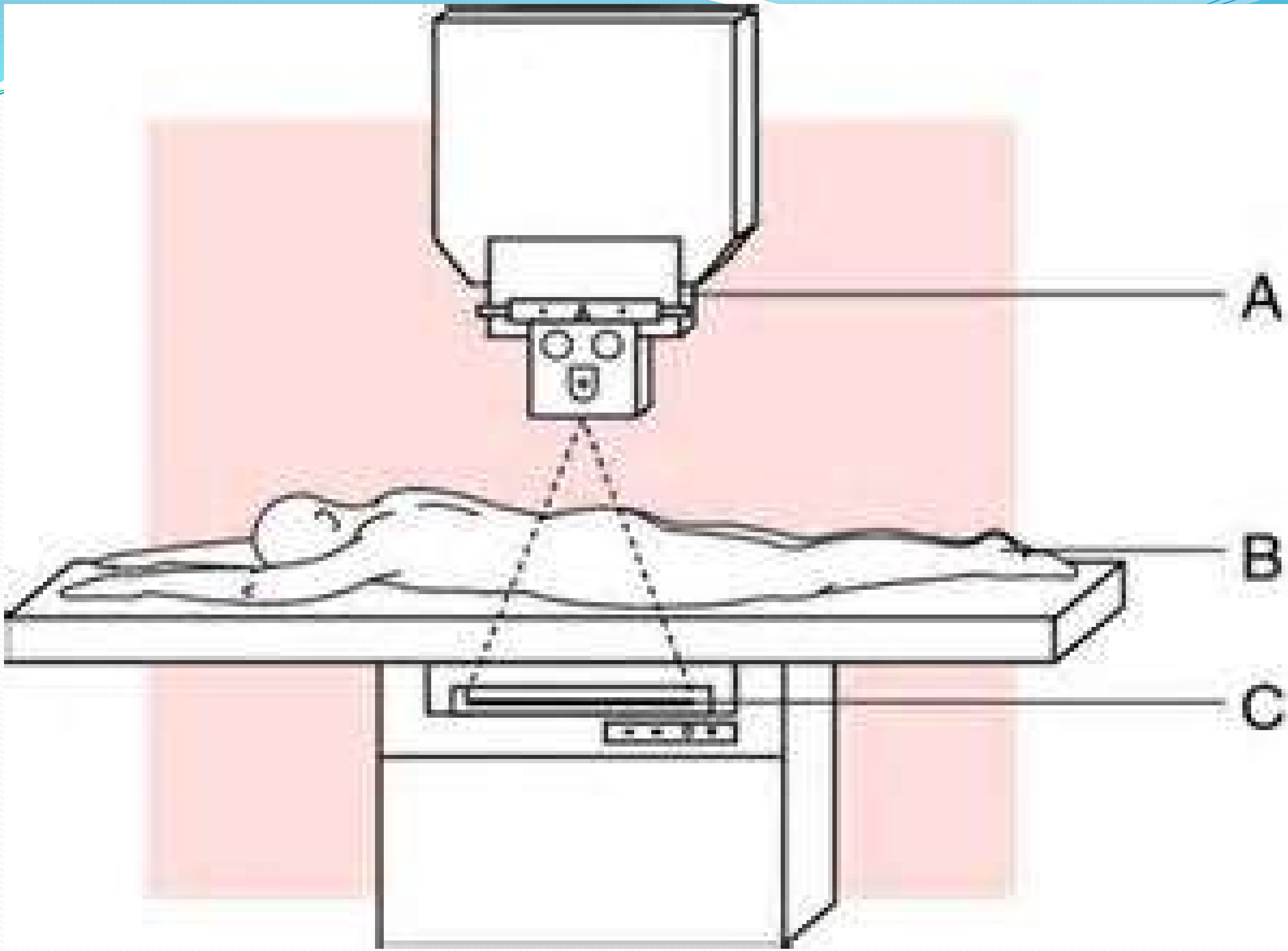
X-RAY MACHINES AND PARTS


A
B
C

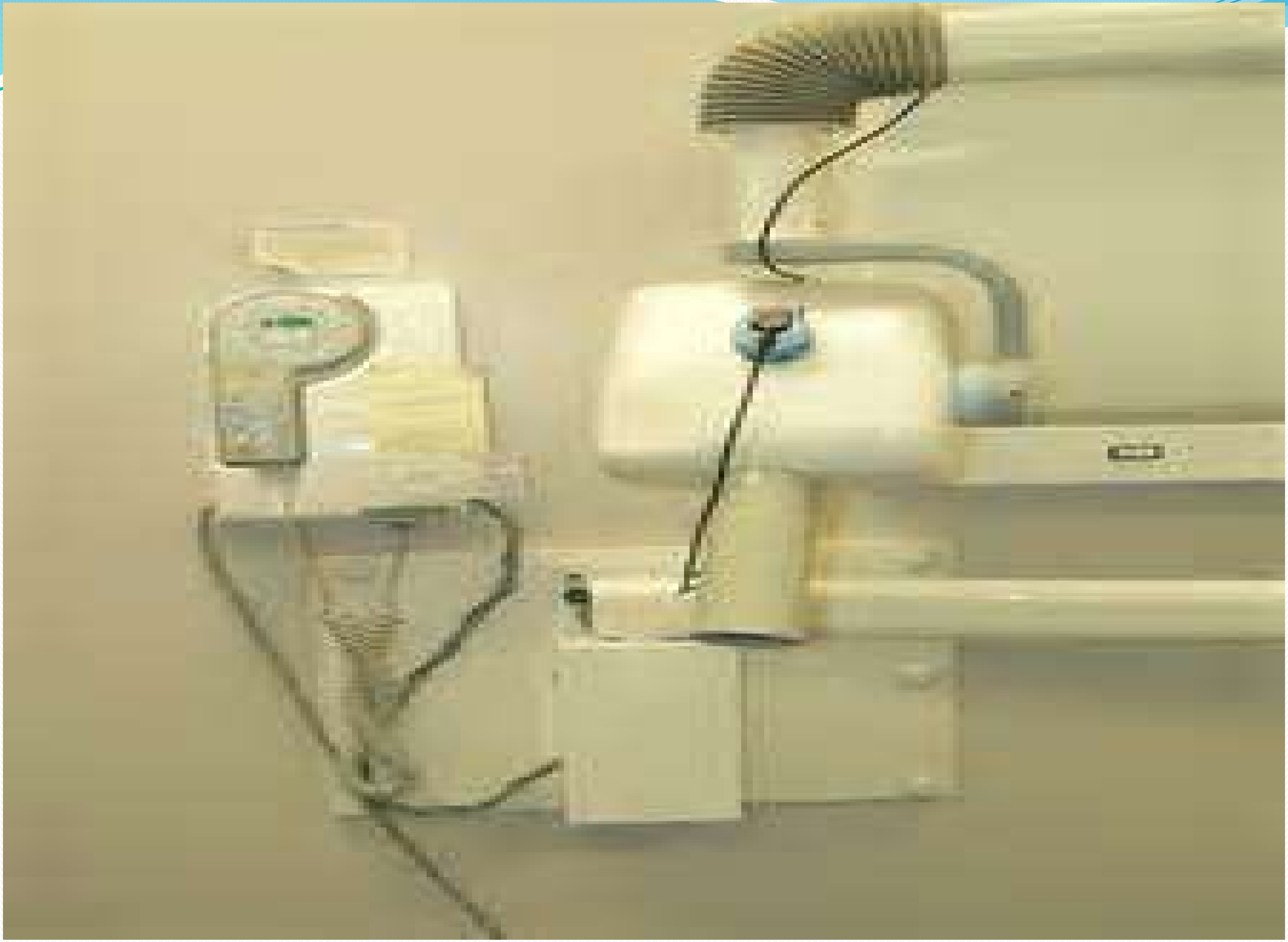
I. Types of X-Ray Machines

X-ray machines can be grouped into three main categories:

- Portable X-ray Machines
- Mobile X-ray Machines
- Fixed X-ray Machines

A. Portable X-Ray Machines

These machines are commonly used in veterinary practice because of they are convenient for transportation. They are equipped with small sized low weight transformers and small control panel. The maximum output varies from70 to 110 kV and 15 – 35 mA. They are relatively cheap and require little maintenance. These are of limited value because anatomical structures above the carpus and tarsus in large animals cannot be examined.

B. Mobile X-Ray Machines

These machines have higher out put than portable machines and are mounted on wheels. Usually these machines have rotating anode with output of 90 to 125 kV and 40 to 300 mA. Most machines are movable on smooth surface within the radiology section and operation theatre

C. Fixed or Stationary X-Ray Machines

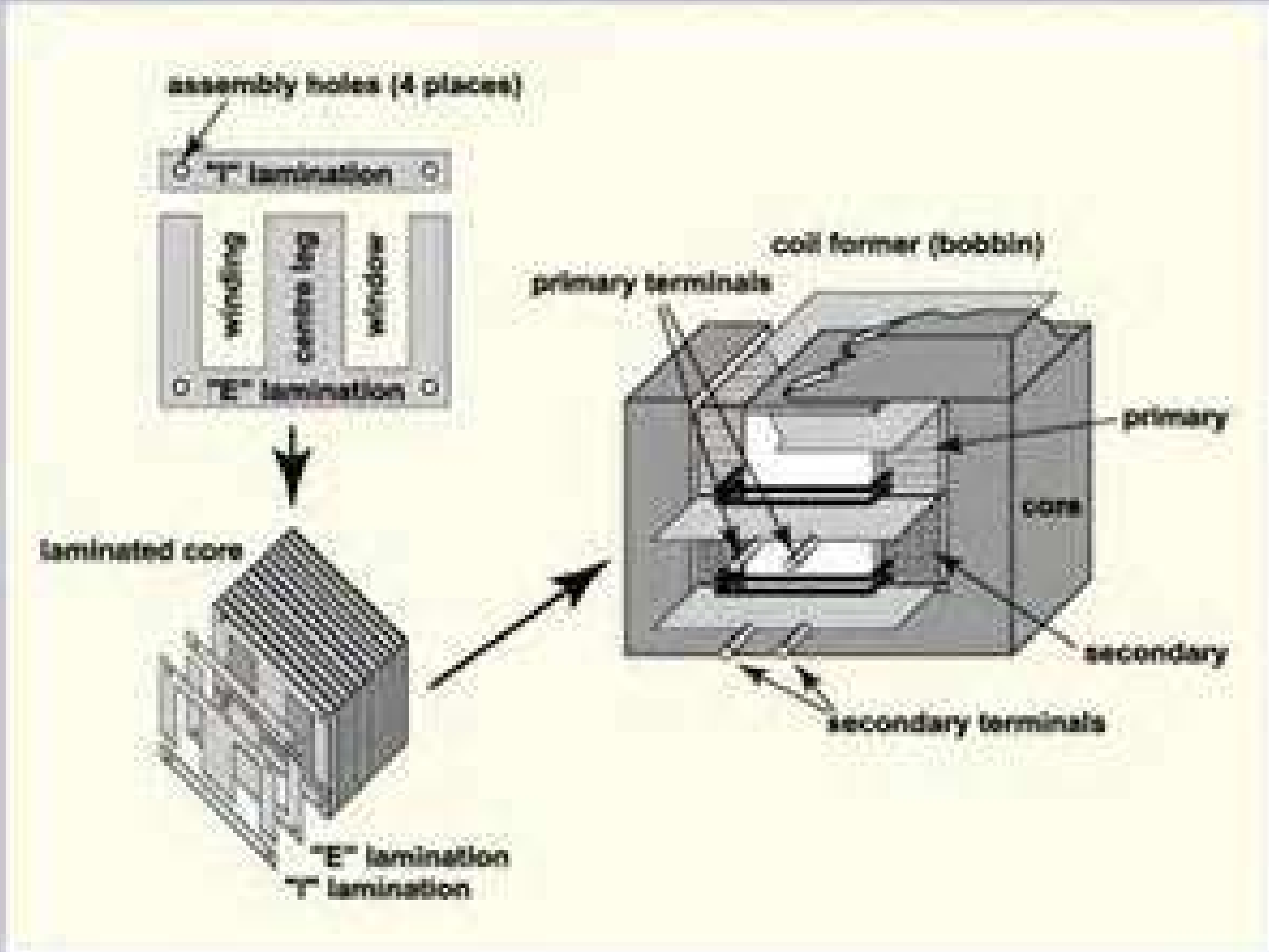
These machines are usually installed in a room specially constructed for the purpose. Their larger transformers are capable of greater output and have high tension cables. The output of these machines may vary from 120 – 200 kV and 300-1000 mA. These are suitable for all types of radiological examinations in cases of small and larger animals but because of their higher kV output there may be more scatter radiations.

II. PARTS OF X-RAY MACHINE

1. Transformer Assembly

A transformer is an electromagnetic device used for increasing or decreasing the voltage of incoming electrical energy to an appropriate level, without appreciable loss of energy. This assembly is enclosed in a metal box filled with a special type of oil which serves as an insulator.

- Step up transformer: supplies the high voltage to the x-ray tube (Voltage increases and current decreases)
- Step-down transformer: supplies power to heat the filament of the x-ray tube (voltage decreases and current increases)
- Autotransformer: supplies the voltage for the two circuits and provide a location for the Kvp (indicates the voltage applied across the x-ray tube)
- Rectifiers: convert AC into the direct current required by the x-ray tube. A rectifier restricts current flow in an x-ray tube to one direction (from cathode to anode), thereby preventing damage to the x-ray tube filament. Two typs: Half wave and full wave.


assembly holes (4 places)
"I" lamination
window
center leg
window
"E" lamination
laminated core
"E" lamination
"I" lamination
coil former (bobbin)
primary terminals
primary
core
secondary
secondary terminals

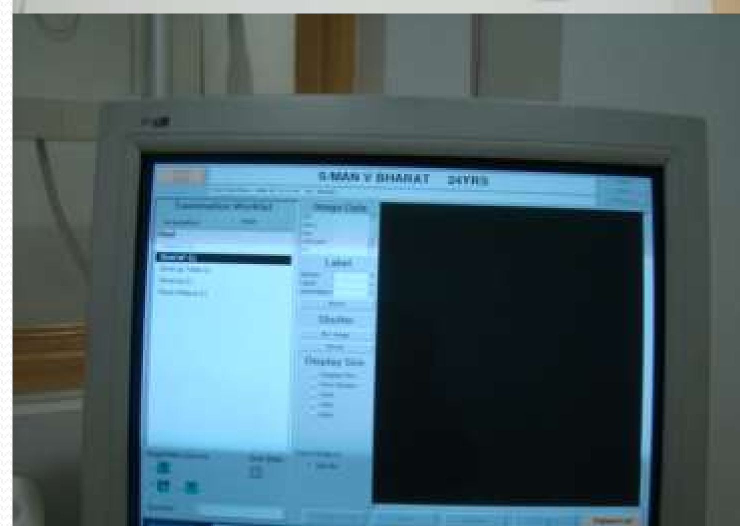
2. Control Panel

It is a separate unit connected electrically to the x-ray machine. It contains the following meters and switches:

- On-off switch
- Voltmeter and Voltage compensator control
- Kilo voltage selector
- Milliammeter and milliampearage control
- Timer exposure button
- Fluoroscopy control
- Tube current indictor
- LED display of mAs
- Pilot light indicator
- Exposure release switch.


NAVER

PHILIPS
SID ??
chest lat
measure SID man.

150kV

24YRS

3. Cable

Cable conducts high voltage current from the rectifier to the x-ray tube. This is designed to eliminate the danger of shock.

4. Tube Stand

Tube stand supports the tube to hold it in a stationary position during an exposure.

The stand should;

- Permit the tube to more vertically.
- Allow the tube to be rotated for horizontal exposure.
- Permit angulations of the tube.

A ceiling mounted stand is another version, and is ideal, as there is maximum degree of tube movement within a limited space. It also permits a radiographer to make exposures from a protected area.

5. X-Ray tube

X-ray tube is also referred to as a diode tube, meaning it has two electrodes. It is also called as Coolidge tube or hot filament x-ray tubes. Vacuum allows unobstructed path for the electron stream and prevents oxidation and burning out of the filament.

X-Ray Tube is the largest thermionic diode type electronic vacuum tube that consists essentially of a glass tube, containing a cathode and a stationary or rotating anode placed 1-3 cm apart. The primary function of an x-ray tube is to convert electrical energy into x-rays.

The essential components of the x-ray tube include;

- A tungsten filament – Cathode, the negative side of the x-ray tube.
- A tungsten target – Anode, the positive side of the x-ray tube.
- An evacuated glass envelop
- Two Circuits – To heat the filament and to drive electrons to the anode.


ANATOMY OF AN X-RAY TUBE
Horn
Filaments/
Focal Spots
Glass Insert
Stator Cord
Port
Expansion
Bellow
Stator
Cathode End (-)
Target
Anode End (+)
Highlights of GTS Products
Trunnion Area

6. Tube Housing:

It is a lead lined protective housing to prevent ‘leaking’ of x-ray. It contains sealed oil, serves as an electrical insulator and also helps in heat dissipation.

7. Collimator

The collimator is a box- like structure attached to the port of the x-ray tube, for the purpose of restricting the x-ray beam with adjustable lead shutter. It is also known as ‘variable aperture collimator’.

The main advantages include;

- The x-ray beam can be adjusted to a variety of rectangular shapes and sizes.
- Exposure field can be illuminated to permit visualization.
- Penumbra is greatly reduced.
- The rectangular beam exposes only the area of interest, thus reducing the patient dose of X-ray.


8. Filters

The filters are devices in the x-ray tube which remove the less energetic x-rays from the x-ray primary beam. The filters in the x-ray tube are of 2 types, namely the inherent filters and the added filters.

Inherent filters are;

- Glass envelope of the x-ray tube
- Insulating oil surround the tube
- The bakelite window in the tube housing

Added filters are the metal filters fixed in the path of the heterogenous x-ray. Copper in combination with aluminum is considered better for high energy producing units.

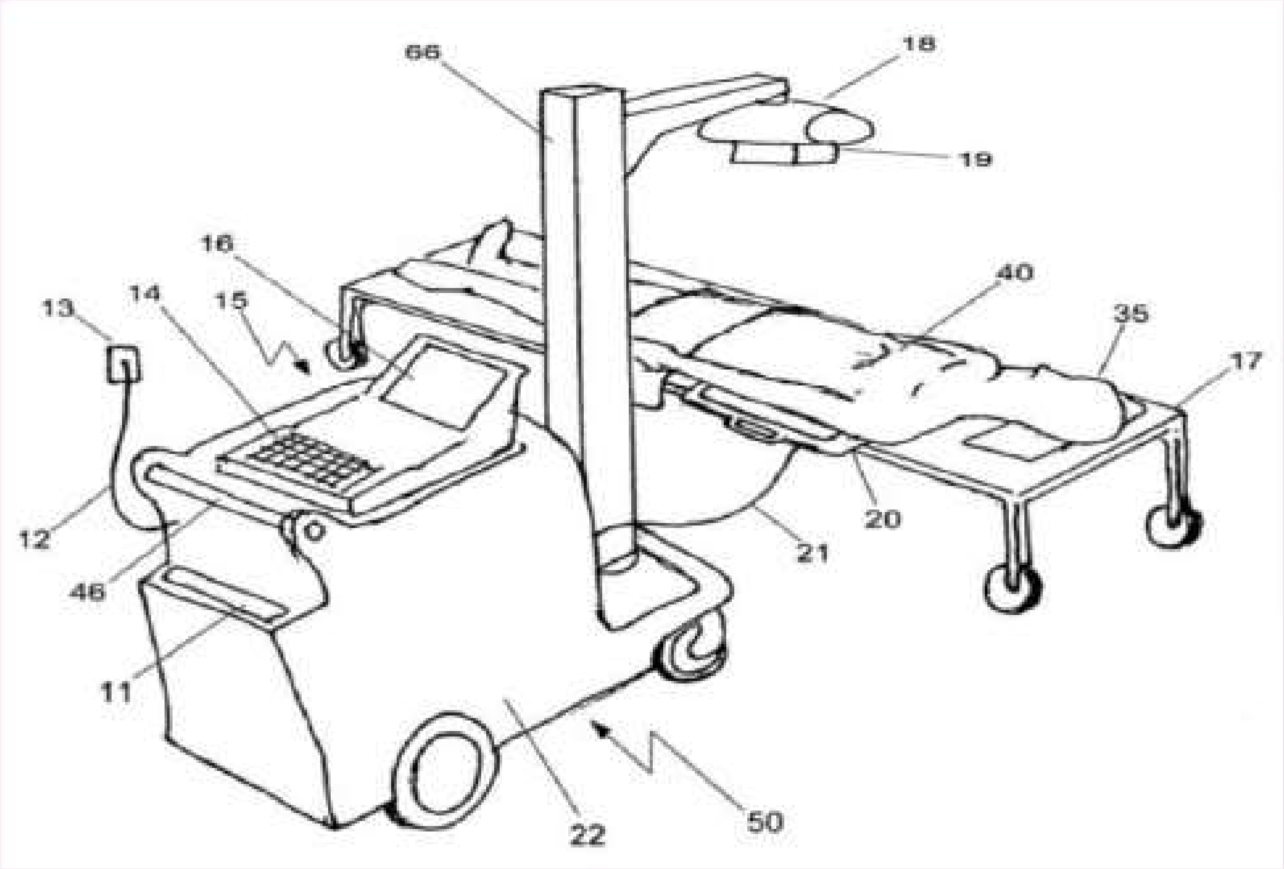
9. Safety Devices

Certain safety devices are incorporated in the x-ray equipment to overcome electrical hazards and they are;

- Switches
- Fuses and circuit breakers
- Grounding or earth
- Shock proofing – insulation
- Interlocking control circuit

SCHEMATIC DIAGRAM

- 11) cassette holder 12) Cable 13) Imaging hand switch 14) Control panel 15) Generator 16) Display screen 17) Stretcher 18) X-ray tube 19) Collimator 20) Cassette 21) Interface cable 22) trolley 46) Hand grip 66)tube



ACCESSORY RADIOGRAPHIC EQUIPMENTS

1. X-Ray Table

A variety of x-ray table are available for use in diagnostic radiology. Most tables are used in small animal radiography, measure 196x61cm with a height of 82cm from the floor. Most tables are used with a floor mounted tube stand. The multiposition x-ray table can move at right angle to the floor.

The x-ray tables usually have a provision for bucky tray beneath its surface which will hold the grid and the film cassette.



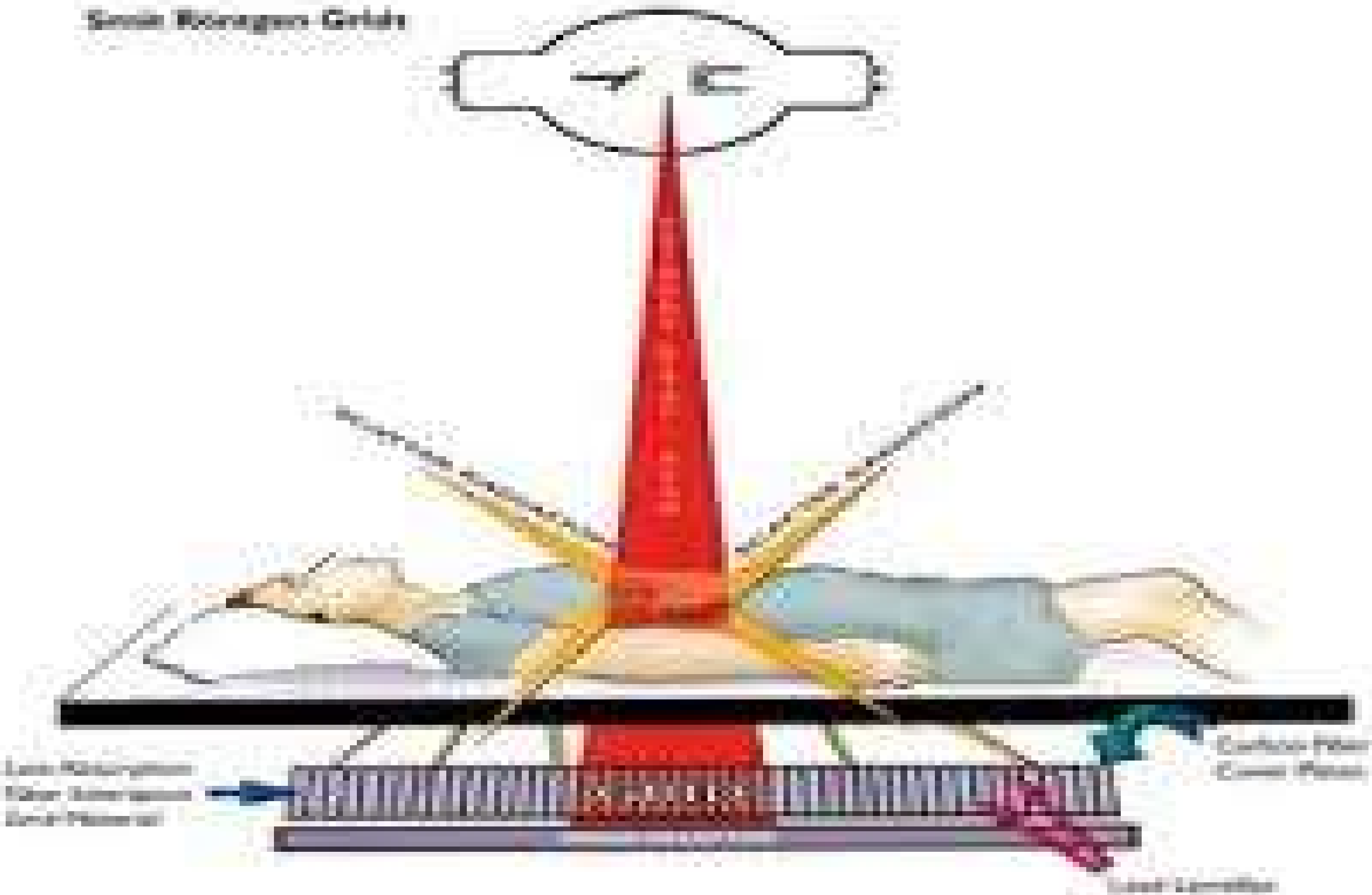

2. Grid

Grid is a flat plate containing a series of alternating strips of radiodense (lead) and radiolucent (interspcer) encased in a protective covering of thin aluminium. The radiographic grid is an accessory used solely for the purpose of improving the radiographic quality of the radiograph. Grids are designed to absorb scatter radiation, before it reaches the recording medium.

Grid is used when the thickness of the part to be radiographed, measure more than 10cm.Grid is placed between the part to be examined and cassette, so as to absorb the scatter radiation falling on the film. As the scatter radiation strikes the grid from an angle, it is absorbed by the grid.

The use of grid requires an increase in exposure factor (mAs) to maintain adequate density, so more exposure is required for the patient and is a disadvantage.

Moving grids are those that move during exposure. Movement of the grid during exposure eliminates the grid lines on the radiograph.



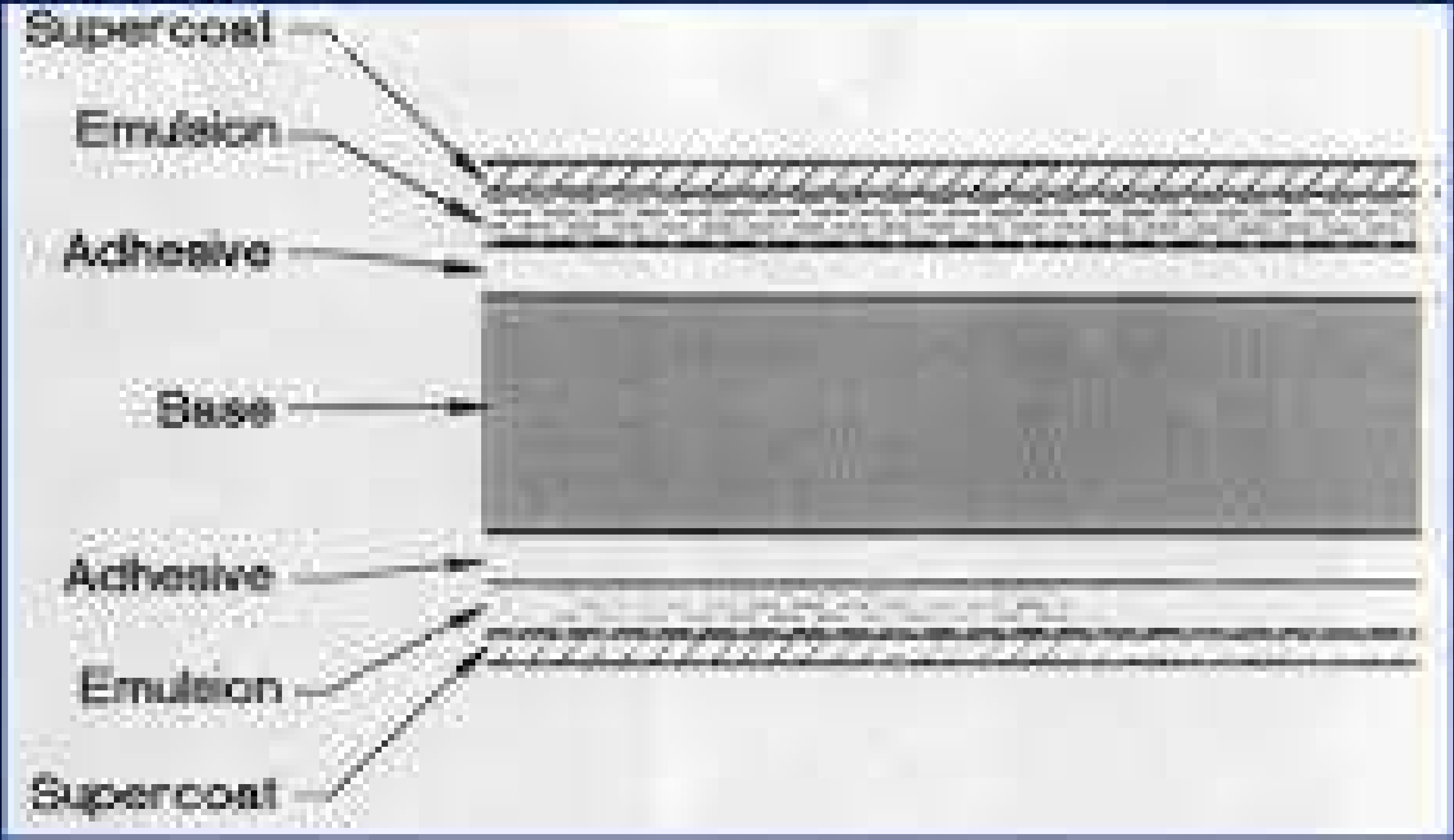
Improved image quality is a result of a grid stopping scatter radiation from reaching the image receptor


XRAC Grid Encasement with Channels
For CR, DR and Standard Grids

3. X-ray Film

- An x-ray film is a photographic film, used to decode the useful information from an x-ray image and it provides a permanent record of the information. The composition of the film is similar to that of photographic film. X-ray film characteristics are speed, latitude and contrast.
- As regards to the type, there are two types of films namely **screen films** and **non-screen films.** Screen films are used with intensifying screens and non-screen films are designated for use directly without intensifying screens (Direct exposure film).

X-RAY FILM- CROSS SECTION

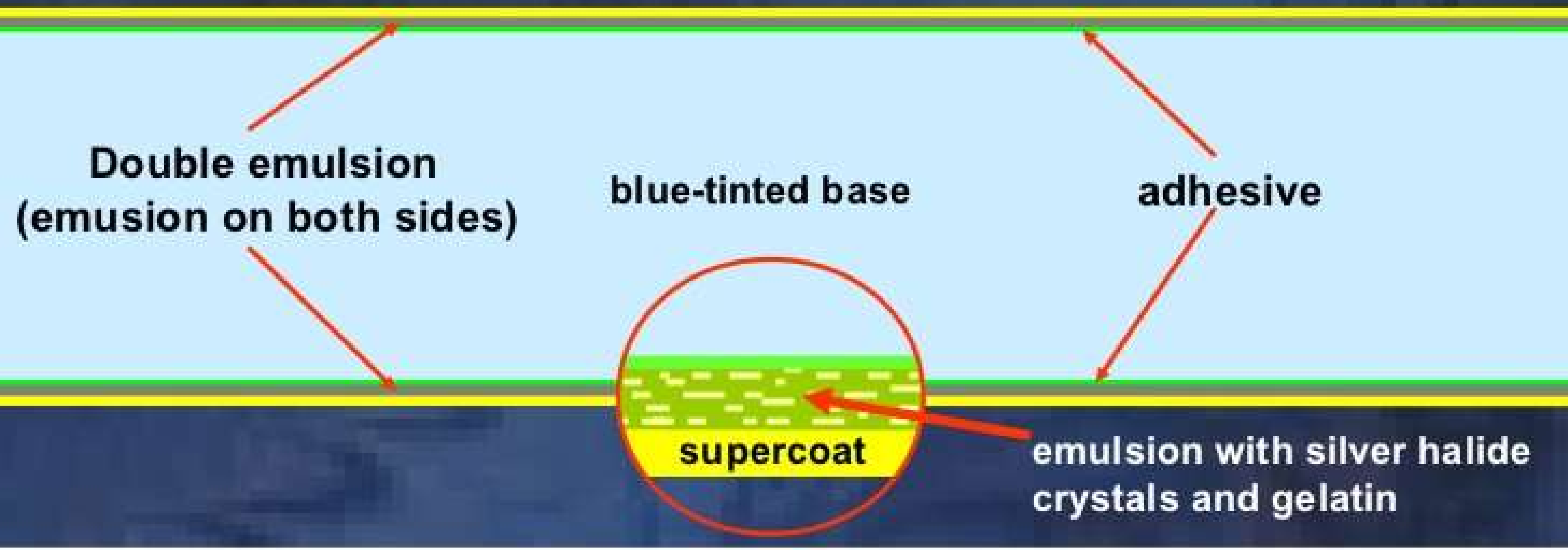


Film Composition

An x-ray film is composed of a plastic (polyester) base covered on both sides with an emulsion; this is called a double-emulsion film. The emulsion contains silver halide crystals which are surrounded by gelatin. The silver halide crystals are affected by the x-rays and eventually form the image during film processing. The gelatin, similar to that used in desserts, is porous, allowing processing chemicals to reach the silver halide crystals, and is also clear, allowing light to readily pass through when viewing films.

Film Composition (continued)

The emulsion (gray lines below) is attached to the base with a very thin layer of **adhesive** (green lines below). The base has a slight **bluish tint** which makes viewing the films easier on the eye. The emulsion is covered with a thin layer of gelatin, a "**supercoat**," which helps to protect the film (yellow lines below).



Care of x-ray films

- Caution must be exercised in the use of and storage of x-ray film as shown below.

Handling

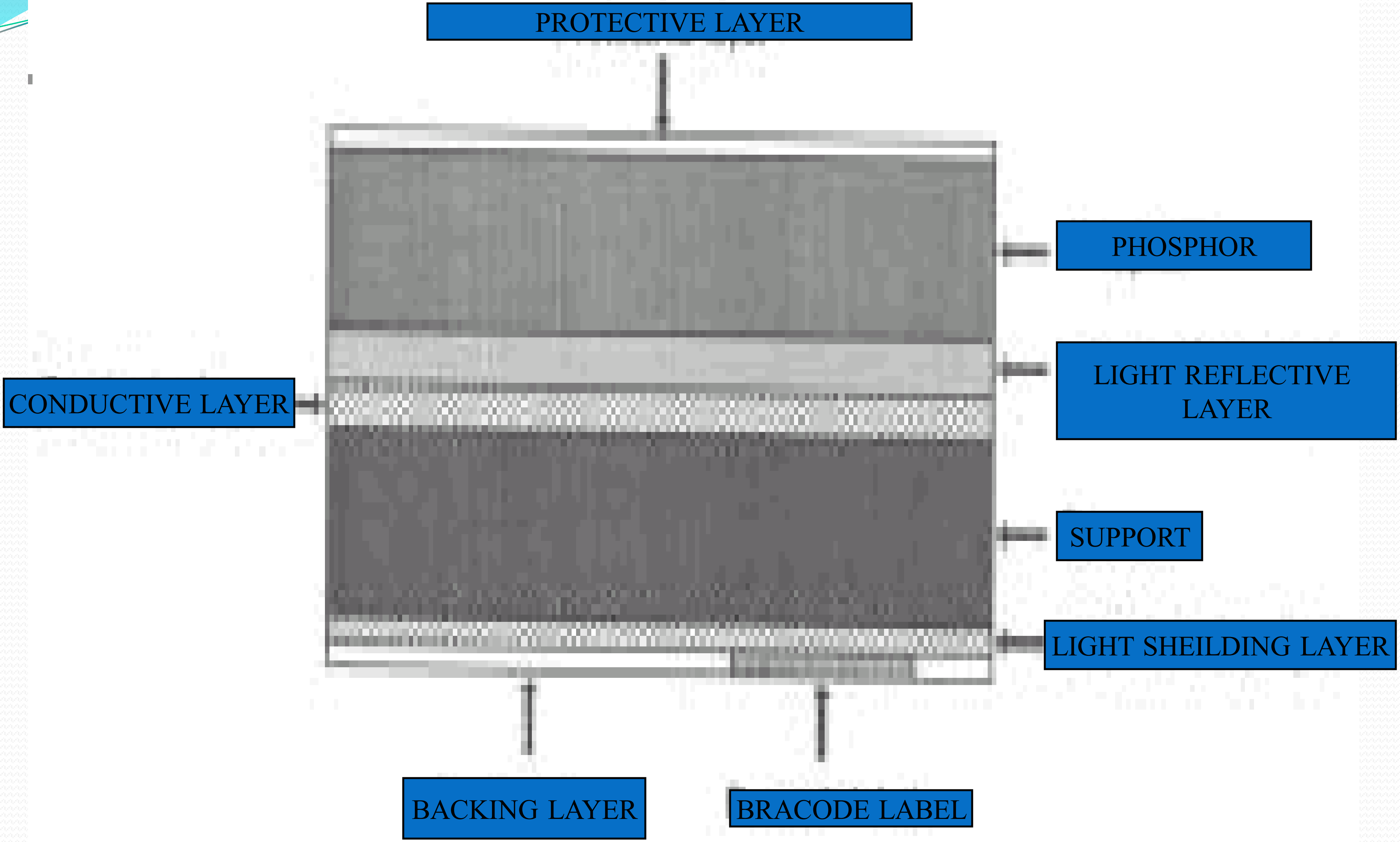
- Hands must be clean and dry.
- Film should not be bent, buckled or pinched.
- Film should not be laid on cabinet or benches
- Film should not be dropped or slid across a surface.
- Film should be taken out only in a dark room, using recommended safe light system.

B. Storage

  - Store the film in a cool and dry place.
  - Store away from radiation area or use protective barriers.
  - Store upright and not in stacks.

4. Cassettes (Film Holders)

- Cassettes are basically light proof boxes designed to hold films and screens for making an x-ray exposure. They maintain good film-screen contact and protect screens and films from physical damage. They have a metal frame with a thermostatic bakelite or magnesium front.


PROTECTIVE LAYER
PHOSPHOR
LIGHT REFLECTIVE LAYER
CONDUCTIVE LAYER
SUPPORT
LIGHT SHEILDING LAYER
BACKING LAYER
BRACODE LABEL

Cassettes are used in association with intensifying screens and screen films. They have related functions:

1. to contain a film
2. to exclude light,
3. to maintain the film in close, uniform contact with both screens during the exposure
4. to protect the intensifying screens from physical damage.


X-ray Film Viewer
Darkroom Light
Cassette
X-ray Film Hanger

5. Intensifying Screens

- The intensifying screens are cardboard or plastic base structures, usually found in pairs inside the cassette. The x-ray film is placed in between them in the cassette. They interact with x-ray beam and intensify the action of the x-ray by converting most of the radiant energy (95%) into visible light. Thus they allow reduction in exposure factors. They must be carefully handled without abrasions or scratches and free of marks, dust and stains.
- An intensifying screen is a plastic sheet coated with fluorescent material called phosphors
- .Phosphors are materials which convert photon energy to light.
- The main function of screens is to reduce radiation to the patient.

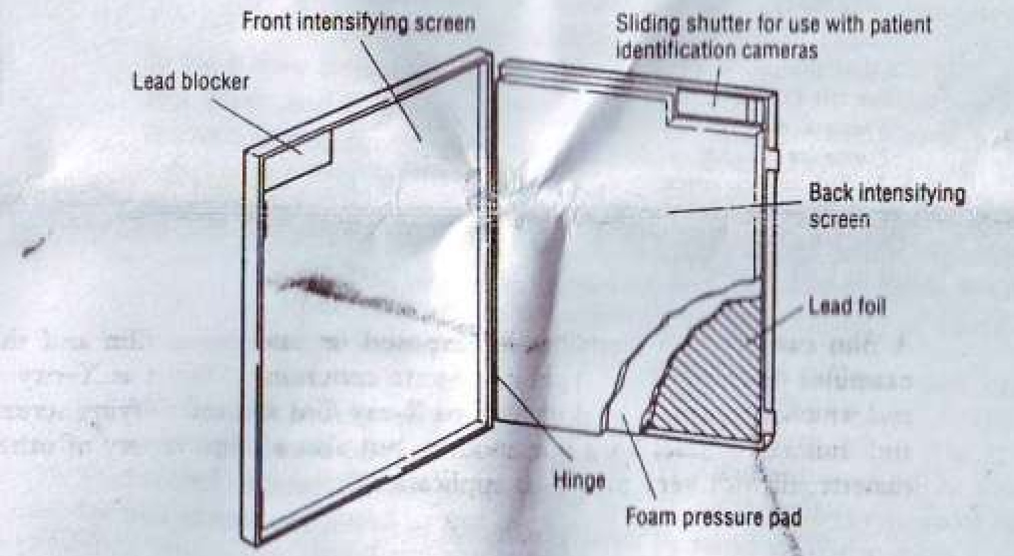
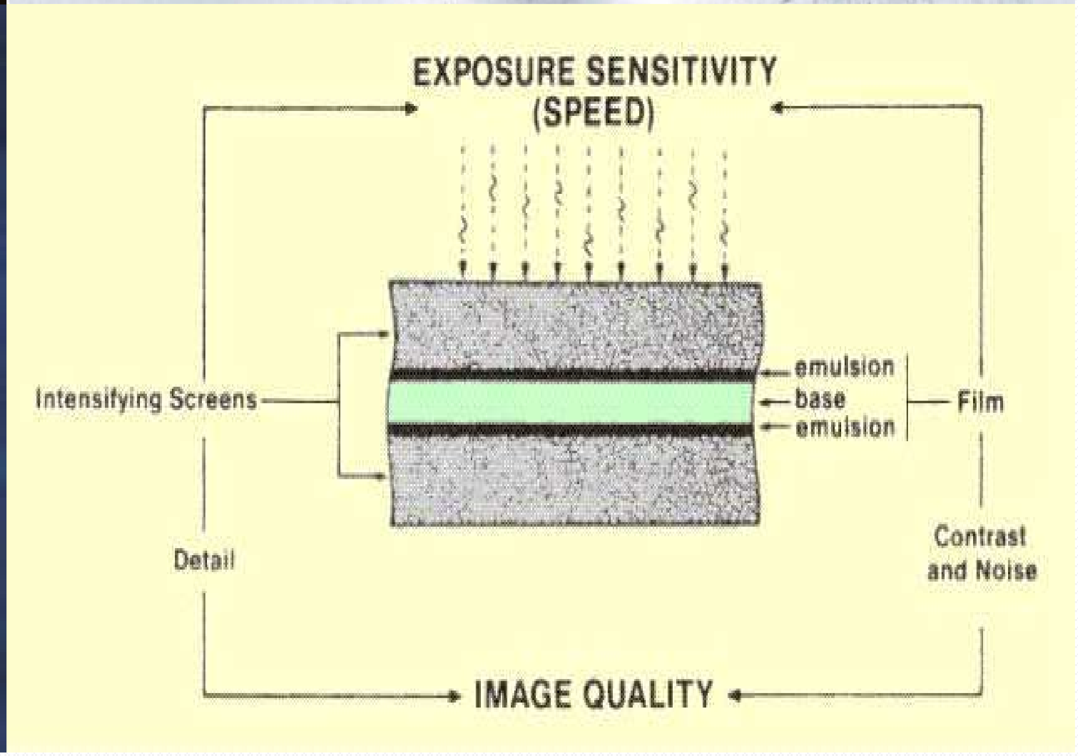


Fig. 8.1 X-ray cassette construction.



- Speeds of Intensifying Screens.

1. Fast screens

- - thick layer, and relatively large crystals used, maximum speed is attained but with some sacrifice in definition.

2. Slow screens or high definition screens - a thin layer and relatively small crystals are used; detail is the best, but speed is slow necessitating a higher dose of ionizing radiation.

3. Medium screens

- - medium thick layer of medium sized crystals in order to provide comprise between speed and definition.

There are three types of intensifying screens:

- a) Standard - slow screens
- b) Rare earth - fast screens
- c) Combination

There are two groups of X-ray films for dental purposes:

1. Non-screen

- Those with emulsions more sensitive to direct exposure of X - rays.
- These are primarily used as intraoral films and provide excellent image quality.

2. Screen

- Those with emulsions more sensitive to blue [standard] OR green [rare earth] light. Emitted when X-rays strike the intensifying screens. The X-ray photons are converted to visible light photons.

Rare Earth Green Screens

Rare Earth Blue Screens

Calcium Tungstate Screens

- Screen films are always used IN COMBINATION with intensifying screens.
- With screen-film, it is mainly the light photons from the intensifying screens that produces the image on the film and not the photons.
- Intensifying screens permit a good radiograph to be produced with the patient receiving a much lower dose of radiation.
- This film is very sensitive to both X-ray photons and light photons but much more sensitive to light photons.

- An intensifying screen is a plastic sheet coated with fluorescent material called phosphors. Phosphors are materials which convert photon energy to light.
- LUMINESCENCE is the emission of light from a substance bombarded by radiation. There are two types; fluorescence and phosphorescence.
- Fluorescence means that luminescence is excited only during the period of irradiation and will terminate at completion of the X-ray exposure. The phosphors in intensifying screens produce fluorescence.
- Phosphorescence is afterglow. The irradiated material continues to emit light for a time after cessation of exposure to radiation and will continue to produce an image which you do not want.

Care of Intensifying Screens

- Screens are easily damaged. Their fluorescent emission will be affected if the active surface is soiled even slightly. Screens must thus be kept clean otherwise light photons will be prevented from reaching the screen and creating an image and the screen in that area will appear clear. Dirt will also create “high” spots which will create wear. Screens are best cleaned with antistatic solution. Use a damp cloth and rub gently. Ensure that the screen is dry before closing the cassette otherwise the gelatin on the surface of the screens will stick together. Never leave the cassette open as it will accumulate dirt and dust on the screen.

6. Cassette holders

- Cassette holders are devices used by the assistants to hold the cassette during exposure, to be away from the primary x-ray beam. It also reduces the chances of possible injury to the personnel from the animals.

7. Lead blockers

- A lead blocker is a sheet of lead placed over the part of the cassette, not desired to be exposed. The lead blocker allows more than one radiographic exposure of the same film. It is important from economy point of view especially, when extremities are to be radiographed.

8. Lead aprons and gloves

- The individuals handling the animals for x-ray should wear protective gloves having lead lining of 0.5mm thickness and lead aprons having a minimum of 0.25mm of lead lining.


CE
www.medical-x-ray.com


9. Lead markers

- Lead markers are used for identification of the place, case number, radiographic view and date. Film identification is necessary to maintain proper records.


TA-1
PT-PK
PT-BK
PT-CP
PT-CY
PT-CS
PT-CG
PT-CO
PT-GP
PT-GB
PT-GA

10. Film hangers

- Film hangers or holders are used to for holding the exposed film during processing and drying.
- Three types of hangers are available: channel type tension type and clip type.

11. Film drier

- The film dryer or drying cabinet with heating provision is used to dry the films quickly after processing.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12. View Box or Viewing Illuminator

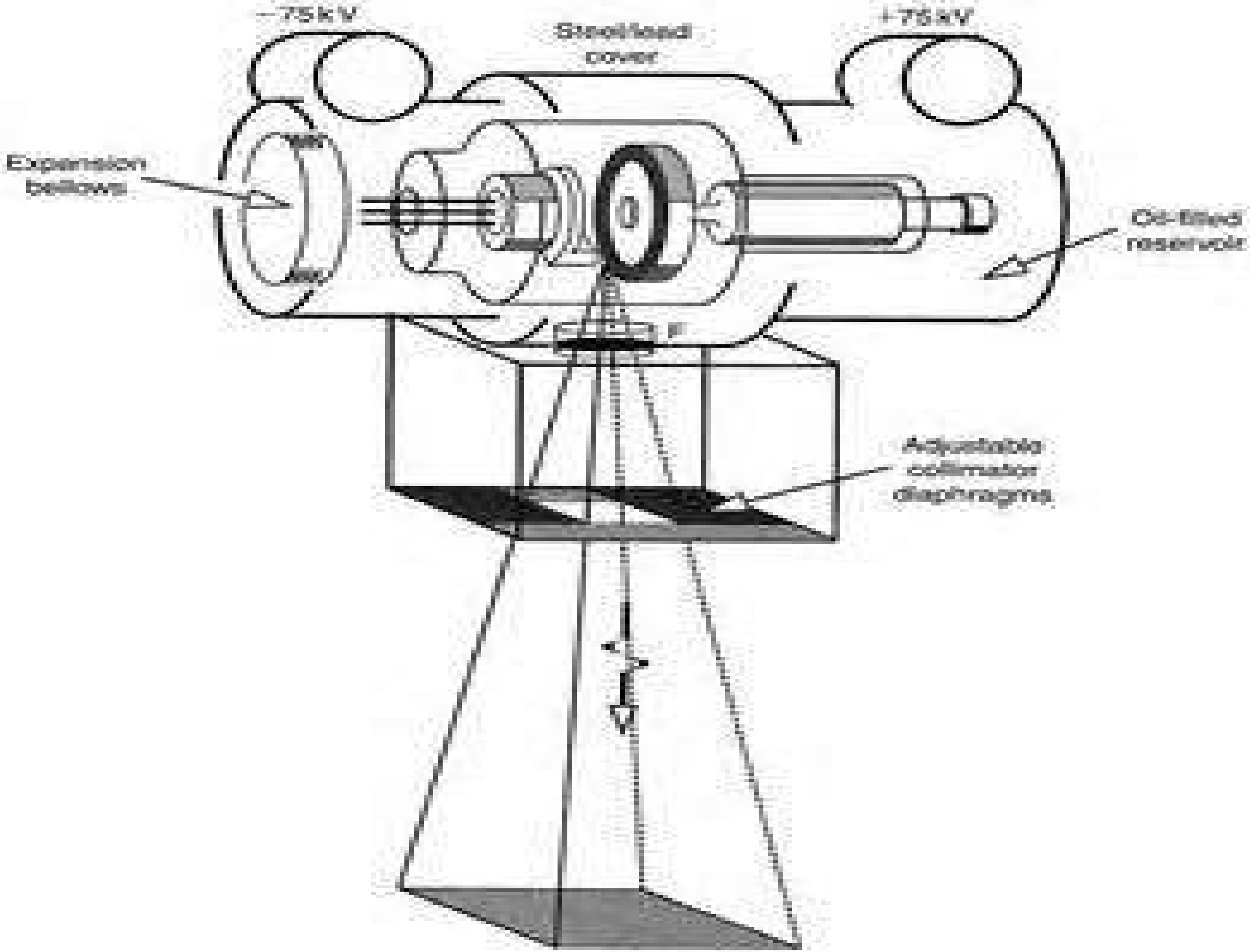
- The view box is a wall mounted or portable device with florescent light bulbs that is covered with white transparent material. The transparent cover causes the light to be diffused evenly across the viewing surface. For proper radiographic interpretation, radiograph should be viewed on an illuminator. Illuminators are available in various sizes to accommodate single film or two or more films.

X-ray Film Viewer

Darkroom Light

Cassette

X-ray Film Hanger


−75 kV
Steel/lead cover
+75 kV
Expansion bellows
Oil-filled reservoir
Adjustable collimator diaphragms

Radiographic Positioning

Introduction

The object of positioning for radiography is devising of the most suitable postures in which the patient may be placed to facilitate:

- The welfare of the patient
- The restraint and immobilization of the patient

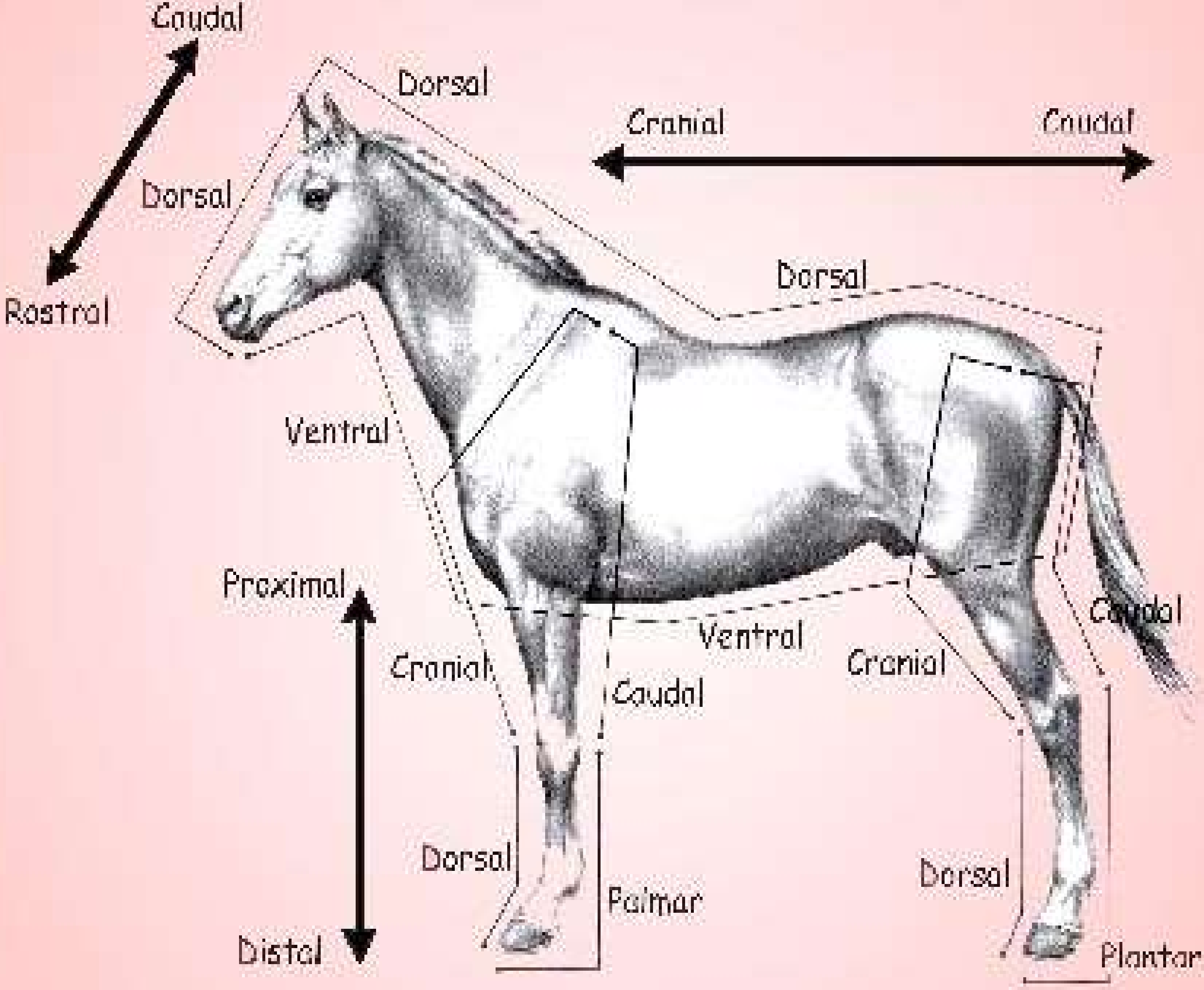
Cont…

- The most accurate reproduction of the part under examination in the radiograph produced
- The least risk of exposing those assisting with the examination to radiation

Cont…

Radiographic projections should be described using only accepted veterinary anatomical directional terms

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


Caudal
Rostral
Dorsal
Dorsal
Cranial
Caudal
Dorsal
Ventral
Proximal
Distal
Cranial
Caudal
Ventral
Cranial
Caudal
Dorsal
Palmar
Dorsal
Plantar

Cont…

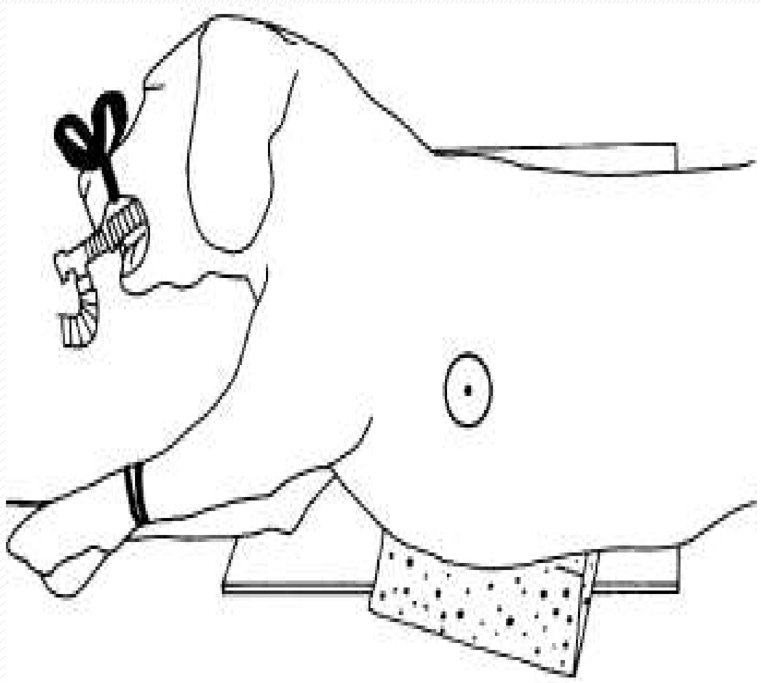
- The radiographic projections should be described by the direction that the central ray of the primary beam penetrates the part of interest from point of entrance to point of exit.
- An anteroposterior (AP) projection of the metacarpal bones becomes dorsopalmar(Dpa).

Cont…

- An anteroposterior-lateromedial oblique view of the tarsal joint is described as a dorsolateral plantaromedial oblique (DL-PIMO) projection.

Thorax - lateral

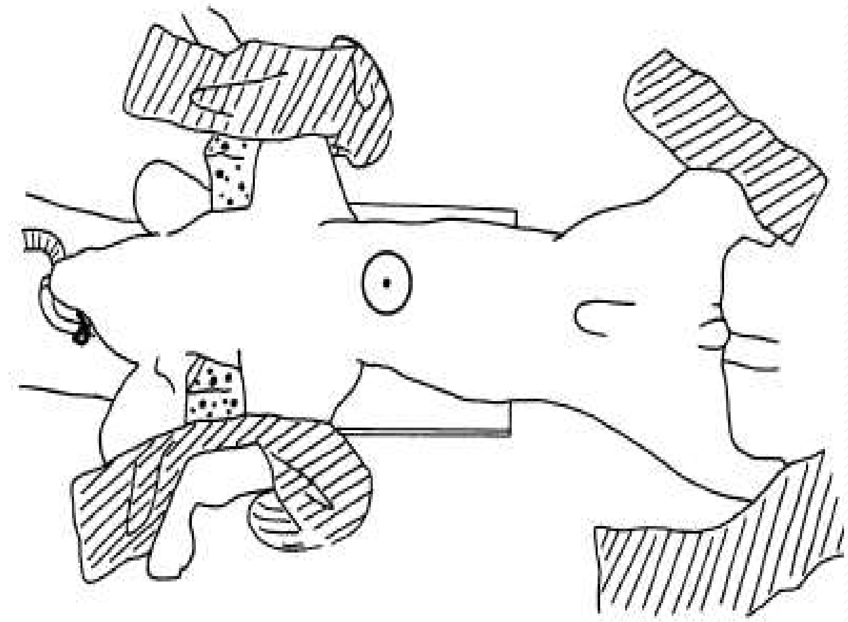
- Right lateral recumbency
- Pull the forelimbs together and extend cranially
- Center the beam over the heart
- Thoracic inlet to the diaphragm



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Thorax - ventrodorsal

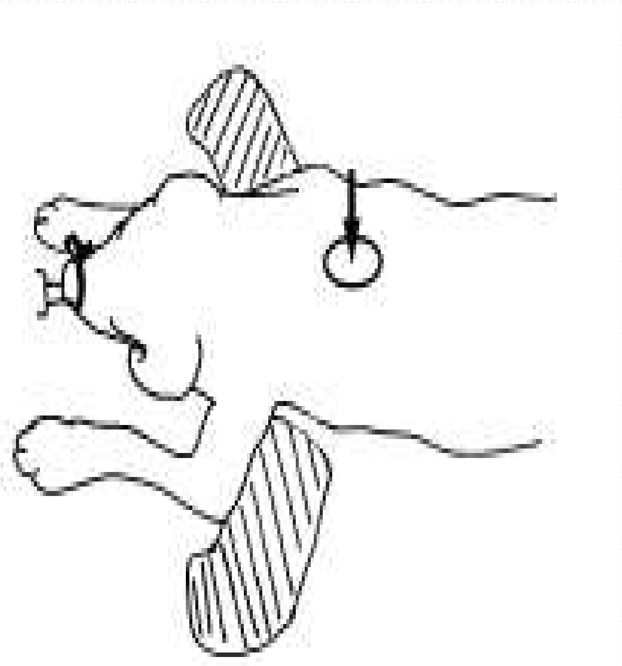
- Dorsal recumbency
- Extend the front limbs cranial
- Nose midline
- Center over the heart
- Ensure you have thoracic inlet to diaphragm



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Thorax - dorsoventral

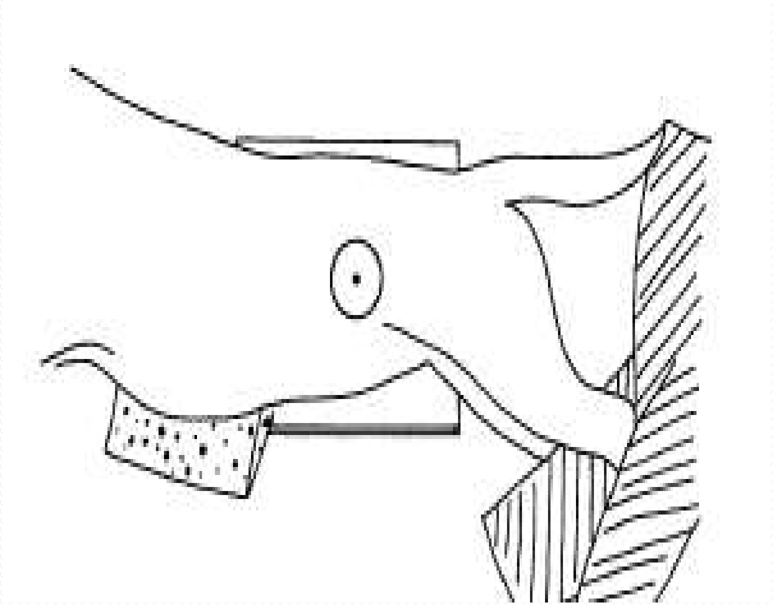
- Sternal recumbency
- Extend the front limbs cranially
- Nose midline
- Center the beam over the heart
- Include thoracic inlet to the diaphragm
- Take the exposure on full inspiration



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Abdomen – right lateral

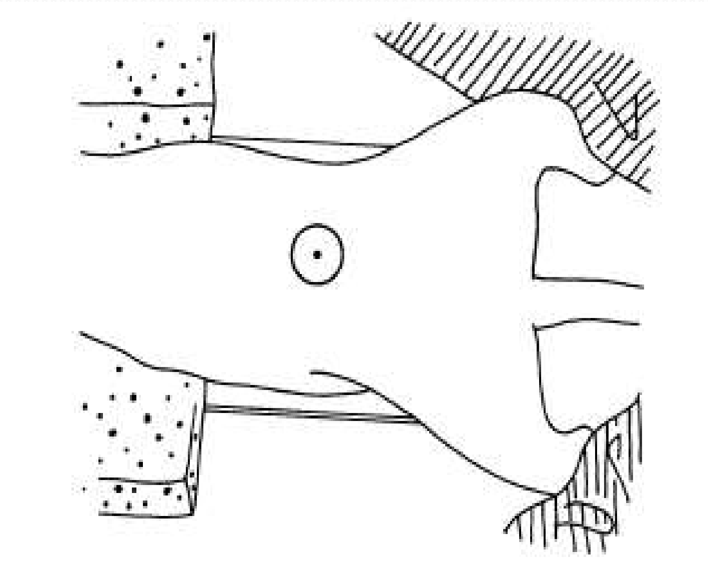
- Right lateral recumbency
- Forelimbs are pulled cranial
- Hind limbs are extended caudally
- Center caudal to the last rib
- Diaphragm to pelvic inlet
- Take exposure on expiration



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Abdomen - ventrodorsal

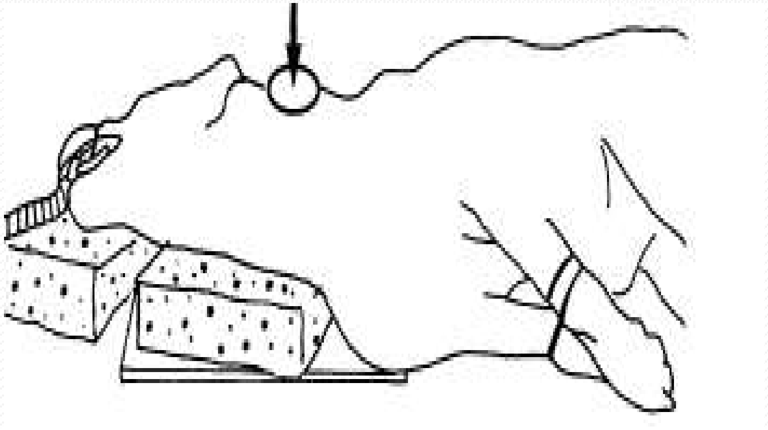
- Dorsal recumbency
- Center the beam caudal to the last rib
- Include diaphragm to pelvic inlet
- Take the exposure on expiration



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Cervical spine - lateral

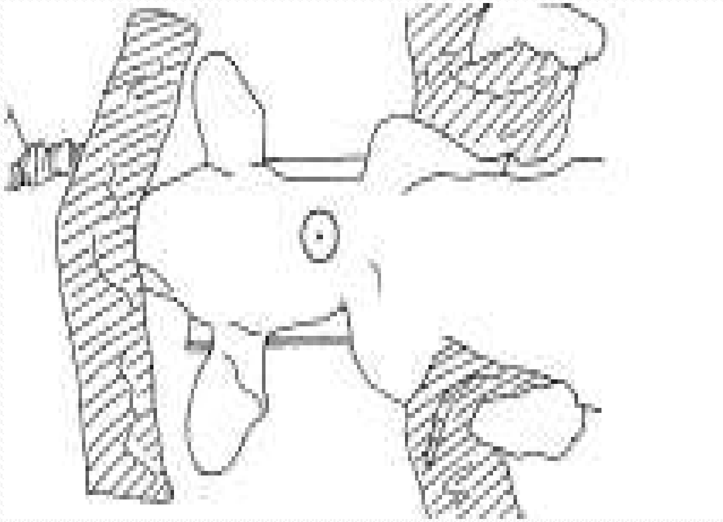
- Sedated or anesthetized
- Lateral recumbency
- Use sponges placed under the neck and nose
- Extend forelimbs caudally
- Center to C3-C4



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Cervical – ventrodorsal view

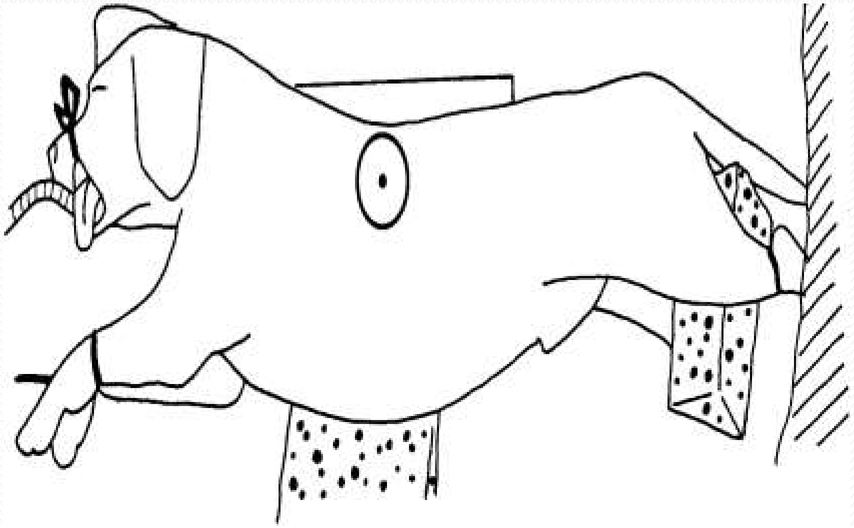
- Sedated or anesthetized patient
- Dorsal recumbency
- Sponges are placed under the neck
- Sandbags placed over the legs to assist in positioning
- Center the beam over C3-C4



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Thoracic spine - lateral

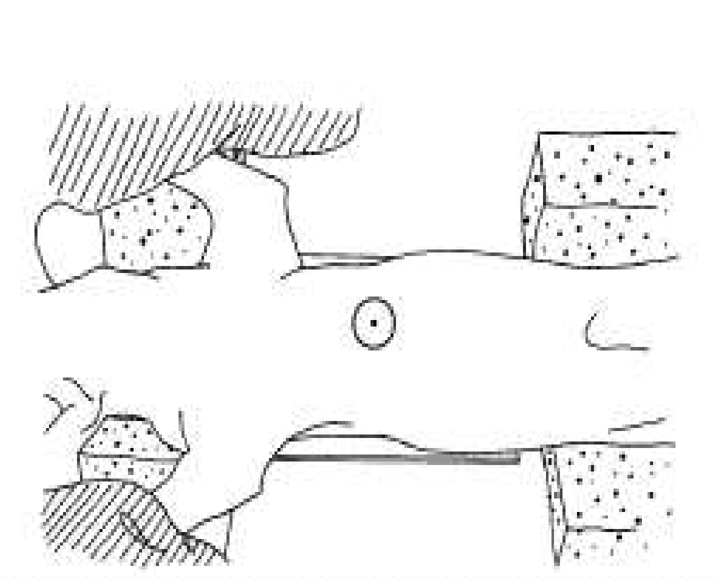
- Lateral recumbency
- Place sponges under the sternum
- Center the beam over T6-T7
- Include the entire thoracic spine



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Thoracic spine - ventrodorsal

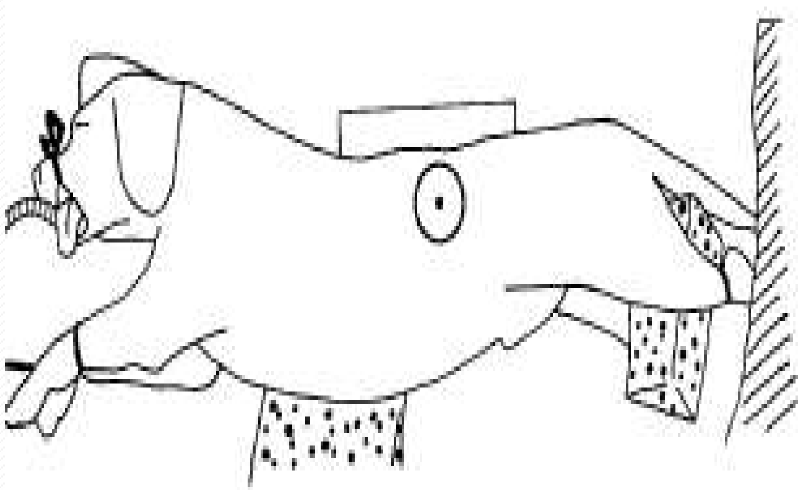
- Anesthetized or sedated patient
- Dorsal recumbency
- Use sandbags to aid in positioning
- Center the beam over T6- T7
- Include the entire thoracic spine



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Lumbar spine - lateral

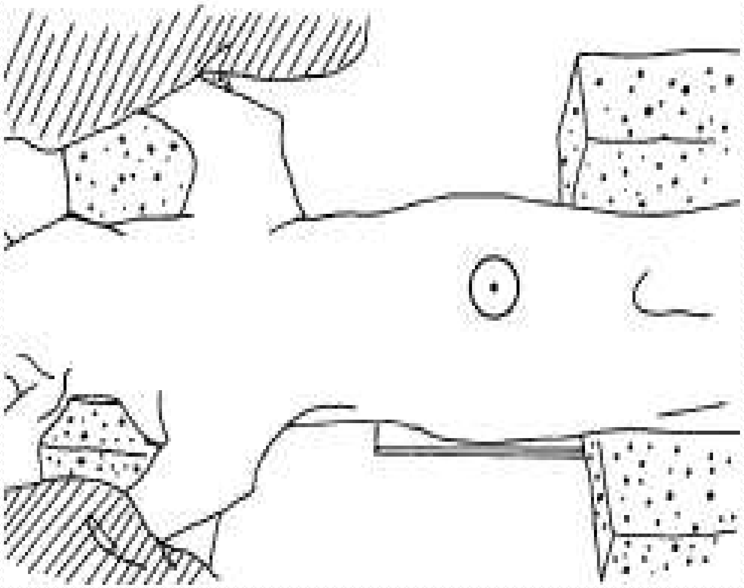
- Sedated or anesthetized patient
- Lateral recumbency
- Place the sponges under the sternum
- Place a sponge between the legs
- Center the beam over L3-L4
- Include the entire lumbar spine



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Lumbar spine - ventrodorsal

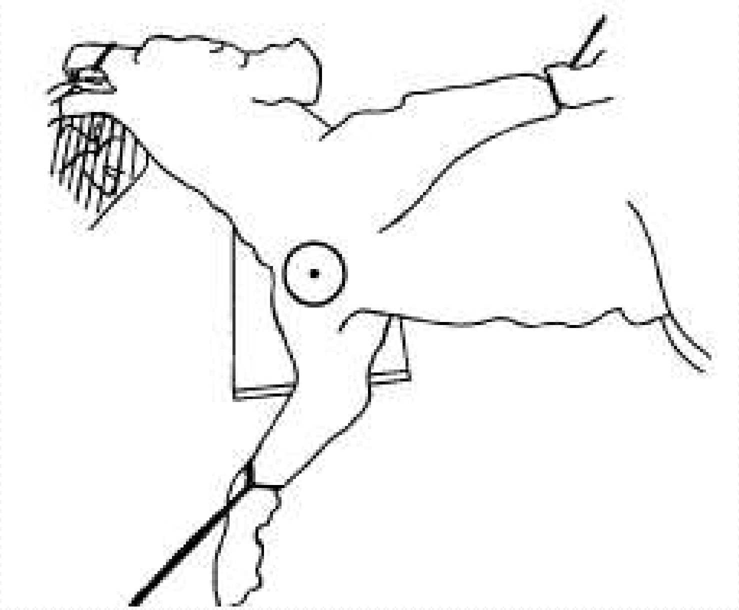
- Sedated or anesthetized animal
- Dorsal recumbency
- Use sandbags to position
- Center the beam over L3-L4
- Ensure the entire lumbar spine is included



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Scapula - lateral

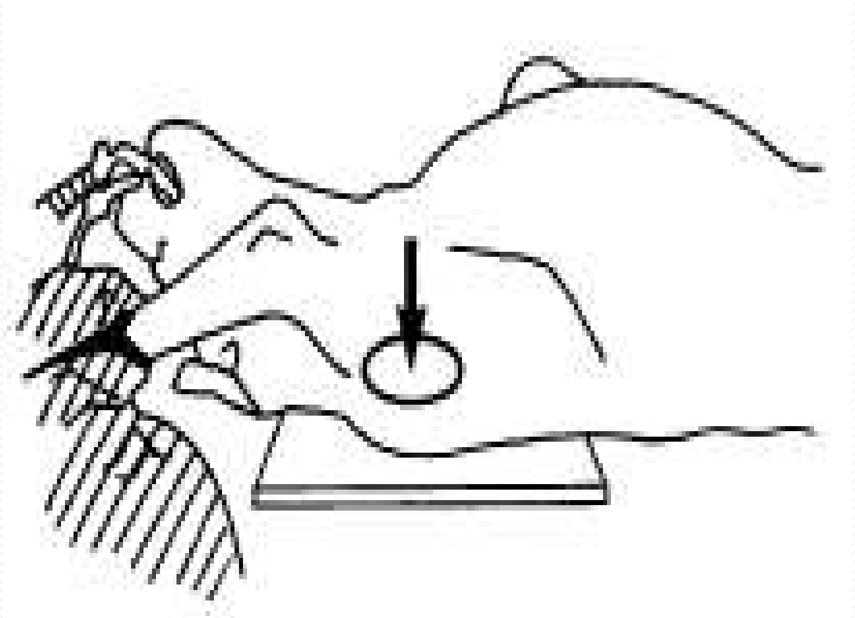
- Sedated patient
- Affected side down
- Extend the limb cranial
- Place traction on it
- Unaffected limb is pulled caudally
- Palpate the affected scapula and center



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Scapula - caudocranial

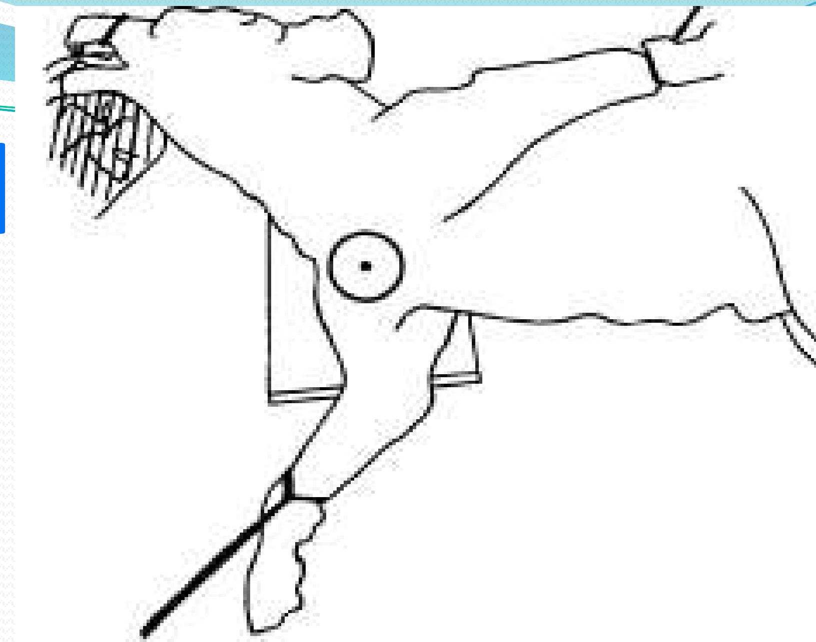
- Sedated patient
- Dorsal recumbency
- Extend the affected limb cranially
- Restrain with sandbags and tape
- Center the beam over the scapula

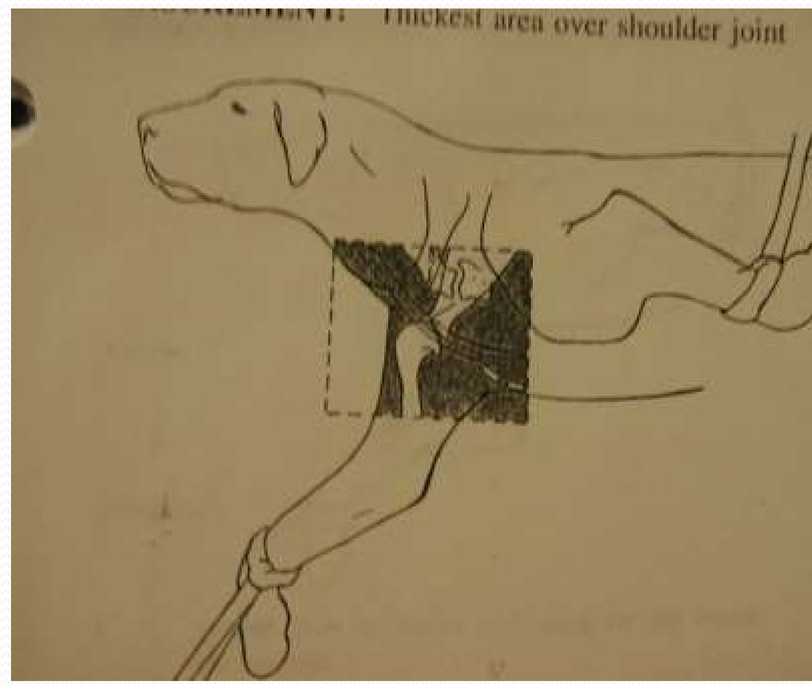


Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Shoulder - lateral

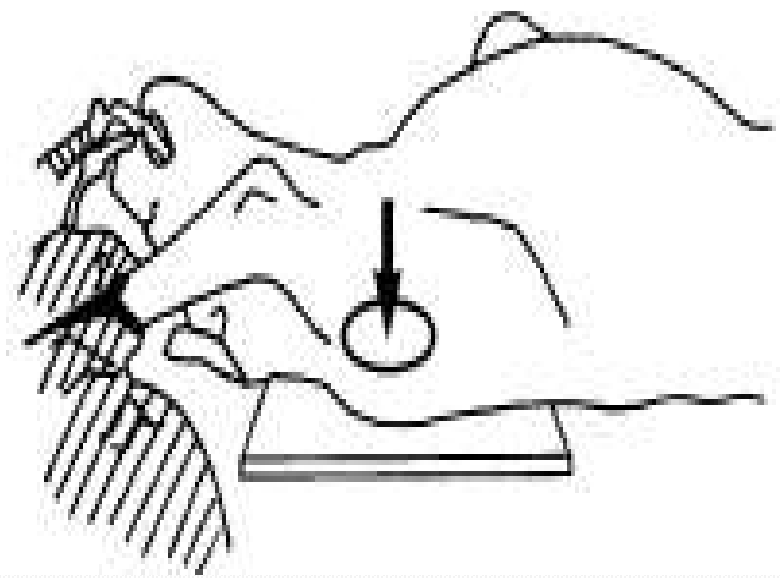
- Sedated patient
- Lateral recumbency
- Affected side down
- Extend the limb out and cranial
- Extend the unaffected limb caudally
- Center over the shoulder joint





Shoulder - caudocranial

- Sedated patient
- Dorsal recumbency
- Extend the affected limb cranially
- Restrain with sandbags
- Center the x-ray beam over the shoulder joint



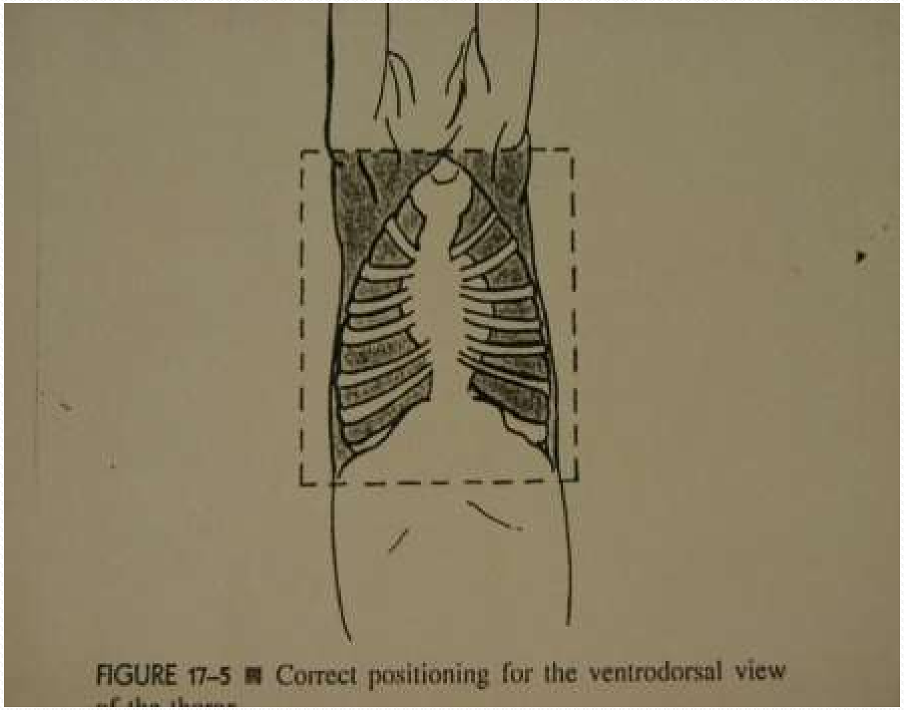
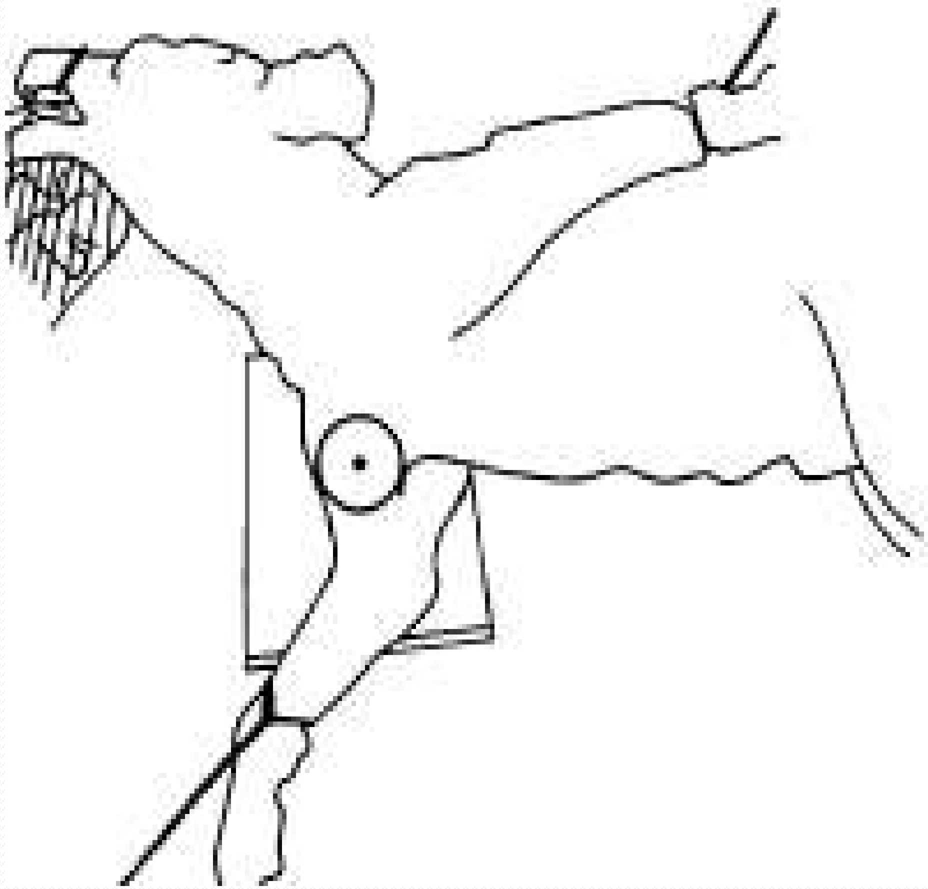


FIGURE 17-5 ■ Correct positioning for the ventrodorsal view

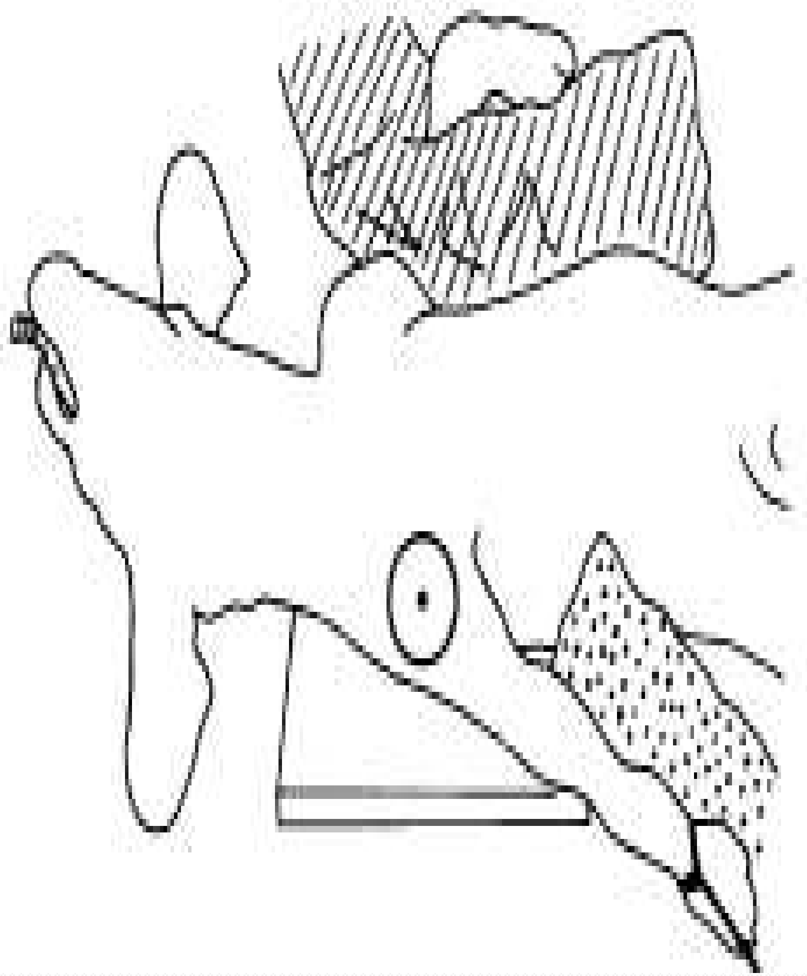
Humerus - lateral

- Lateral recumbency
- Affected side down
- The opposite limb is extended caudally
- Center the beam over the humerus
- Include the shoulder and elbow



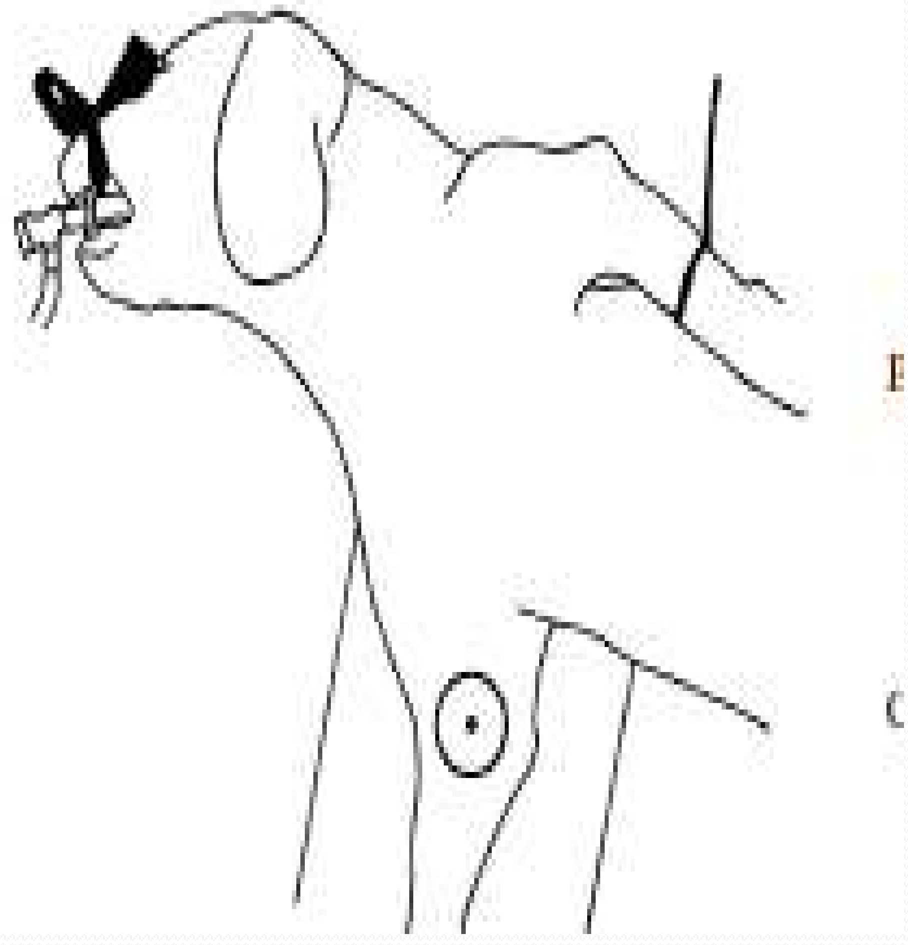
Humerus - craniocaudal

- Dorsal recumbency
- Extend the affected limb caudally
- Center the x-ray beam to the humerus
- Include the shoulder joint and elbow joint



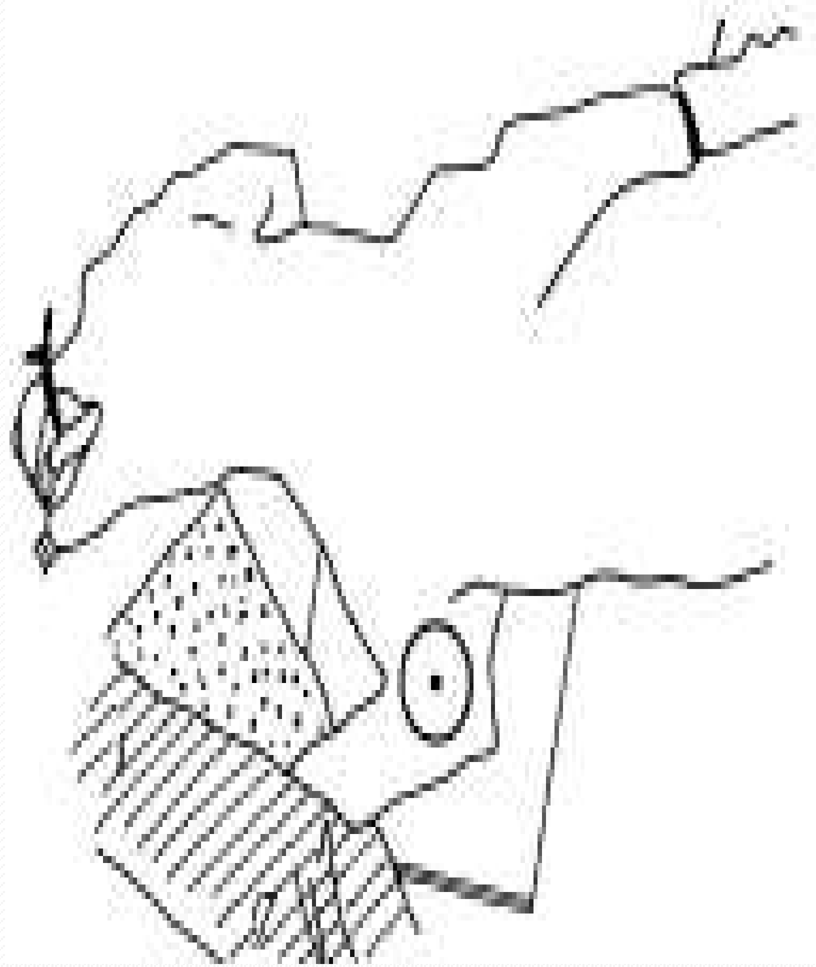
Elbow - lateral

- Lateral recumbency
- Affected side down
- Place the elbow in a neutral lateral position
- Center the x-ray beam over the elbow joint



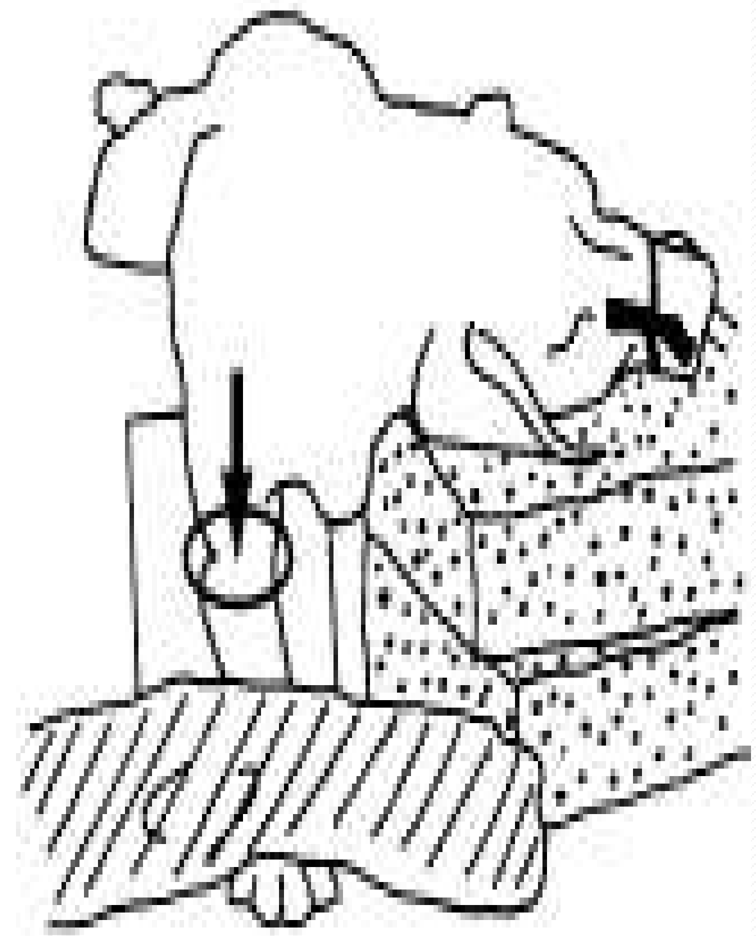
Elbow – flexed lateral

- Lateral recumbency
- Affected side down
- Position the elbow laterally
- Flex the elbow
- Center the x-ray beam over the elbow



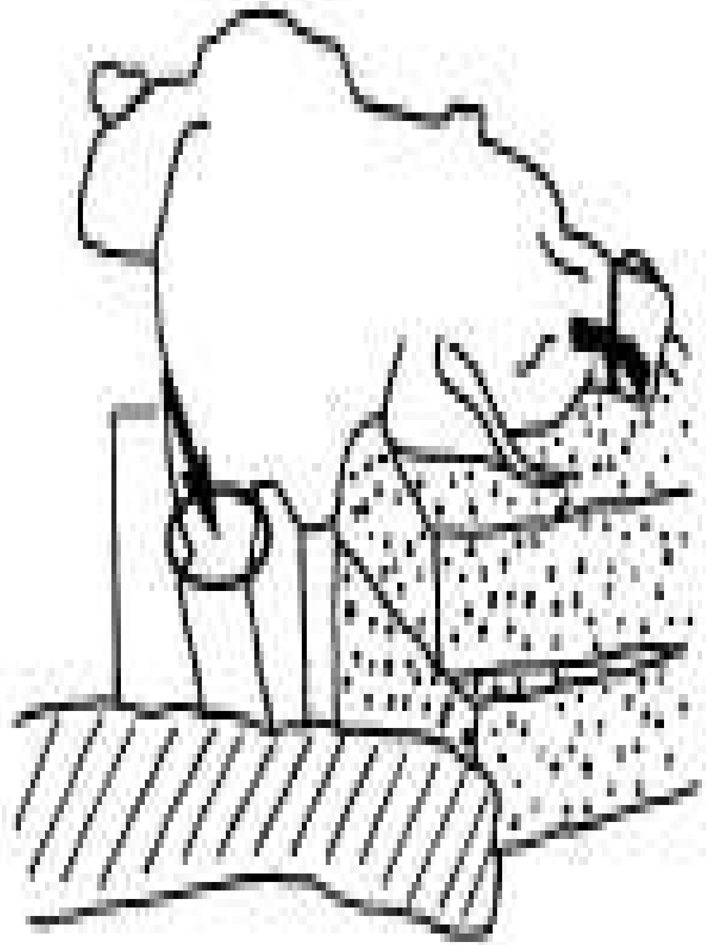
Elbow - craniocaudal

- Sternal recumbency
- Affected limb extended cranial
- Hyperextend the patients head
- Pull slightly towards unaffected limb
- Center the beam to the elbow joint



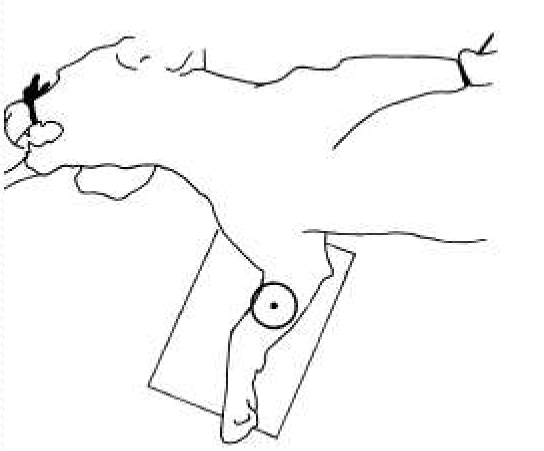
Elbow – medial oblique

- Sternal recumbency
- Extend the affected limb cranial
- Hyperextend the head
- Rotate the patient's body 15 degrees
- Toward the unaffected limb
- Center the beam to the elbow joint



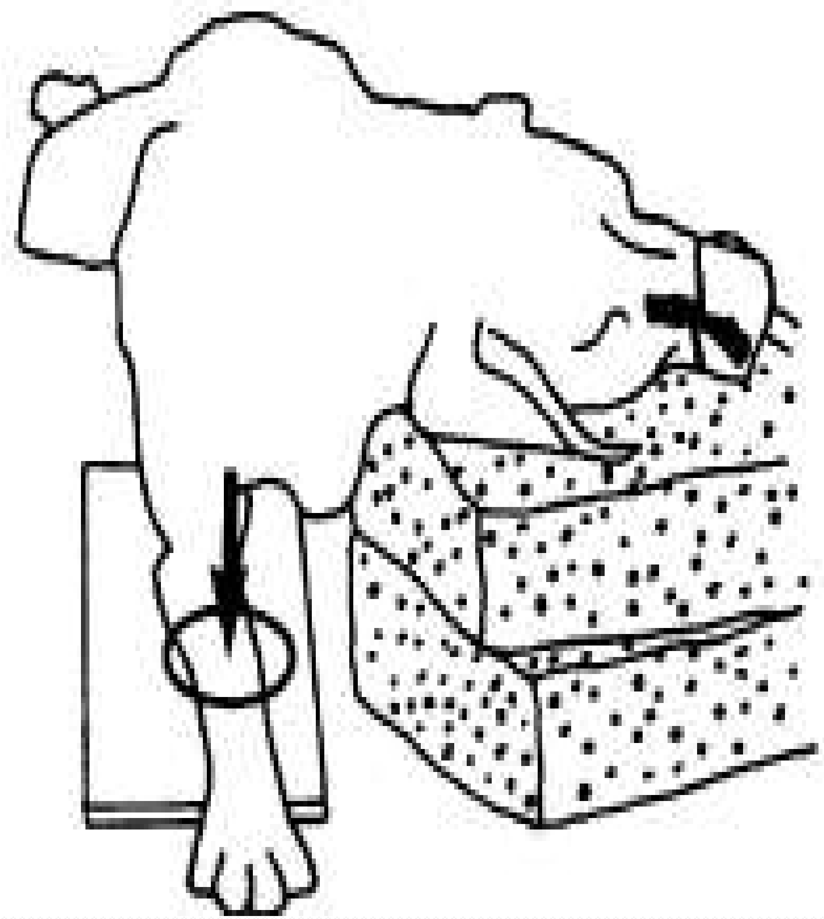
Radius/Ulna - lateral

- Lateral recumbency
- Affected side down
- Extend the limb away from the chest wall
- Extend the unaffected limb caudal
- Center the beam to the radius/ulna
- Include the elbow and the carpus



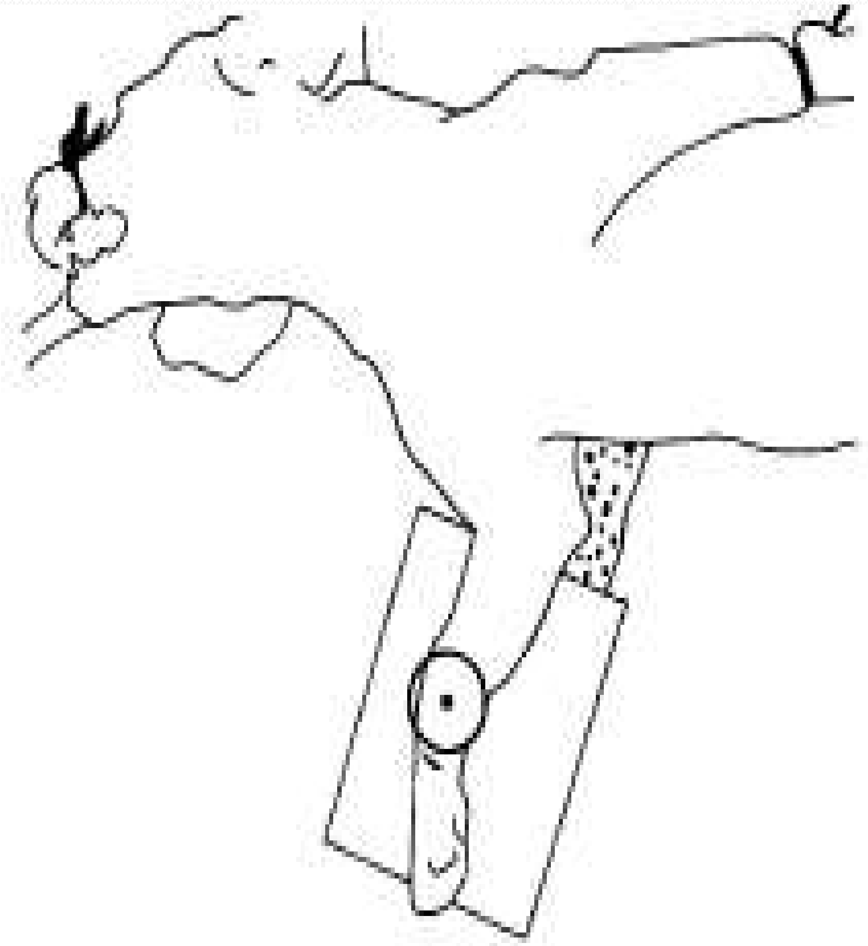
Radius/Ulna - craniocaudal

- Sternal recumbency
- Extend the affected limb
- Hyperextend the patient's head
- Center the x-ray beam to the radius/ulna
- Include the elbow and carpus



Carpus - lateral

- Lateral recumbency
- Affected side down
- Extend the limb
- Pull the unaffected limb caudally
- Position the carpus in lateral
- Center the beam over th carpus joint

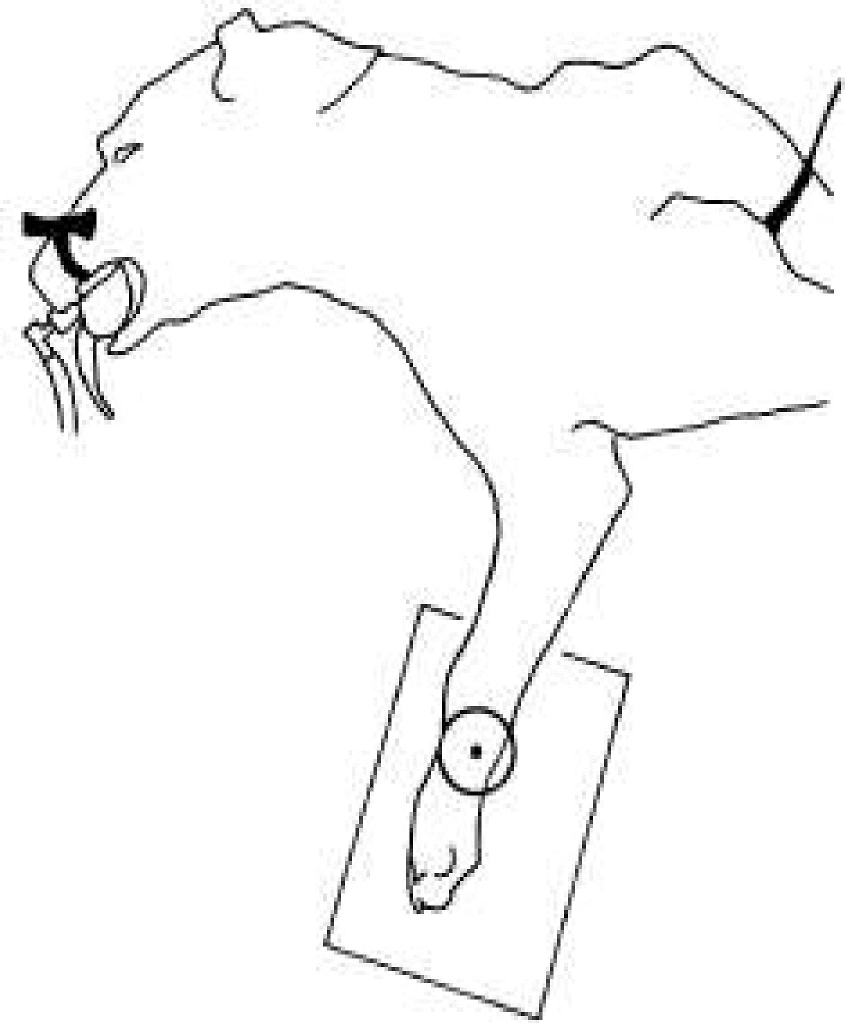


Carpus – dorsalpalmer

- Sternal recumbency
- Extend the limb as far cranial as possible
- Position the head up on sponges
- Away from the affected limb
- Center the beam to the carpus joint

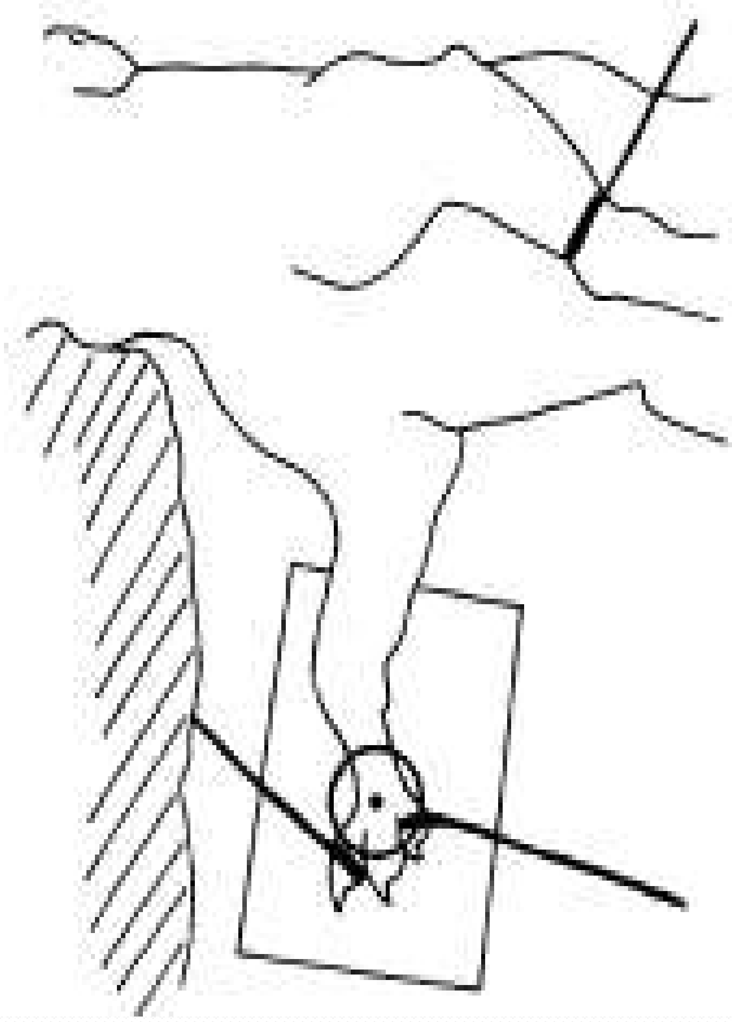
Digits - lateral

- Lateral recumbency
- Affected side down
- Extend the limb away from the chest wall
- Place the part in lateral
- Center the x-ray beam over the toes



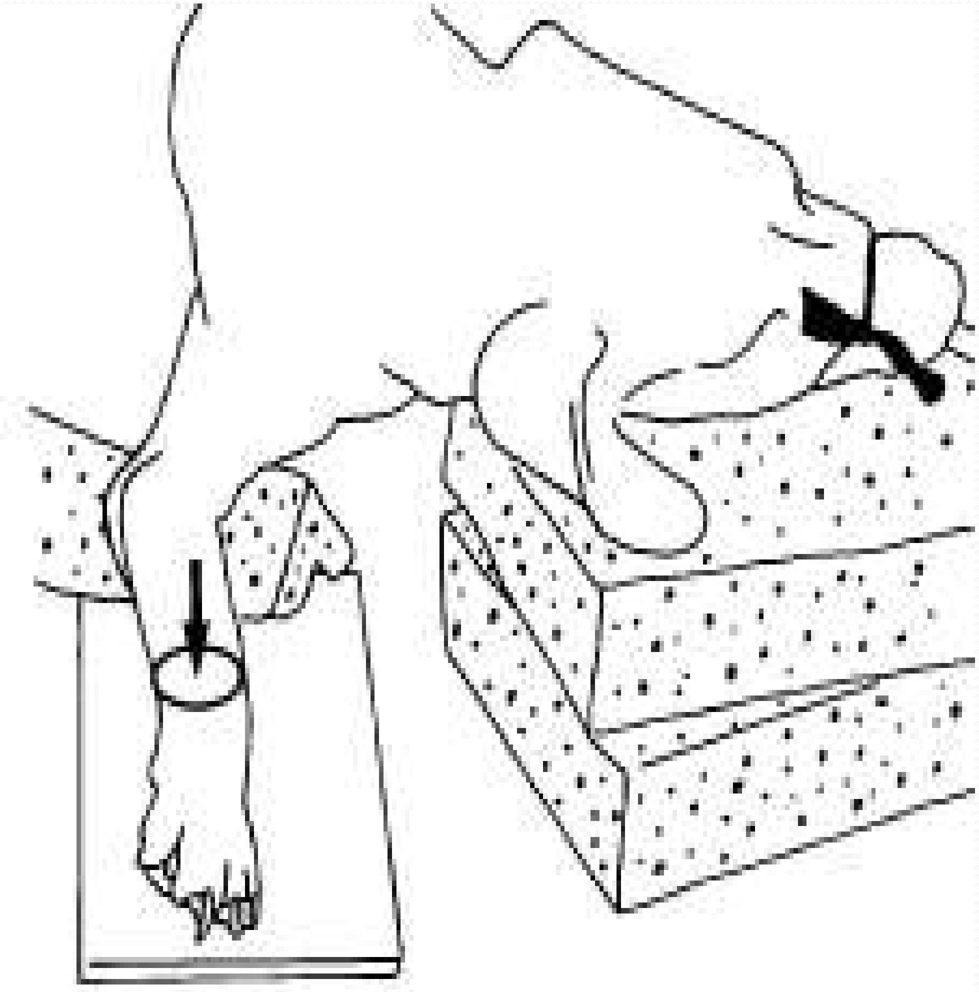
Digits – spread lateral

- Sedated patient
- Lateral recumbency
- Affected side down
- Use cotton balls or tape
- Spread the toes in a lateral position
- Center the beam over the toes



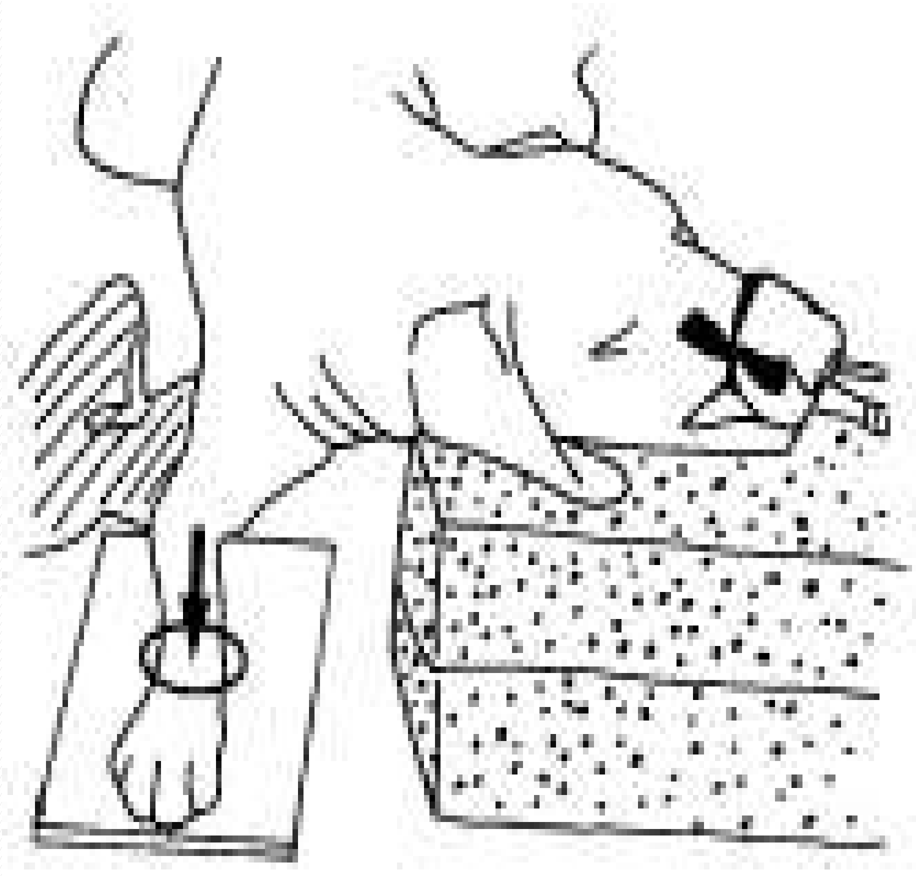
Digits - oblique

- Sternal recumbency
- Extend the affected limb cranial
- Position the head slightly away from the affected side
- Oblique the toes 15 degrees
- Center over the digits



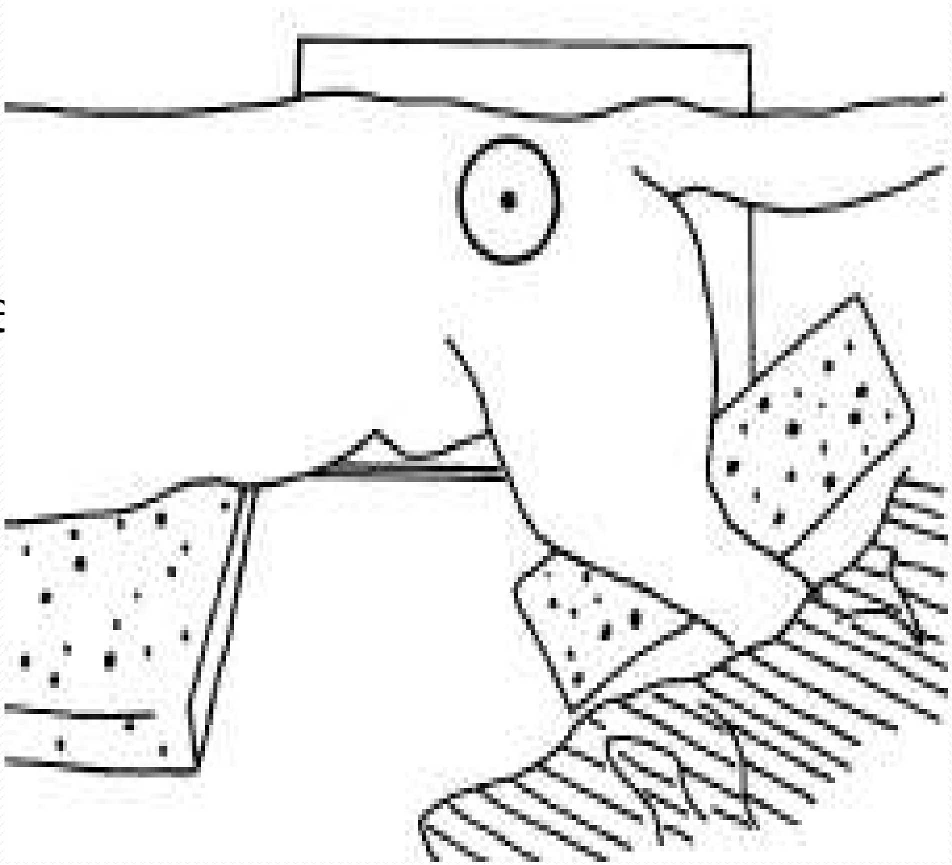
Digits - dorsopalmer

- Sternal recumbency
- Extend the affected limb
- Hyperextend the head
- Center the beam over the toes



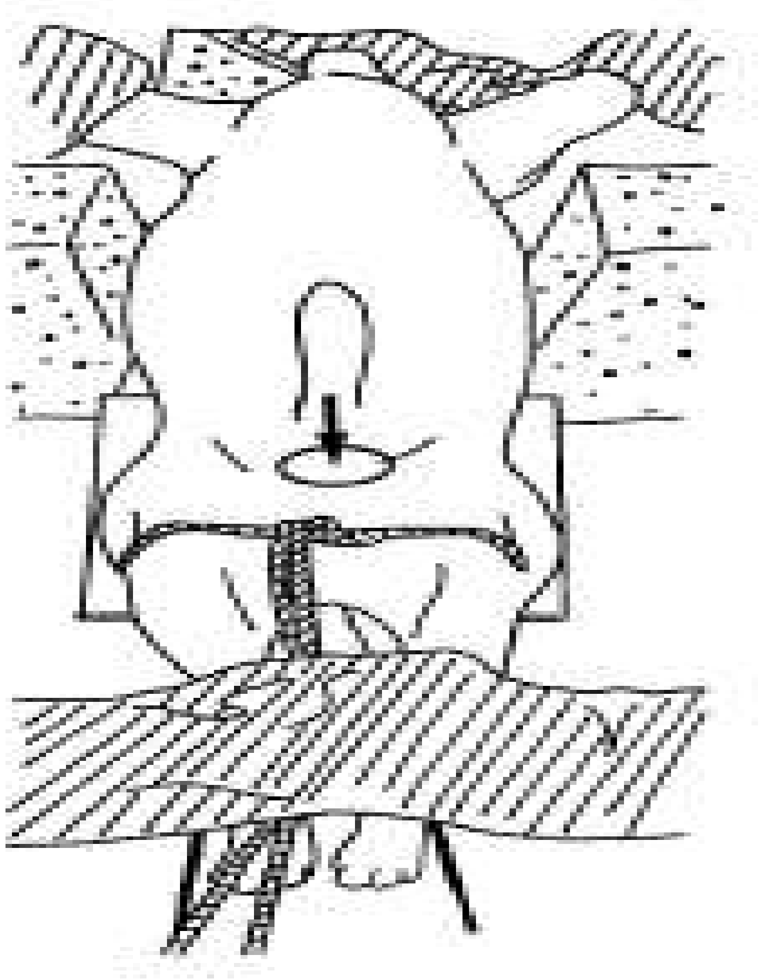
Pelvis - lateral

- Lateral recumbency
- Affected side down
- Place a sponge between the legs
- Center the beam over the hip
- Include the entire pelvis



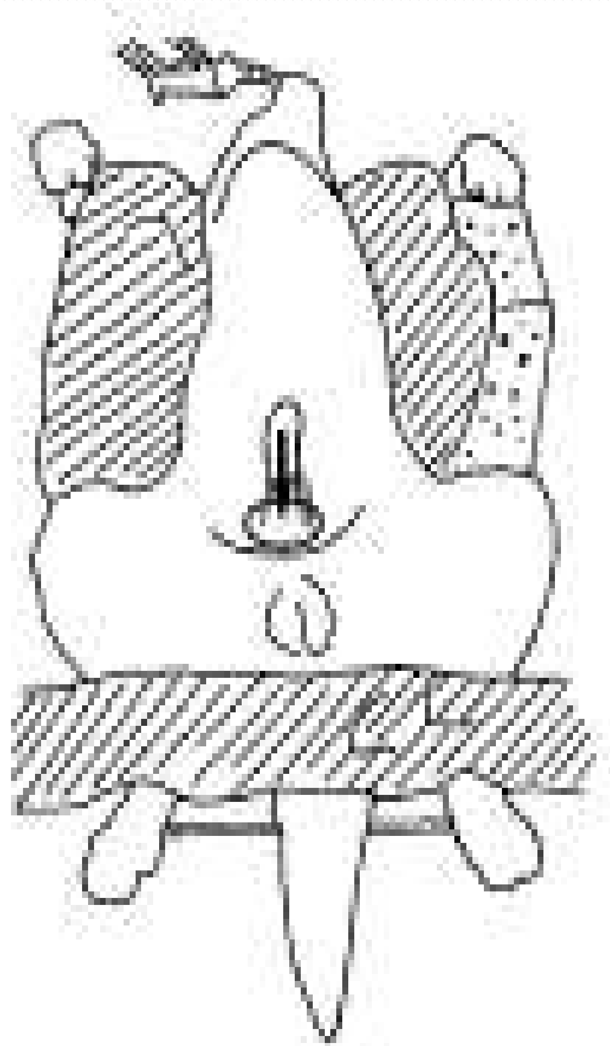
Pelvis - ventrodorsal

- Dorsal recumbency
- Use trough to aid in positioning
- The pelvic limbs are extended and internal rotated
- Straight pelvis, patella midline, and the tail centered
- Include iliac wing to stifle



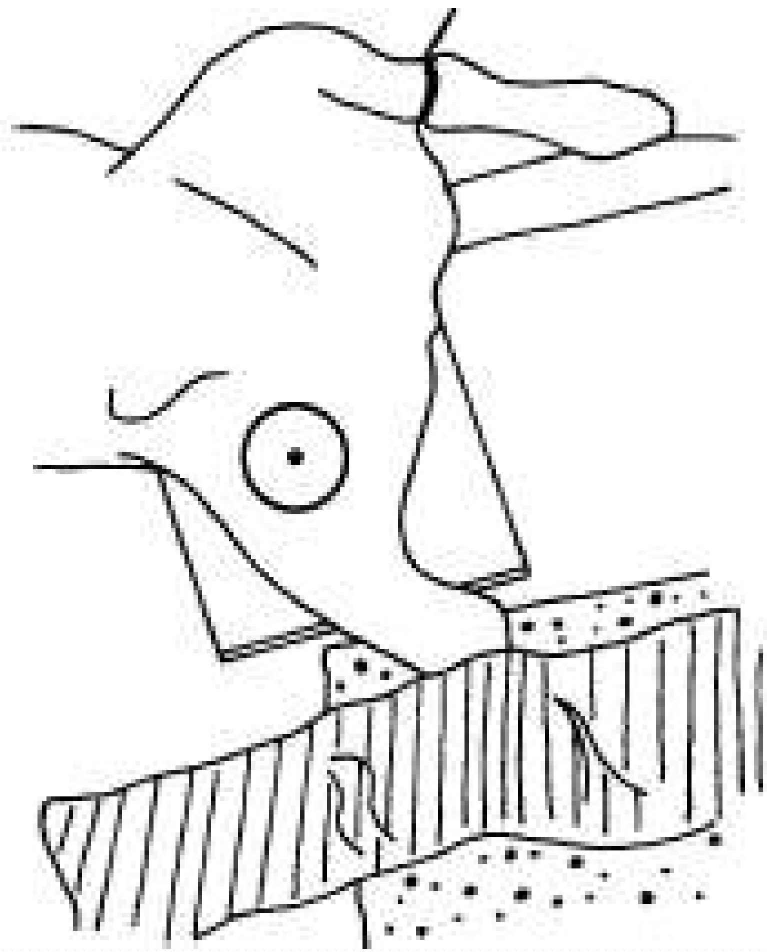
Pelvis - frog legged view

- Dorsal recumbency
- Use a v trough
- Abduct the femurs
- Pelvis is in a frog legged position
- Center the x-ray beam over the hips



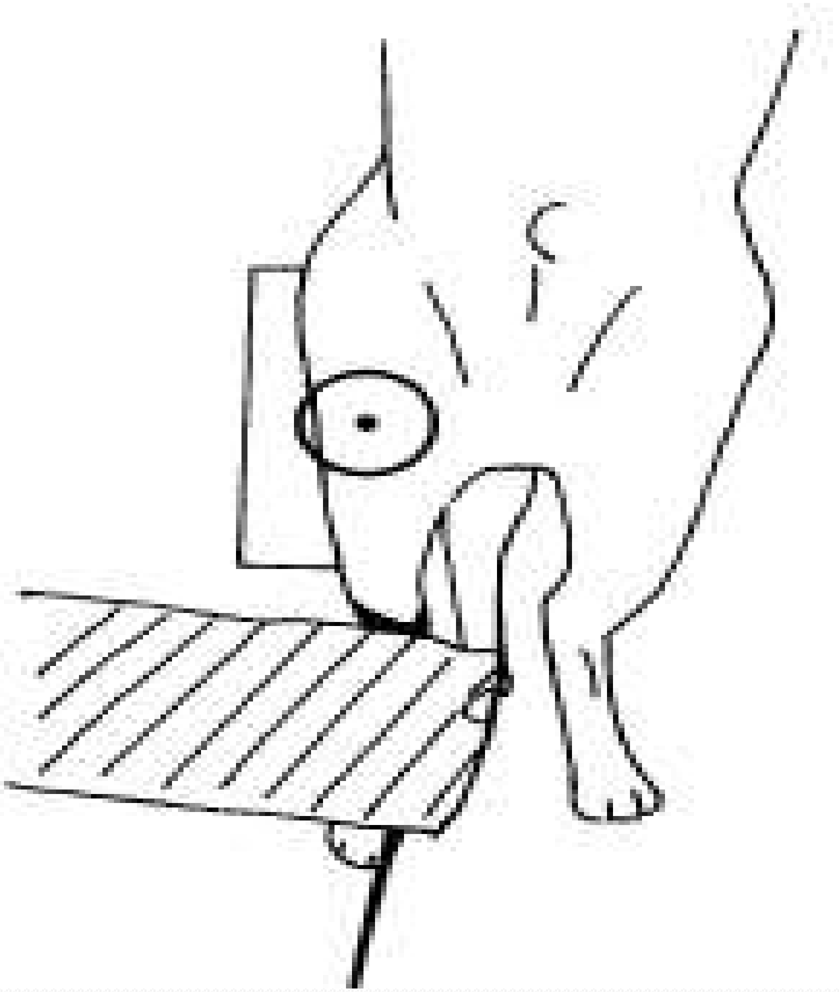
Femur - lateral

- Lateral recumbency
- Affected side down
- Extend the unaffected limb out of the way.
- Restrain with a sandbag or tape
- Extend the affected limb and position laterally
- Center the beam over the femur
- Include the hip and the stifle



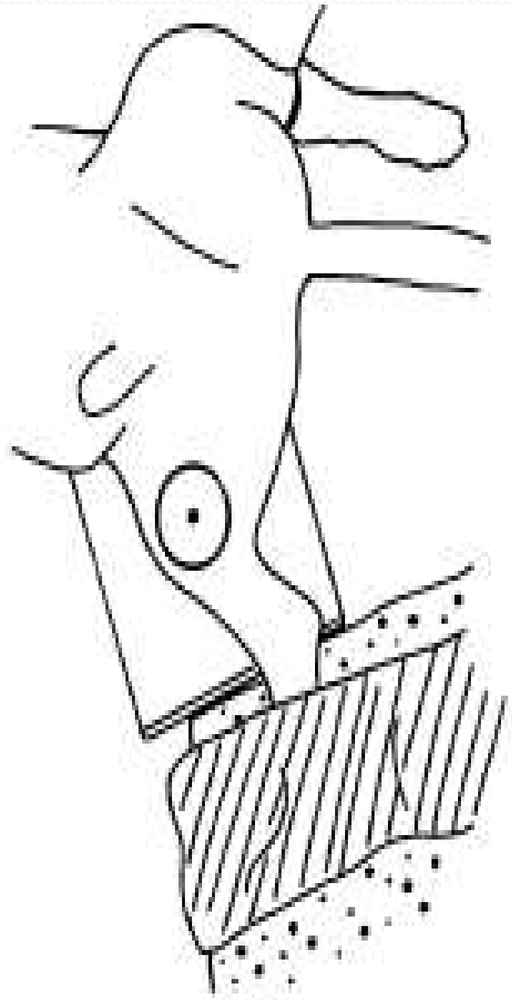
Femur - craniocaudal

- Dorsal recumbency
- Extend the affected leg caudally
- Rotate the leg internally
- Center the beam over the femur
- Include the hip and stifle joint



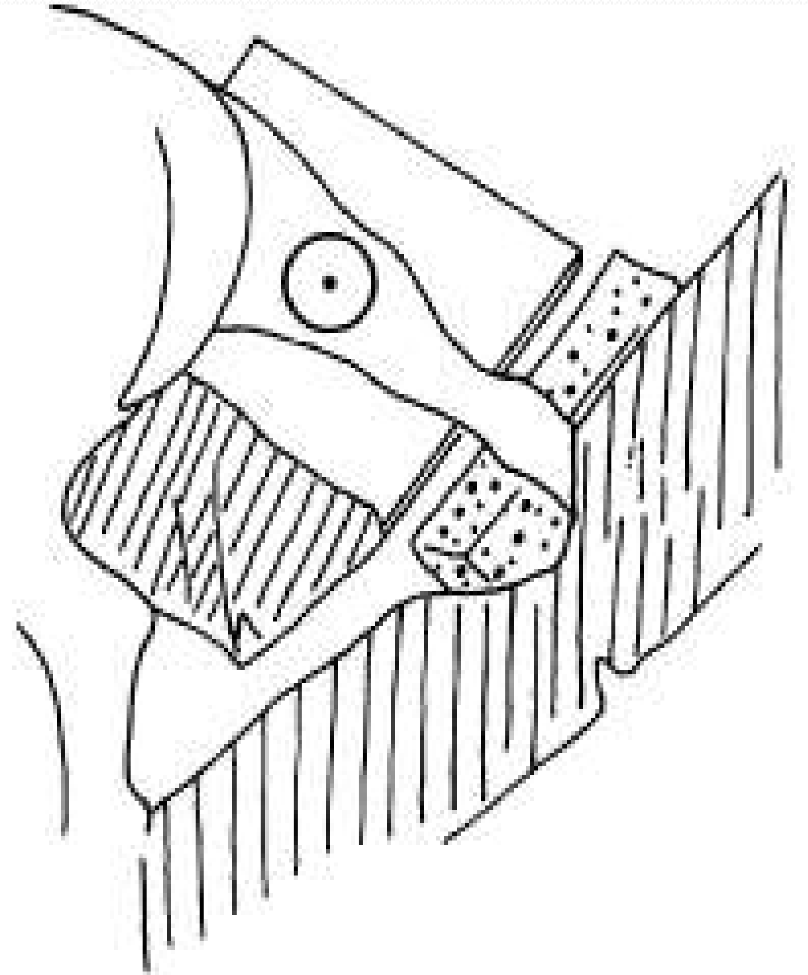
Stifle - lateral

- Lateral recumbency
- Affected side down
- Stifle is in a neutral lateral position
- Pull the unaffected leg back
- Restrain with sandbags
- Rotate the affected limb cranial
- Center the beam over the stifle joint



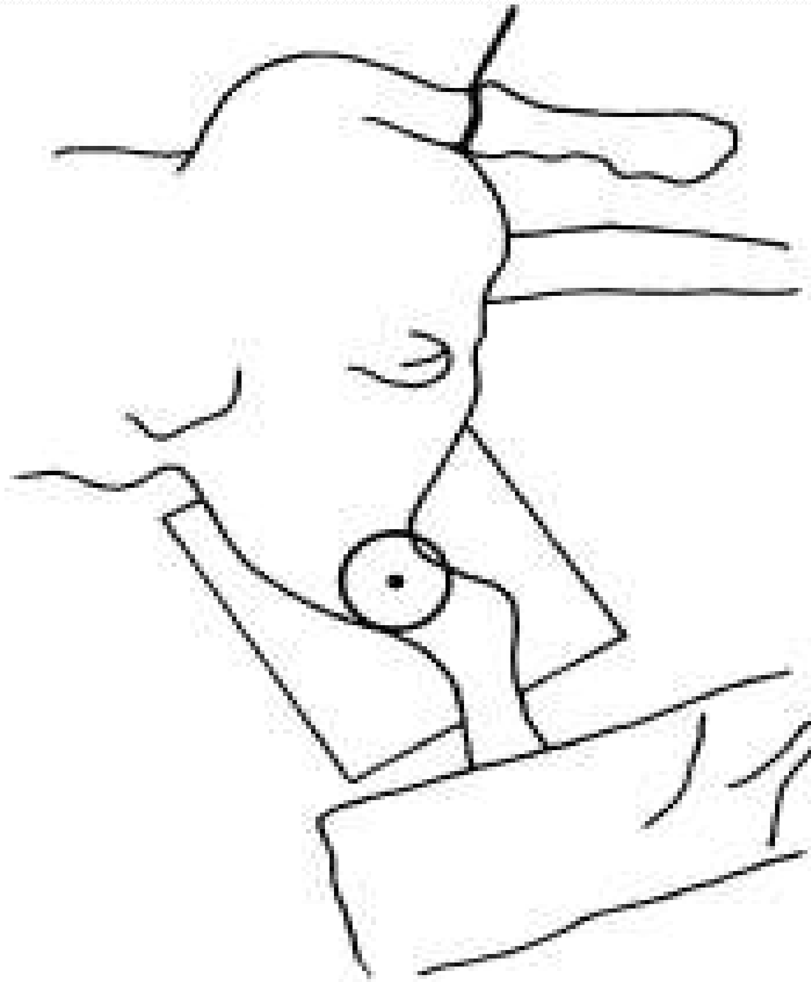
Stifle - caudocranial

- Sternal recumbency
- Extend the affected limb
- Lift the unaffected limb up with sponges
- Patella midline
- Center the x-ray beam to the stifle joint



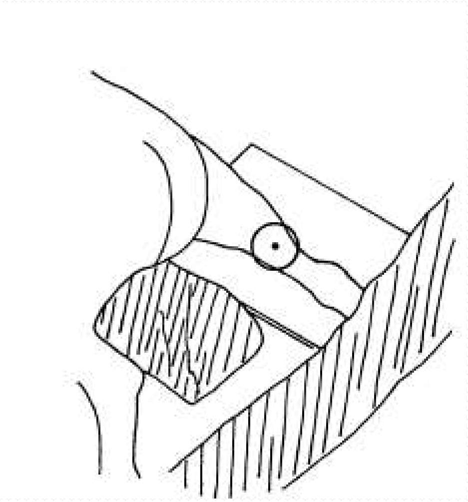
Tibia/Fibula - lateral

- Lateral recumbency
- Affected side down
- Extend the affected limb and position laterally
- Pull the unaffected limb out of the way
- Center the x-ray beam to the tib/fib
- Include stifle and the tarsus joint



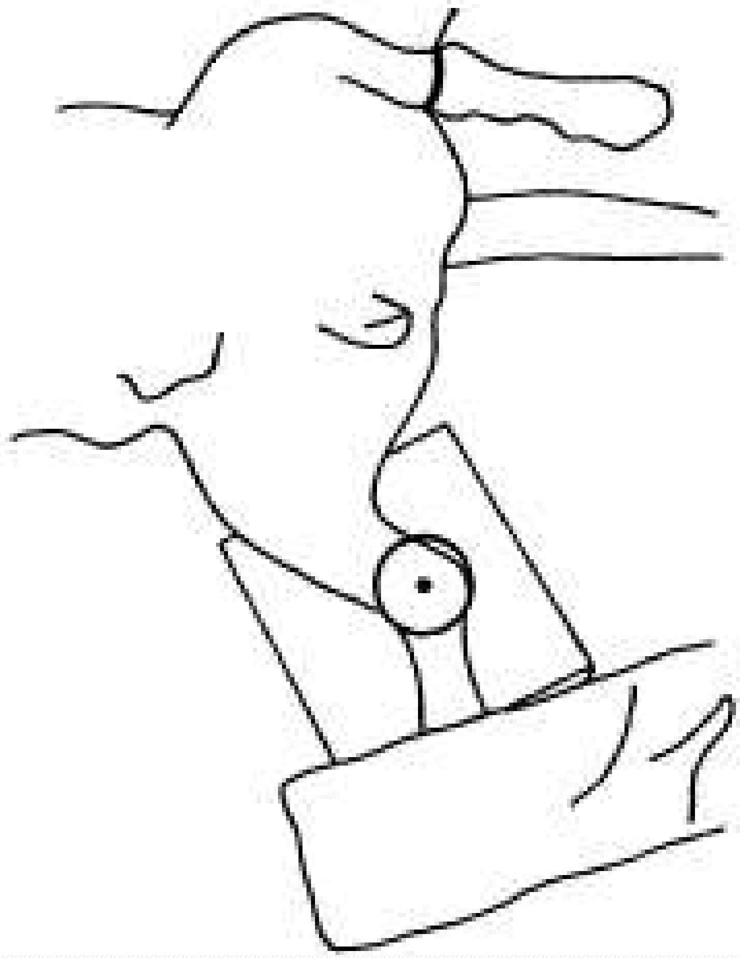
Tibia/Fibula - caudocranial

- Sternal recumbency
- Extend the affected leg caudally
- Place the unaffected limb up on sponges
- Center the x-ray beam to the tib/fib
- Include the stifle and tarsus



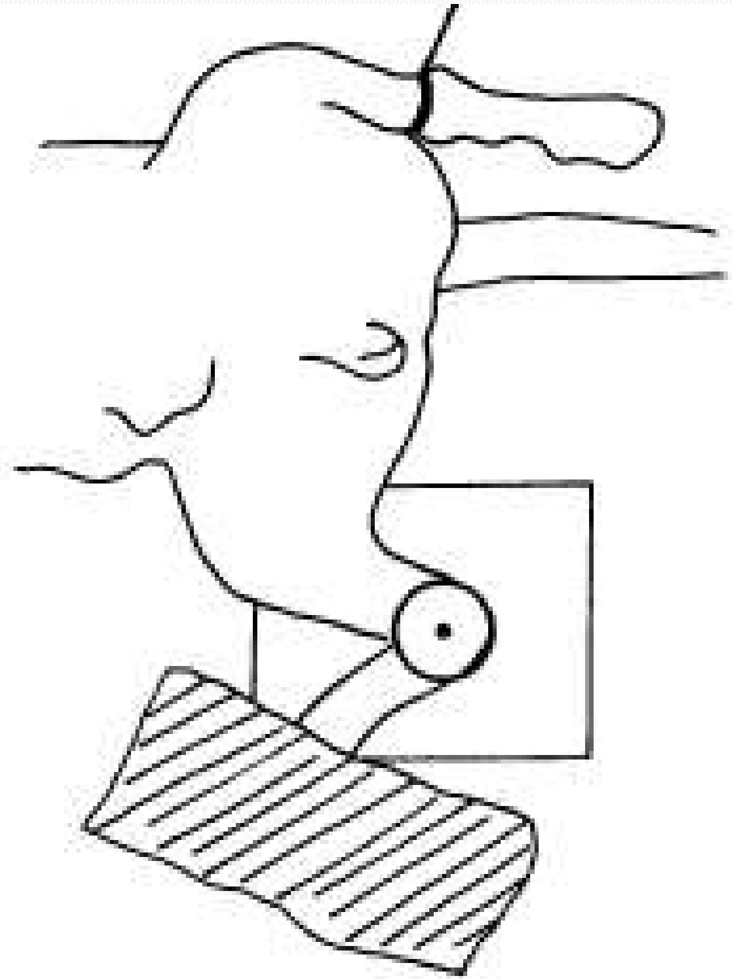
Tarsus - lateral

- Lateral recumbency
- Affected side down
- Position the tarsus in a neutral lateral position
- Restrain with sandbags or tape
- Extend the unaffected leg
- Center the x-ray beam over the tarsus



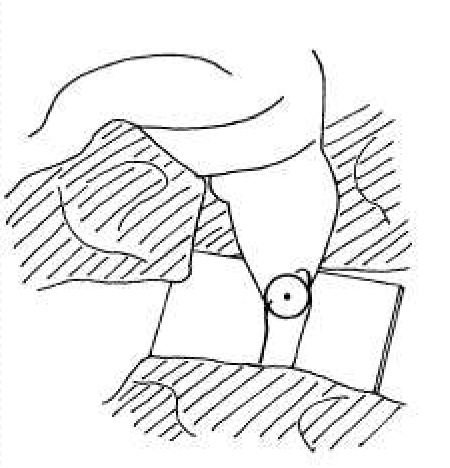
Tarsus – flexed lateral

- Lateral recumbency
- Affected side down
- Pull the unaffected limb out of the way
- Flex the tarsus
- Center over the tarsus

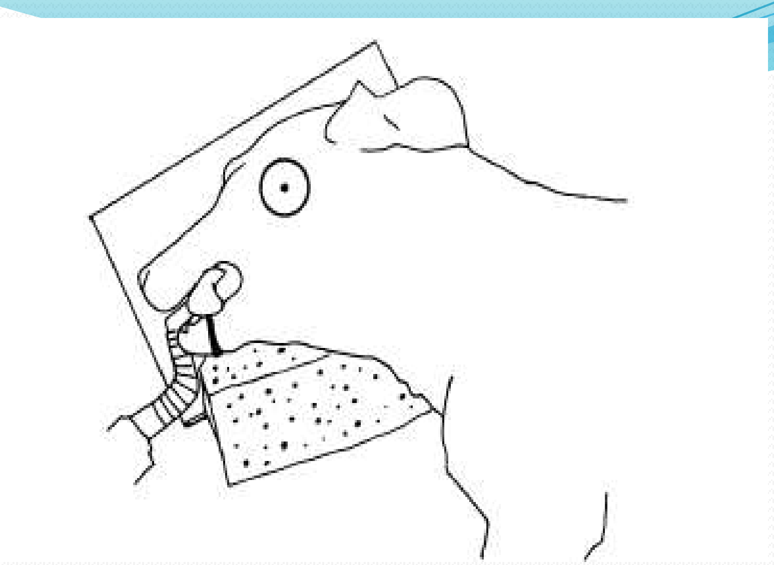


Tarsus - plantarodorsal

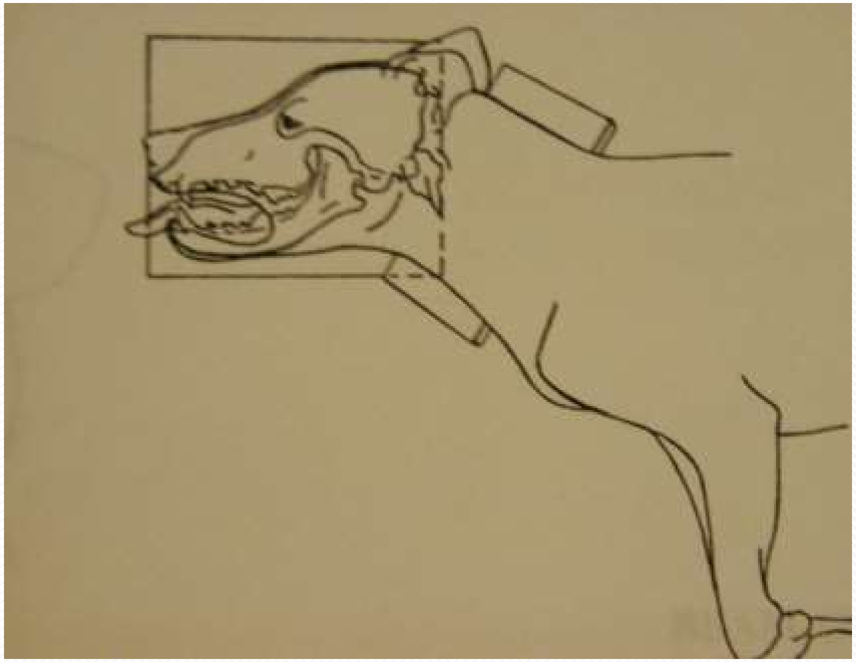
- Sternal recumbency
- Extend the affected leg caudally
- Position the unaffected leg up on sponges
- Center the beam over the tarsus



Skull - lateral

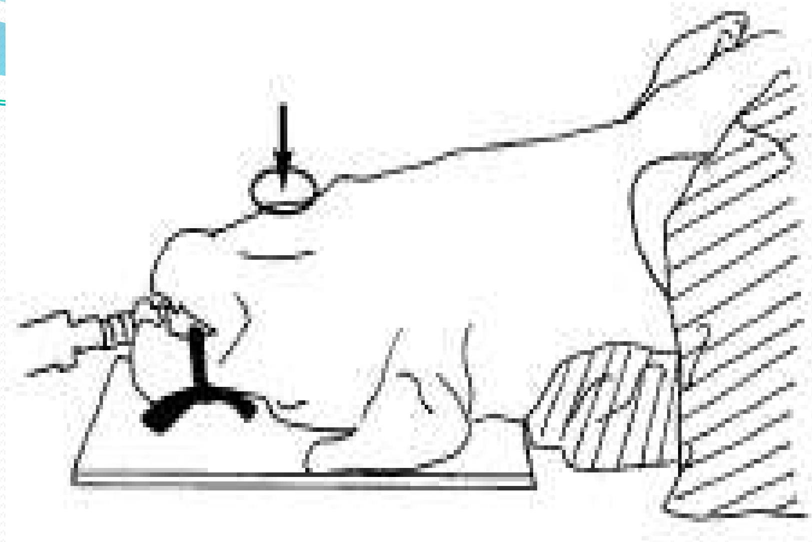


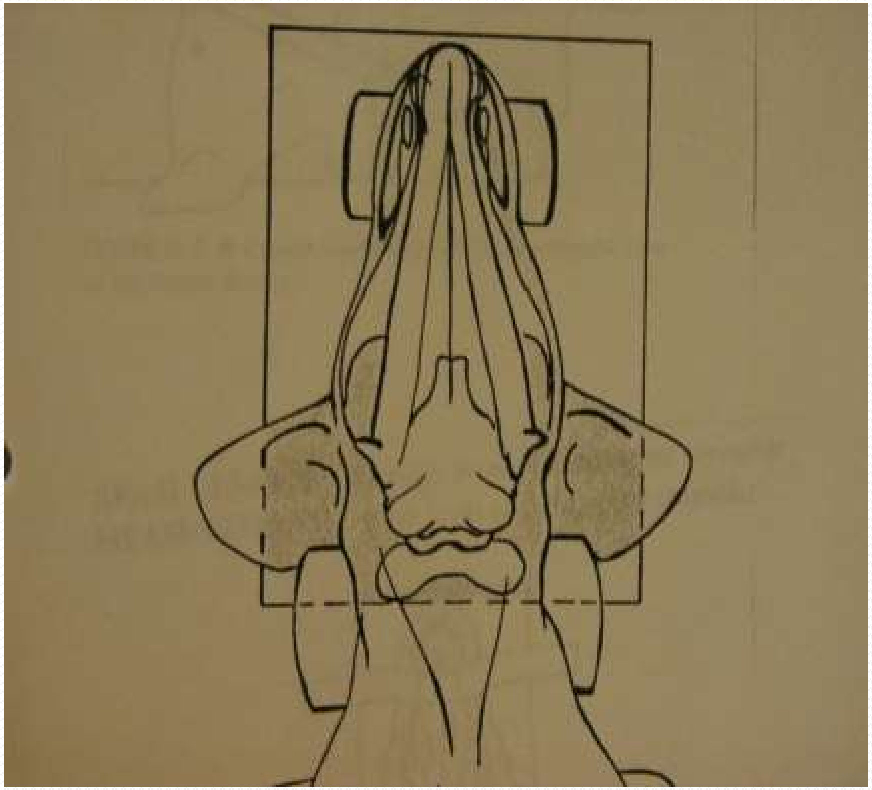
- Anesthetized patient
- Lateral recumbency
- Affected side down
- Place a sponge under the patient nose
- Center the x-ray beam to the zygomatic arch
- Include the entire skull

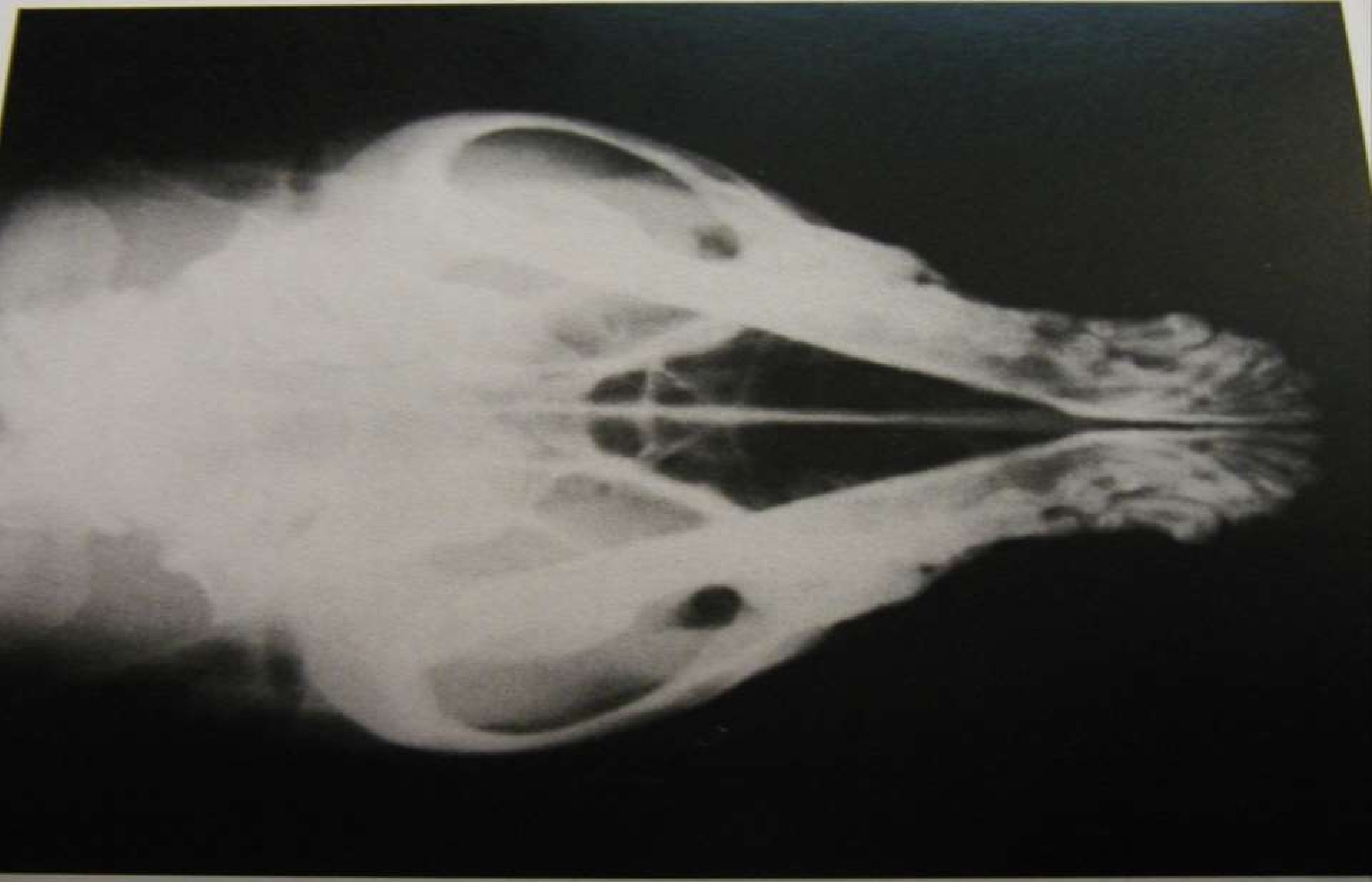


Skull – ventrodorsal/dorsoventral

- Anesthetized patient
- Dorsal recumbency
- Position the skull perpendicular to the tabletop
- Center the beam to the skull

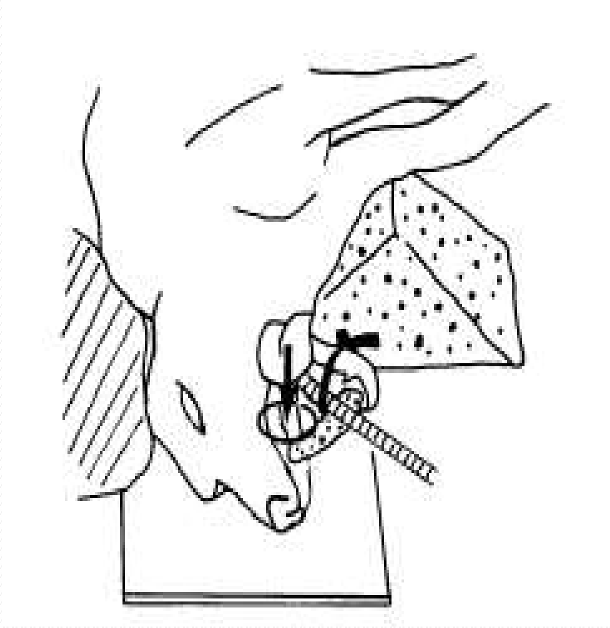






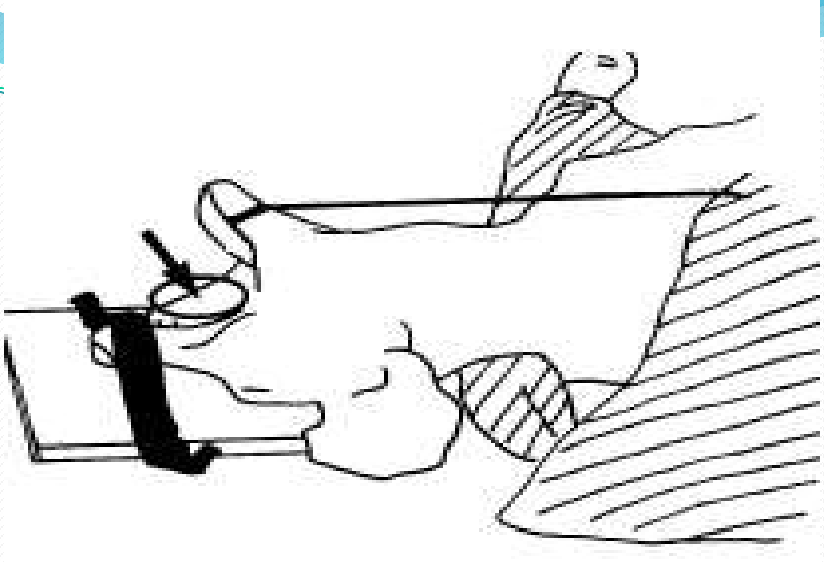
Nasal - lateral

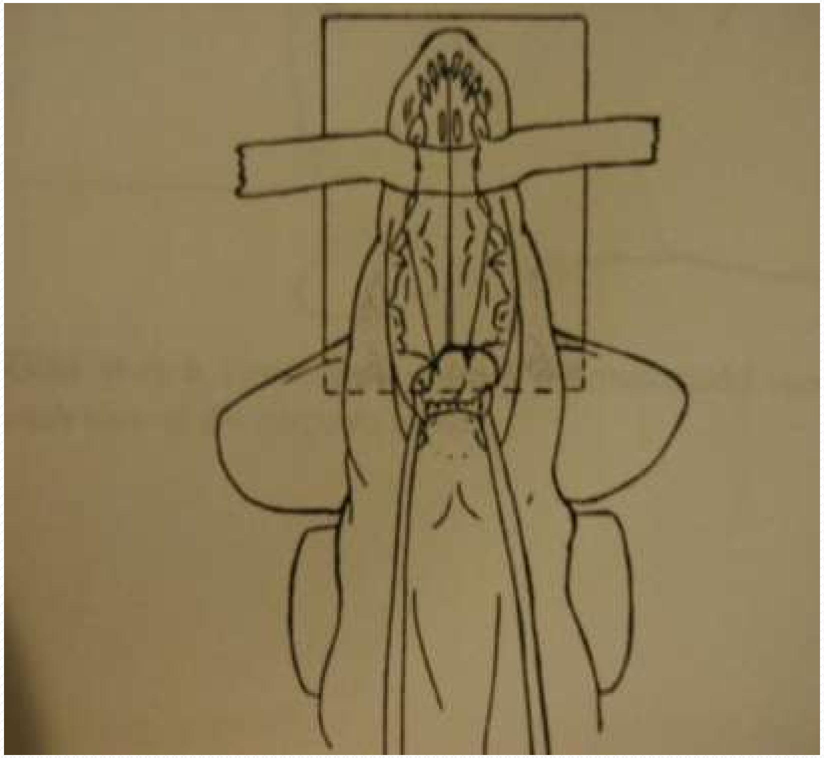
- Anesthetized patient
- Lateral recumbency
- Affected side down
- Place a speculum between the patient's canines
- Use sponges
- Include the frontal sinuses

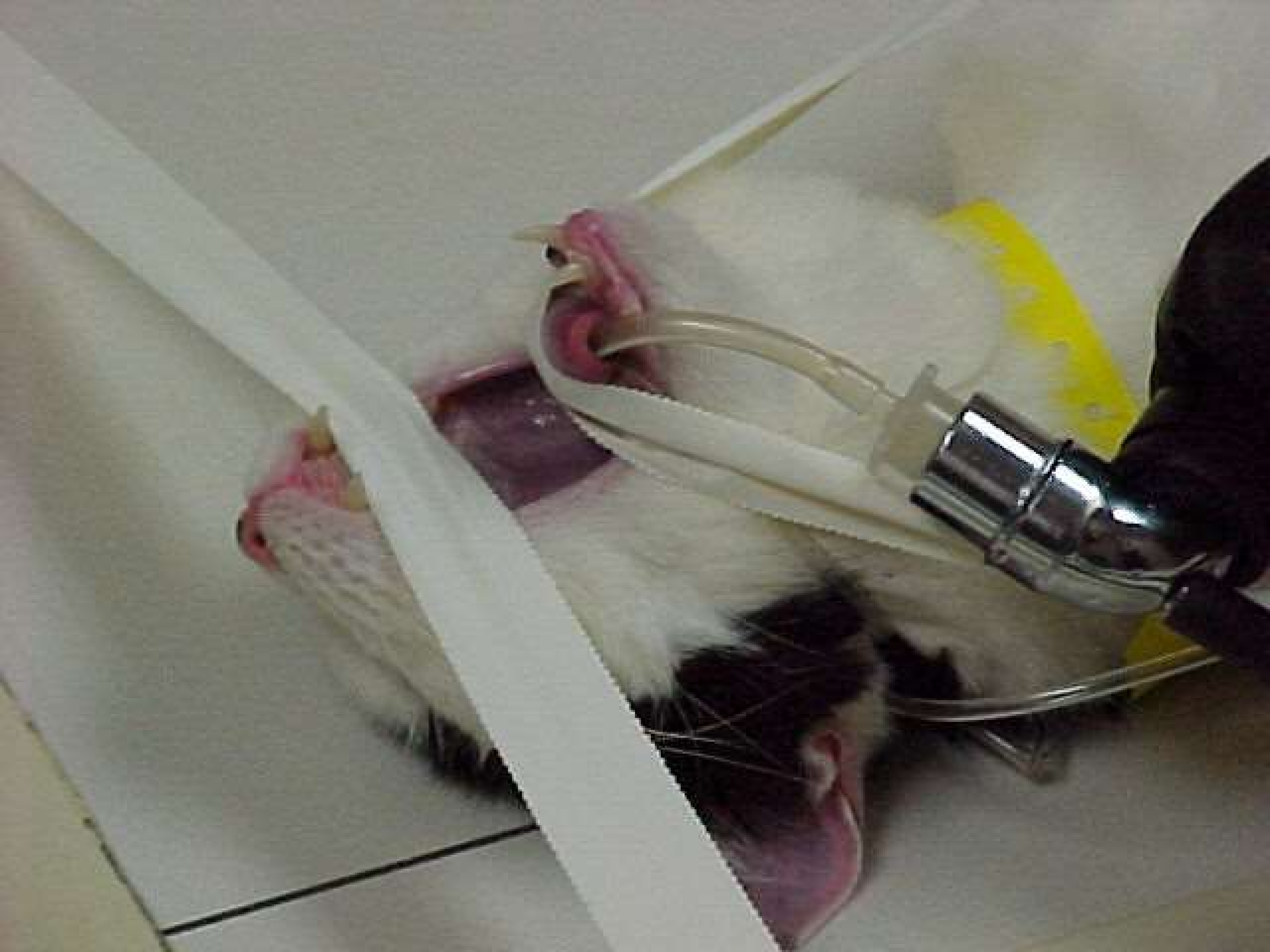


Nasal – ventrodorsal (open mouth)

- Anesthetized patient
- Dorsal recumbency
- Tape the maxilla close to the tabletop
- Tape the mandible out of the way
- Pull the tongue and the tube out of the view
- Angle the x-ray beam slightly in a rostrocaudal direction
- Center the beam to the nasal cavity





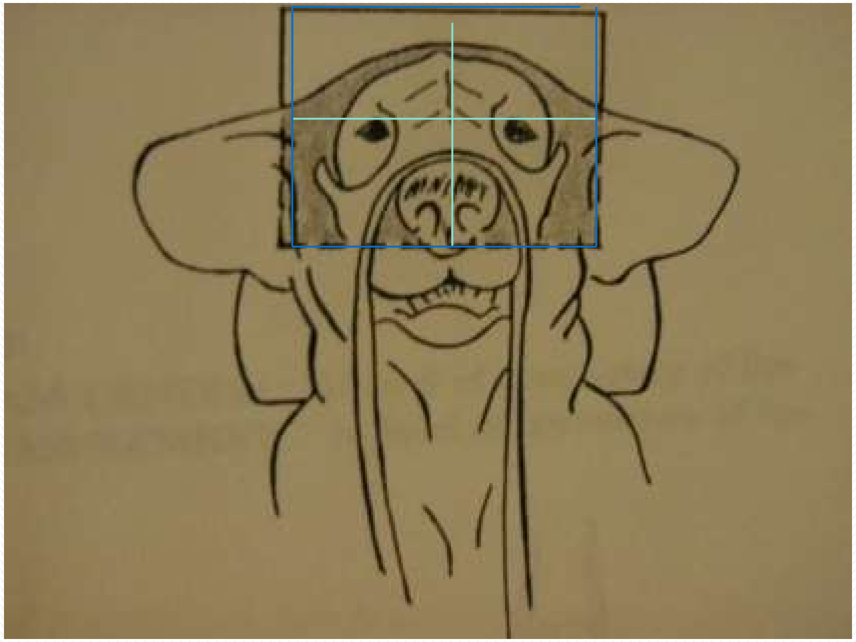


Nasal – frontal view

- Anesthetized patient
- Dorsal recumbency
- Patient in a closed mouth position
- Nose pointing to the ceiling
- Tape the endotracheal tube to the x-ray tube housing
- Center the beam between the eyes

Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Skull Positioning-Rostrocaudal Frontal View



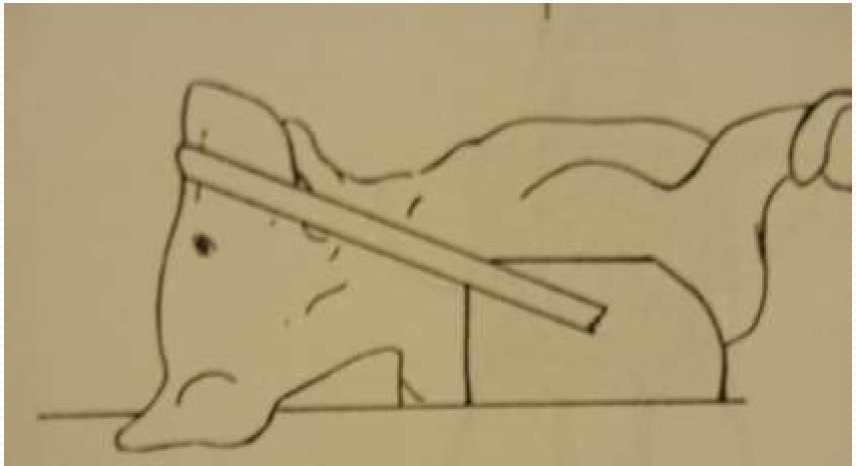
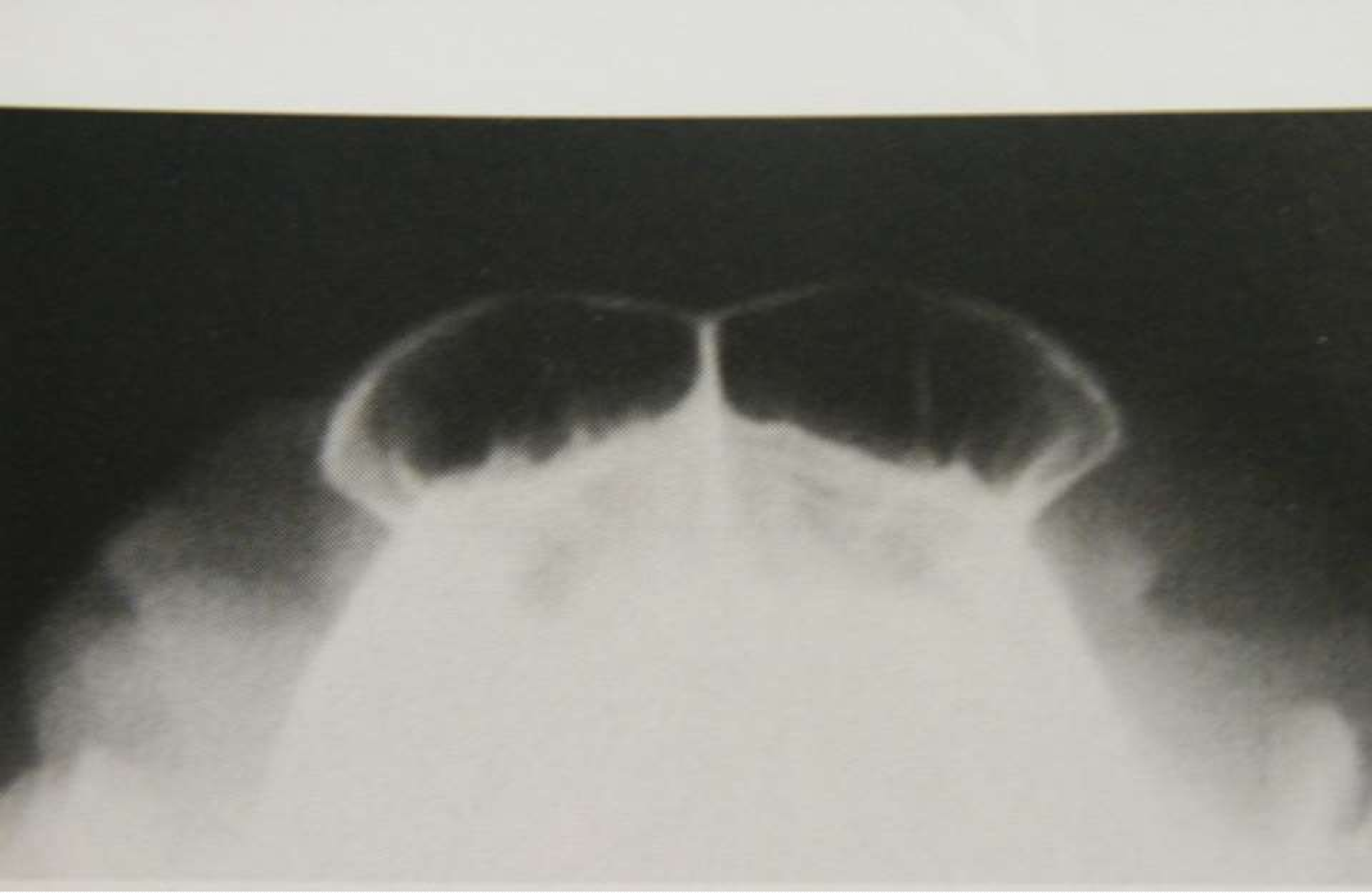
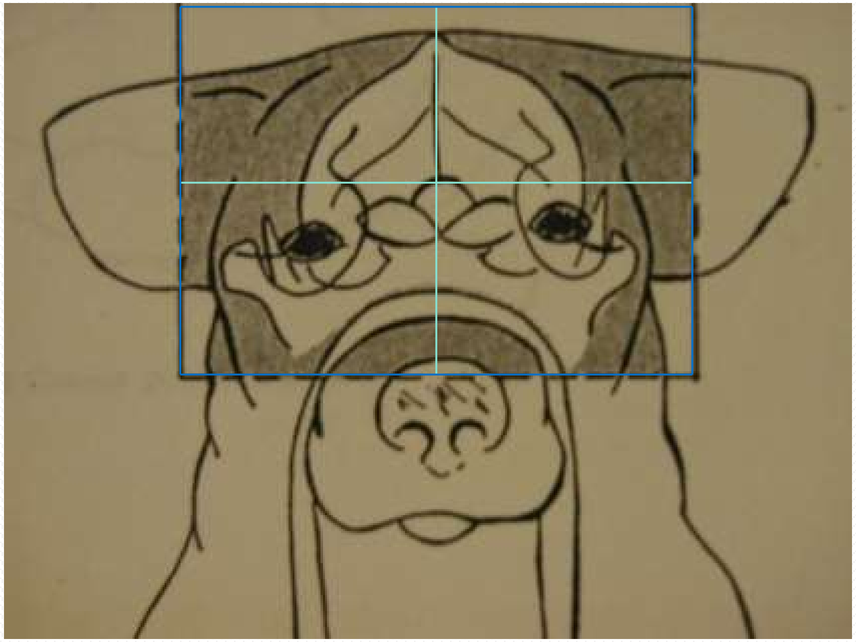


FIGURE 15–9 ■ Correct positioning for the rostrocaudal v
of the frontal sinuses.



Skull Positioning-Rostrocaudal Cranium



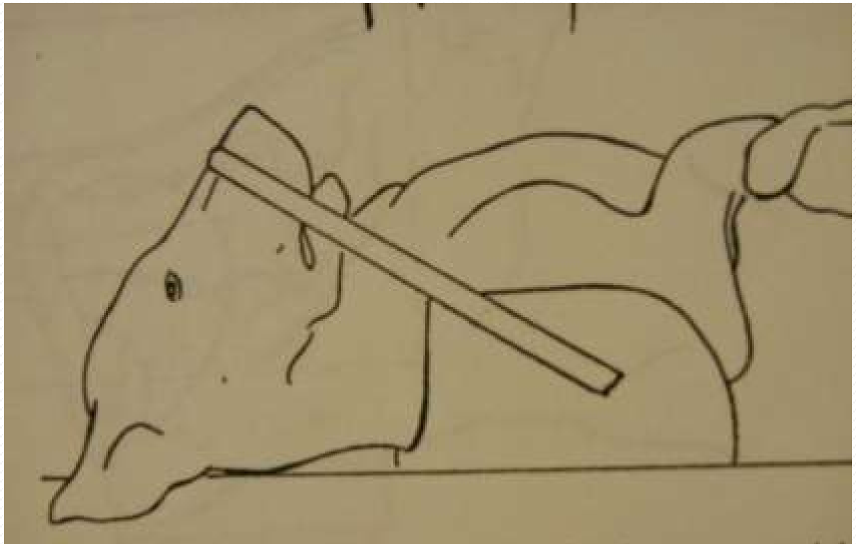
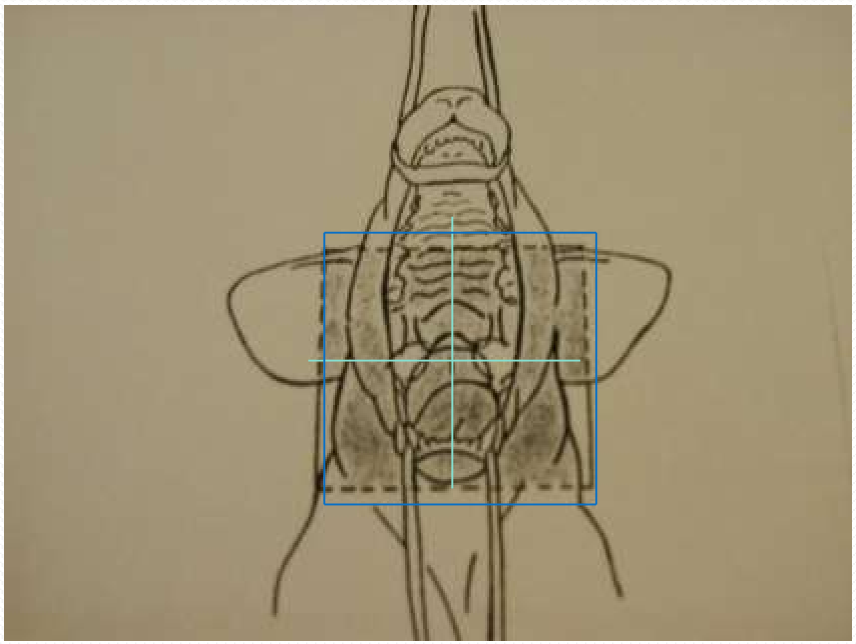
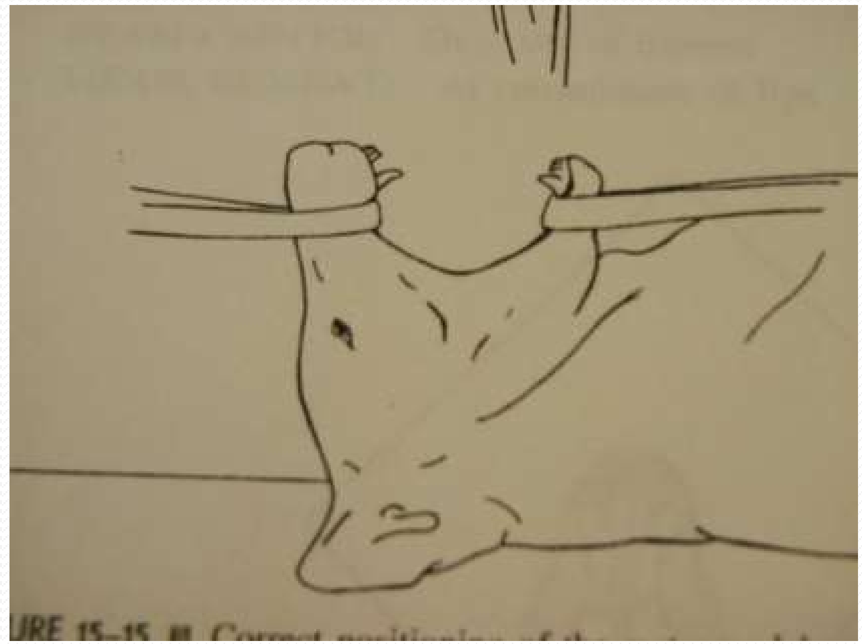


FIGURE 15–11 ■ Correct positioning for the rostrocaudal of the cranium.

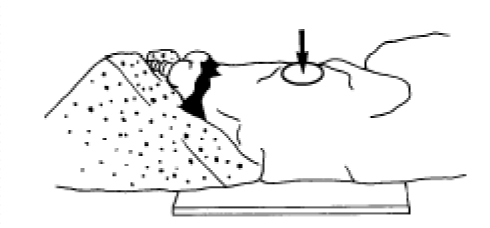
Skull Positioning-Rostrocaudal Tympanic Bulla



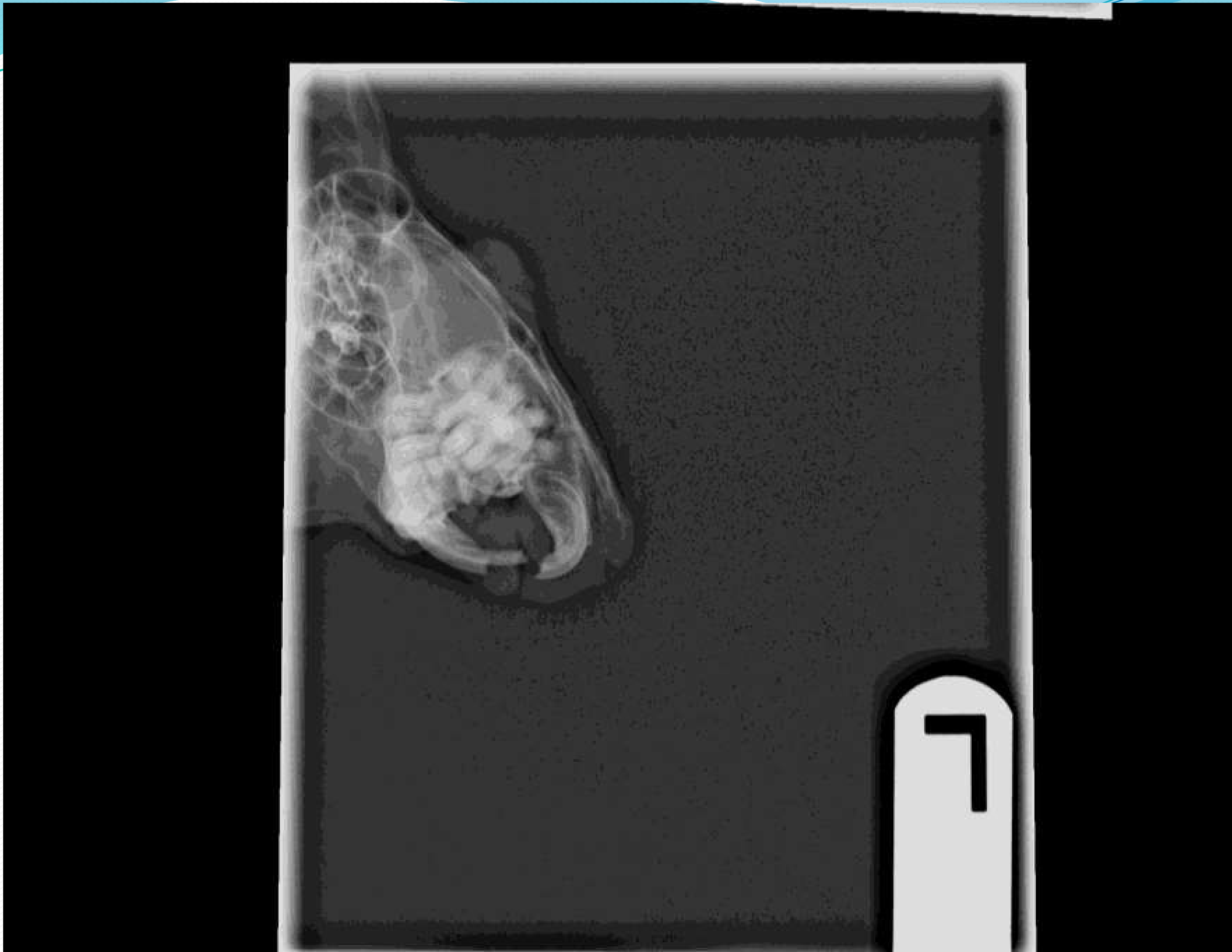


TMJ – lateral oblique's

- Anesthetized patient
- Lateral recumbency
- Elevate the nose with a wedge 15 degrees
- Rotate the head back 15 degrees
- Center the x-ray over the TMJ
- Do both obliques



Skull Positioning-Oblique


L

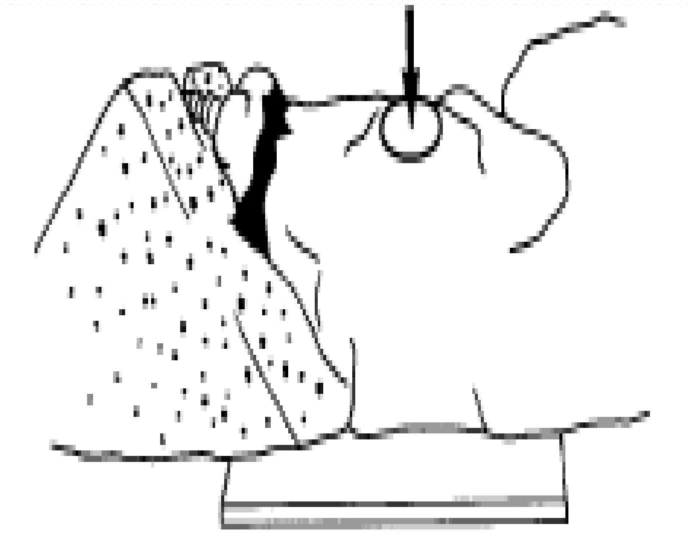
TMJ - ventrodorsal

- Anesthetized patient
- Sternal recumbency
- Occipital bone is perpendicular to the tabletop
- Center over the TMJ

Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Bulla – oblique's

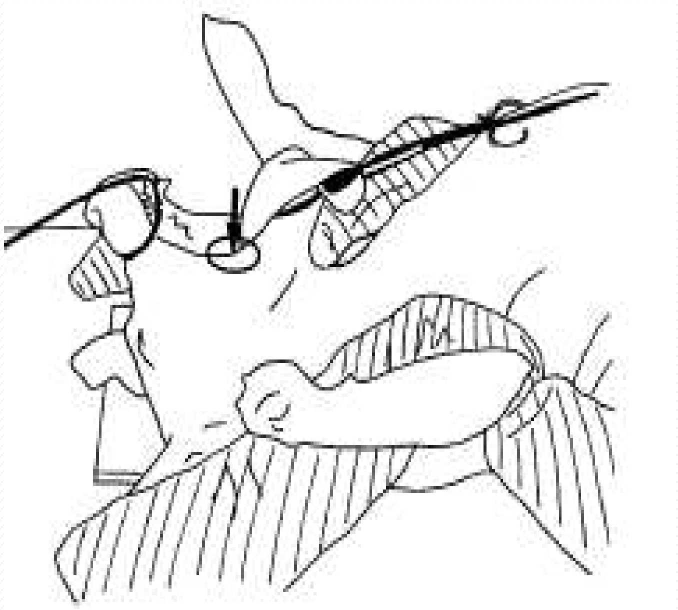
- Anesthetized patient
- Lateral recumbency
- Elevate nose 15 degrees
- Rotate head back 15 degrees
- Center the beam over the bulla region



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Bulla - ventrodorsal

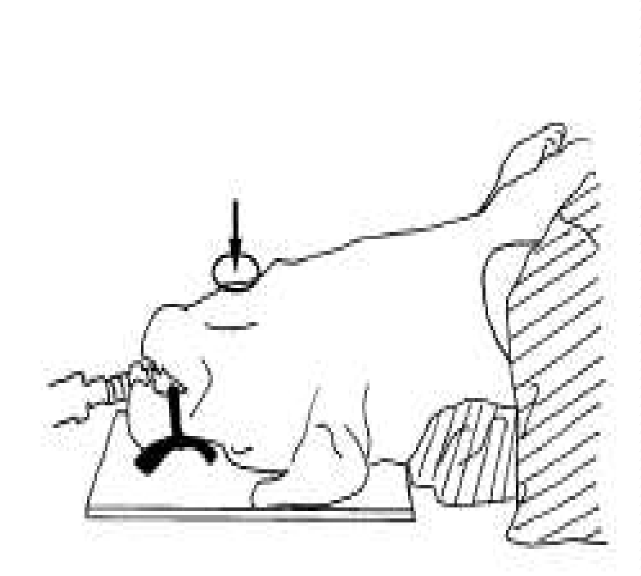
- Anesthetized patient
- Dorsal recumbency
- Nose pointing upward
- Prop the mouth open using tape
- Tape the endotracheal tube
- Ears are positioned laterally
- Center on the bulla



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

Bulla – vendrodorsal (closed mouth)

- Anesthetized patient in dorsal recumbency
- Tape the skull in a straight position
- Place ears laterally
- Center the beam to the bulla



Line drawing from: Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat.* (1st ed.). Oxford: Blackwell Sciences Ltd.

LARGE ANIMAL POSITIONING

Carpus joint

- Dorsopalmar view
- Lateral view
- Flexed lateral view
- Oblique views (lateral and medial)
- Skyline view

Tarsus joint

- Dorsoplantar view
- Lateral view
- Oblique views (lateral and medial)

Cont…

Elbow joint

- Craniocaudal view
- Lateral view

Shoulder joint

- Lateral view
- Caudocranial view
- Lateral view

Pelvis

- Ventrodorsal

Cont…

Skull

- Lateral

Guttural pouch /larynx/pharynx

- Lateral
- Dorsoventral

Teeth (mandibular and maxillary)

- Oblique
- Cervical spine
- lateral

References

- Coulson, A., Lewis, N. (Eds.). (2002). *An atlas of interpretive radiographic anatomy of the dog and cat*. (1st ed.). Oxford: Blackwell Sciences Ltd.
- Morgan, J.P. (Ed.). (1993). *Techniques of veterinary radiography*. (5th ed.). Ames (IW): Iowa State University Press.

CONTRAST RADIOGRAPHY

Contrast radiography

- Alters the radiodensity of the tissue itself or its surrounding structures to obtain radiography with enhanced visualization and demarcation
- The substance used for the purpose is called **contrast medium**
- In plain radiography no deliberate attempt is made to alter the density of the body tissues and at times, the demarcation of adjacent tissue is not clear due to lack of contrast

- The materials which increase radiodensity of structures or tissue in relation to surrounding tissues are called **positive contrast media**
- Those which relatively decrease the radiodensity are **negative contrast media.**
- In **double contrast radiography** two contrast media are used together.

The advantages of contrast radiography are;

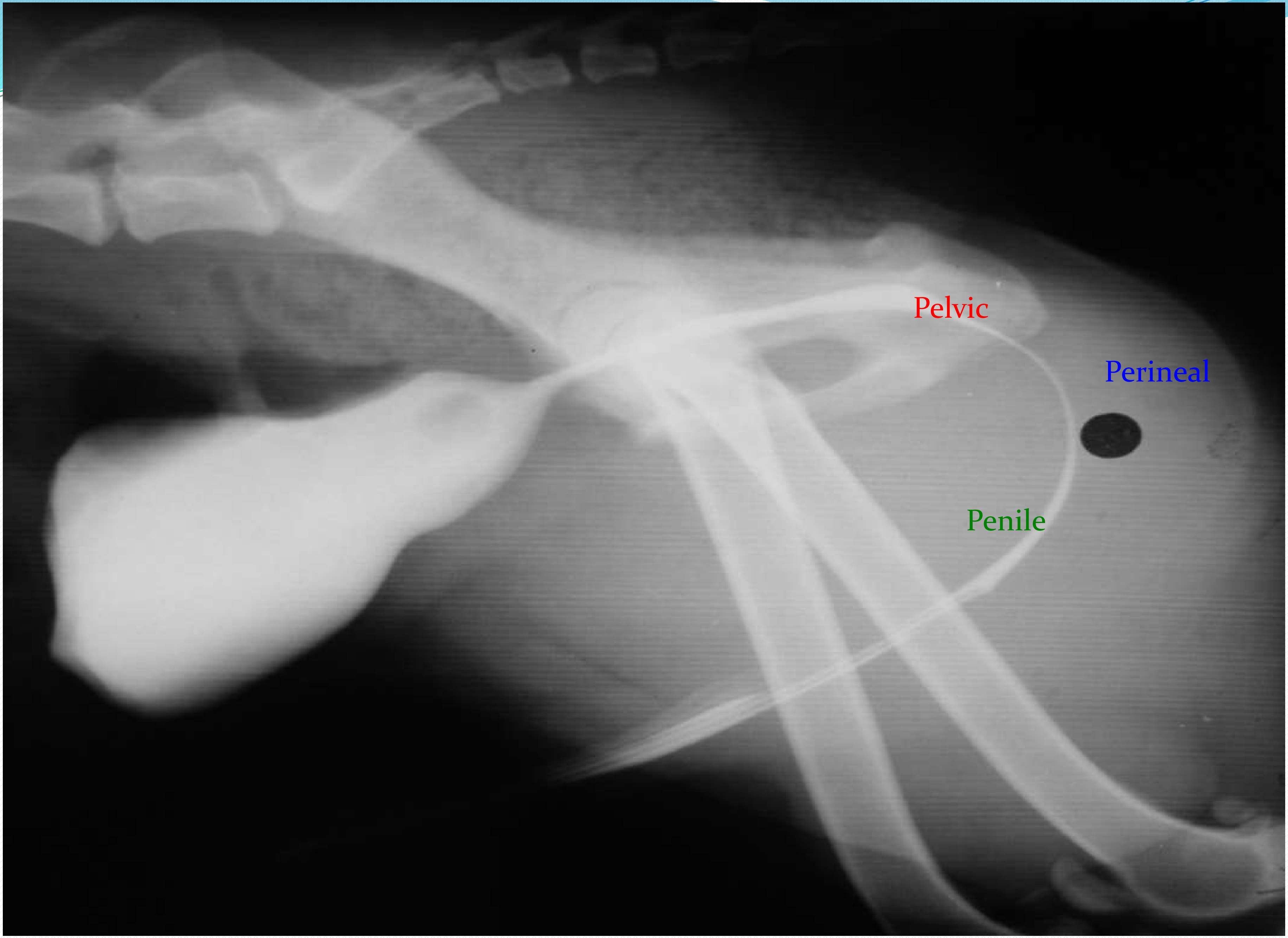
- Structures or organs can be evaluated more effectively for their size, shape and position.
- Valuable information can be gained regarding serosal and mucosal surfaces of hallow organs.
- In some instances some idea of the functions of the organs can be formed.

Positive contrast media

- Barium sulfate preparations e.g. barium suspension, barium meal and barium enema.
- Water soluble iodine preparations. It forms the largest single group of contrast media.
- Commonest conventional agents are ; sodium and meglumine salts of iothalamic, diatrizoic and metrizoic acid
- Cholycystapaques: these are excreted through biliary system e.g. sodiumiopodate.
- Viscous and oily preparations: e.g. propyliodine.

Negative contrast media

- ✓Most commonly used negative contrast media are; room air, carbon dioxide and oxygen. Gases are best used in double contrast studies.
- ✓Indications include arthrography, fasciography, pneumoperitoniography, pneumocystography etc.


Pelvic
Perineal
Penile

Contrast Techniques

1. Barium Series

Indicated to evaluate the structural and functional status of the gastrointestinal tract in small animals. It should be avoided if rupture of the stomach or intestine is suspected

Technique (Calves, Sheep & Goat)

- ✓ Keep the animal off feed for 36 hours and off water for 12 hours.
- ✓ Administer 0.5kg. Magnesium sulphate orally 24 hours before the study.
- ✓ 100gms.of activated charcoal given orally 12 hours before, to clear the gas in GI.tract.
- ✓ Give warm soap-water enema to clear the bowel.
- ✓ Administer 70% solution of barium sulphate @ 25-30ml/kg orally.
- ✓ Obtain lateral and ventrodorsal projections at various intervals.

2. Barium Enema

Indicated to outline the colon and rectum to rule out intramural or extraluminal obstructions. It should not be used if perforation is suspected.

Technique

- Keep the animal off feed for 36 hours and off water off water for 12hours.
- Give magnesium sulphate orally before 12 hours as a laxative.
- Give warm soap- water enema 2hours before.
- Sedate the animal deeply after controlling it in lateral recumbency.
- Raise the hind quarters for retention of contrast agent in the gut.

- Insert cuffed lubricated catheter into the rectum and inflate it.
- Administer micropulvarised barium sulphate 15-20% @15-20ml / kg.
- Obtain right lateral and ventrodorsal projections.
- Evacuate the contrast materials from the gut by elevating the cranial part of the abdomen

3. Barium Swallow (Esophagography)

Used to evaluate both structural and functional status of the esophagus after introduction of positive contrast agent.

The indications are;

- Esophageal obstruction
- Esophageal stenosis
- Esophageal diverticulum
- Esophageal perforations
- Esophageal mucosal diseases

Technique

- First obtain a survey radiograph of the area.
- Prepare barium suspension in water with the viscosity of light cream.
- Administer orally the barium swallow slowly (1-2ml / kg.).
- Make lateral radiograph of esophagus at the last swallow.

4. Reticulography

It is indicated to diagnose, reticular hernia in bovines.

Technique:

- Keep the animal off feed for 24 hours and off water for 12 hours.
- Administer orally thick barium suspension(1-2kg.).
- Restrain the animal in lateral recumbency.
- Take a lateral radiograph after 40minutes.
- It helps to differentially diagnose diaphragmatic hernia from pleurisy and pherinic abscess.

5. Pneumoperitoneography

Pneumoperitoneography is the radiographic study of the peritoneal cavity and its contents after introduction of a negative contrast agent.

If barium series and pneumoperitoneum are combined it is called double contrast peritoneography. These are indicated to visualize outline of various abdominal organs. It should not be used if diaphragmatic hernia is suspected because of the risk of pneumothorax.

Urinary Tract

Contrast examination of the urinary tract

3.Pneumocystography

- bladder emptying prior to examination
- 5-10 ml air (or CO_2)/kg
- indication: evaluation of the thickness of the bladder wall

Urinary Tract

Contrast examination of the urinary tract

3.Pneumocystography

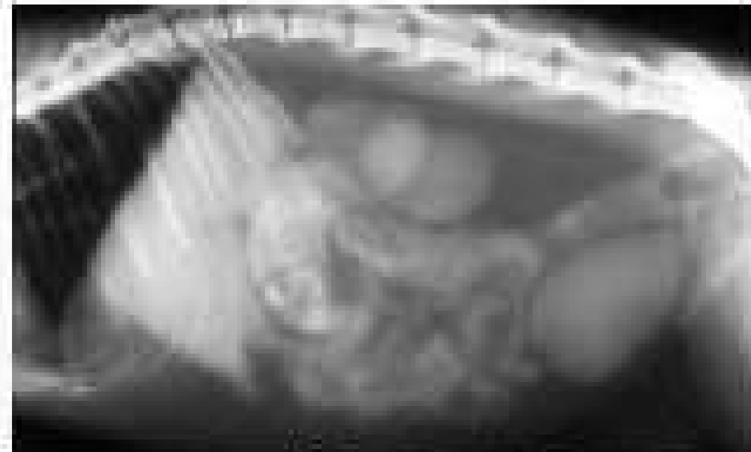
6. Arthrography

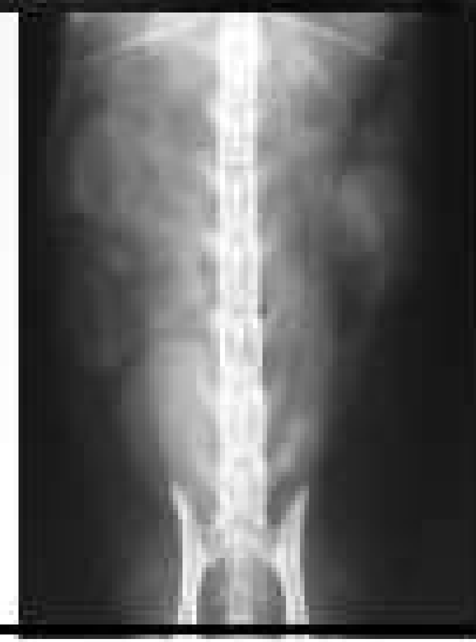
Used to visualize structures of a diarthrodial joint after injecting a positive or negative contrast medium or a combination of both. It is indicated to diagnose various joint abnormalities.

7. Intravenous Pylography

Refers to the contrast radiographic examination of the kidneys and ureters after intravenous introduction of a positive contrast agent like iothalmate. It will also give a rough index of kidney function. It is contraindicated in severely dehydrated patients.

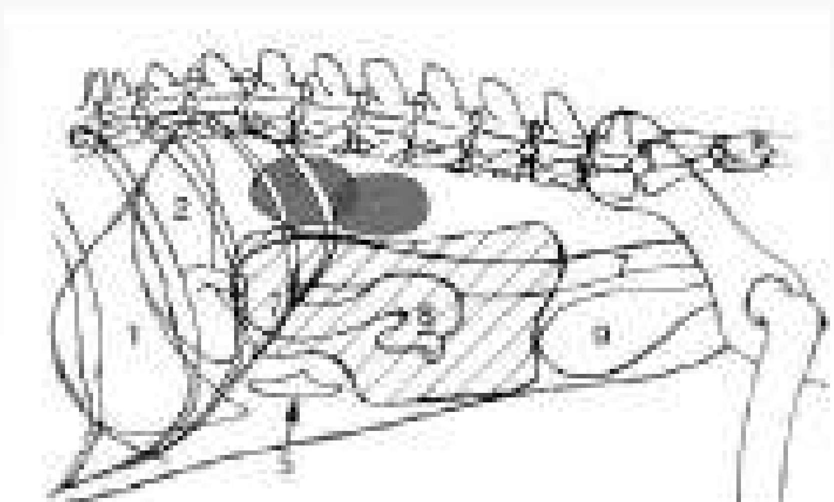
Radiography of the Urinary System





Kidneys

- position: retroperitoneum (craniodorsal)
- same size (L2x2-3)
- well defined (retroperitoneal fat)



8.Mylography

Contrast radiographic examination of the spinal cord and emerging spinal roots after injecting the contrast material, the metrizamide into the subarachinoid space. It is indicated for the diagnosis of intervertebral disc protrusion, intraspinal lesions and spinal cord edema.

Urinary Tract - Abnormalities

Urethra

Urethral calculi

- survey: radiopaque calculi

Urinary Tract - Abnormalities

Urethra

Narrowing of the urethral lumen

Urinary Tract - Abnormalities

Urethra

Urethral calculi

- filling defect

Urinary Tract - Abnormalities

Urethra

Rupture of the urethra

S. NO	Endoscopy	Contrast radiographic procedures
1	Gastrodudenoscopy-more sensitive	Less sensitive
2	Offers a chance for removal of FBs	No chance – only diagnosis
3	Can find the gastric lesions	Cannot accurately distinguish inflammations
4	Unnecessary surgery can be avoided	No chance
5	Biopsy can be taken	No biopsy can be taken

Double-contrast

studies using both air and a positive contrast agent (BaSo4) are more sensitive than positive contrast procedures, but are more difficult to perform. Contrast procedures are especially more useful if the foreign body absorbs or gets coated by the contrast material.

FILM PROCESSING

I. Dark Room

The darkroom procedures include;

- Loading of the film in a cassette.
- Unloading of the exposed film.
- Processing of the film to make latent image, visible for viewing.

II. Safe light system

The special illumination required for a radiographic darkroom is called a **safe light system** with a bulb of 10 watts.

III. Processing Tanks

The tanks used are made of either plastic or stainless steel. Four tanks are required, for developing, rinsing, fixing, and washing. The developing and fixing tanks must always remain covered with lids.

IV. Processing Solutions

a) **Developer** reduces exposed silver halide crystals of the film to metallic silver, which converts latent image into a visible one. Developer contains;

1. Reducing agent—Hydroquinone or metol. It reduces silver halide into metallic silver
2. Activator—Sodium carbonate -- To soften and swell film emulsion for the action of reducing agent.
3. Restrainer—Potassium bromide. It controls the activity of the reducing agent.
4. Preservative—Sodium sulphite. It controls rapid oxidation of reducing agent.
5. Solvent—Water is used as a solvent for chemicals.

B. Rinser: After developing, the film is rinsed to stop over developing and to avoid developer being carried to contaminate fixer. Rinsing should be done by agitating the film for 10 to 30 seconds. Rinsing may also be done in running water.

C) Fixer: Fixer contains;

- Fixing agent — Sodium thiosulfate or Ammonium thiosulfate. It acts to remove unexposed silver crystals.
- Acidifier – acetic acid or sulfuric acid -- To neutralize the developer.
- Hardener – Ammonium chloride or Ammonium sulfide. It shrinks and hardens the film emulsion.
- Preservative – Sodium sulfite – to maintain chemical balance of the agents used in the fixer solution.
- Solvent – water is used as solvent for chemicals.

V. Processing Techniques

Developing: Developing time is usually 4 to 5 minutes at 20^0C or as per the recommendations of the manufacturer.

Fixing: The fixing time is usually twice the developing time. At least 10 minutes will be required for hardening the film emulsion. Films are usually kept in the fixer for 20 minutes

- **Washing:** Film washing is done after fixing, to remove excess fixer and residual silver. It is done in a large tank with provision of running water.
- **Film drying:** After washing, the film is drained and hung up to dry. Films should not come in contact with each other and air should freely circulate around them. Drying cabinets with heating provision can be used to quicken the process.

PRINCIPLES OF RADIOGRAPHIC INTERPRETATION

- Quality radiographs, detection knowledge and correlation of significant radiographic findings with clinical data are essential.
- Radiography is not an absolute diagnostic tool but only an adjunct to clinical diagnosis.

- Each radiograph can only represent a fraction of a second in the life of a patient, and the development of disease process.
- The x-ray picture is a static image of a dynamic process.
- All the changes from the normal, should be used to build up an impression which can be related to disease process known to occur in that region.

- In order to interpret a radiograph for pathological lesion, it is essential that radiographic appearance of normal structures are known. The radiograph should be interpreted without any preconceived idea.

- For a given site, adequate evaluation usually requires a minimum of two views, to be made at 900 to each other (orthogonal views). To evaluate fractures and postoperative fracture repairs radiographs of the long bones must include the joints above and below the bone of interest.

- Serial radiographs are necessary for correct interpretation of dynamic process e.g. fracture healing and growth of bone tumors.

- Radiographic interpretation should be done when the film is dry. The emulsion swells when wet and details cannot be appreciated on wet films.
- It is helpful if the radiographs are always viewed using the same orientation, i.e. with the animal facing the viewer's left.

- Satisfactory radiographic interpretation is dependent on complete and systematic evaluation of all the information that is found on the film. Close attention should be paid to the variations in the outline and densities of the images in the film. Fine details of the radiograph should be examined minutely.

1.Important Factors for Accurate Interpretation

- The period of time during which the clinical signs have been present.
- The age, sex and breed
- The validity of history
- Possible complicating factors.

2. Viewing Box

- X-ray should be viewed only on a viewing box with subdued light. This optimizes the ability of the reader to differentiate the structures and to obtain the maximum information from the film.
- The darker the film, the more important is to read the film under ideal conditions. Radiograph has variable grey shades. Black areas indicate areas or structures of low density e.g. Air in Lungs. White areas indicate structures that have relatively high density e.g. Bone.

3. Distant Evaluation of X-ray

- Prior to closer view, initially the film should be evaluated from a distance of several feet, in order to get an overall impression before concentrating on details.

Then start assessing the radiograph itself for;

- Quality of the film
- Processing artifacts and other artifacts
- Exposure factors & penetration of the part of interest
- Sufficient radiographic density & contrast
- Elimination of motion during exposure
- Approximate age of the patient
- Soft tissue abnormalities
- Bone outline and internal structures.

4. Asses the Identified Abnormality

- Ensure that it is real and confirm it on another view.
- Asses the possibilities due to overlapping of bones or soft tissues.
- Differentiate normal variations and real abnormalities e.g. Nutrient foramen.
- Explain the radiolucent zone - whether due to introduction of air during injection of local analgesics.

5. Describe the radiographic lesion in radiographic terms.

- Terms like smooth, regular, well defined etc. It will lead towards a conclusion of normal, benign or long standing lesion.
- Other terms such as roughened, irregular, sharp, poorly demarcated or destructive, lead to conclusions of active disease.
- Other pathological lesions also should be considered.

6. Assessment of the Duration of the Lesion

- Osteophite formation less than three weeks
- Incomplete fracture takes 2 weeks to become visible
- Active bone lesions have irregular margins and less opaque than parent bone
- Inactive bone changes appear generally smooth, regular and uniformly opaque
- Scars in bone, as in other tissue, do not model.

The purpose of x-ray in facture is to asses;

- The type and severity
- The degree of displacement
- The damage to adjacent joint
- The damage to soft tissue
- The degree of reduction achieved.

7. For Interpretation of Skeletal X-Rays

- For detection fractures and dislocations, one x-ray is not enough
- For correct assessment of fracture at times more than one view is required
- Obtain minimum two views at right angles for all suspected fractures and dislocations
- The films must show the joint above and below any suspected fracture of the limbs
- The tendon or vascular damage cannot be seen on routine x-rays
- Fractures of the shaft of bones are easily seen when there is break in the thick cortex

- When an obvious injury is seen, continue searching, as there may be other abnormalities
- In non-union, the fracture line persists, the broken ends of the bone appear whiter
- For best visualization of a fracture, the x-ray beam must be parallel with the plane of fracture
- All the changes from the normal should be used to build up an impression, which can be related to disease process known to occur in that region
- Serial radiographs are necessary for correct interpretation of dynamic process e.g. fracture healing and growth of bone tumors.

- A working diagnosis can then be formed, which will complement any laboratory findings and other imaging techniques and to help to confirm a clinical diagnosis.
- There is no substitute for a good clinical diagnosis and examination, and radiograph should only be used as an aid to clinical diagnosis.

The Radiographic Features of a few Specific Conditions

1. Fracture – Evaluation of normal healing pattern

- A lucent line or lines noticed at the beginning
- Osteocalcin along the fracture line within 5 days
- Bridging calcified periosteal callous formation
- Remodeling of callus with restoration of continuity of the modularly cavity and cortex
- Reformation of the normal trebacular pattern from one fragment to another.

2. Fracture - Non-union

- The irregular translucent fracture line present
- The broken ends of the bone appear whiter (sclerotic)
- There is often thick new bone around the fracture
- There may be movement clinically
- Obliteration of the medullary cavity.

3. Dislocation

- Malalignment and displacement of the apposing articular surfaces
- Disruption of adjacent fascial plane
- Periarticular soft tissue swelling.

4. Septic Arthritis

- Periarticular soft tissue swelling and distension of joint capsule
- In early stages – increase in joint space due to synovial effusion
- As the disease progresses – Narrowing of the joint space due to destruction of the articular surface
- In Advanced cases – Widening of joint space due to subchondral bone destruction.

5. Degenerative Joint Diseases

- Spurs/osteophyte formation along the articular margins of the bones (Lipping)
- Increased density of the articular ends the bones
- Narrowing or collapse of the joint space
- Intra-articular and /or Periarticular calcification may also be present.

6. Lungs – Pneumonia

- Lung markings increased both in size and number
- Increased patchy densities with irregular and indistinct borders
- In aspiration pneumonia – Irregular poorly defined areas of increased density noticed.

7. Pericarditis

- Cardiac shadow appears rounded and enlarged
- If traumatic in origin – Foreign body embedded in the pericardium may be visible.

- Thus to read a radiograph successfully, it is important to relate the changes seen to known behavior of tissues under consideration, rather than relating radiographic appearance to a clinical condition seen before.

- It is also important to remember that each radiograph can only represent a fraction of a second in the life of a patient, and the development of disease process.
- The x-ray picture is a static image of a dynamic process.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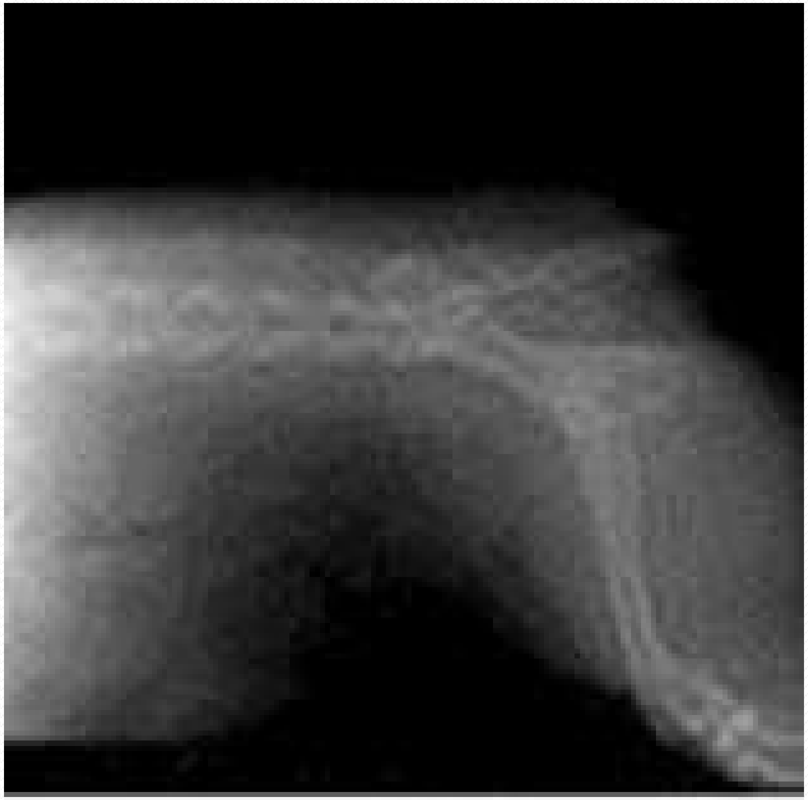

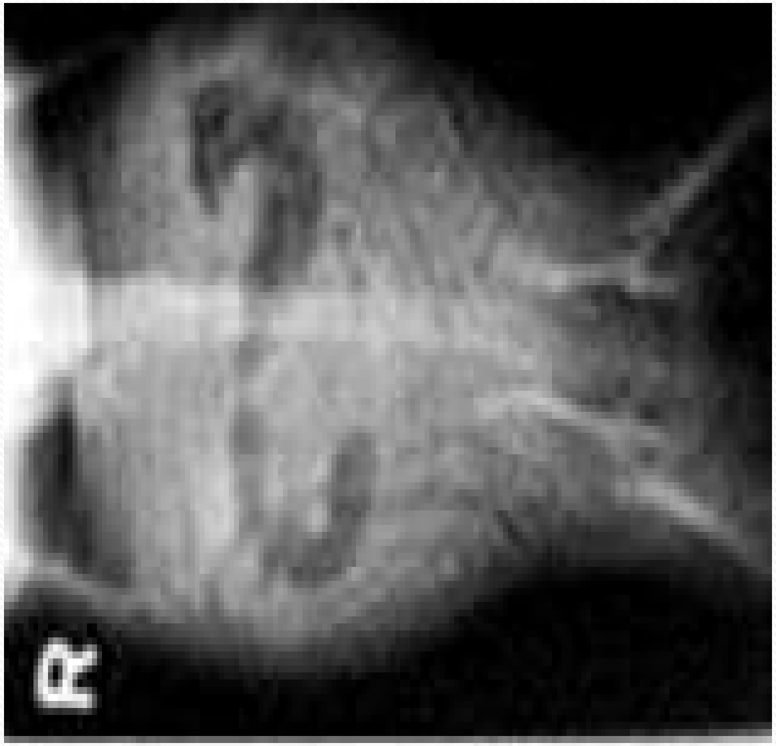
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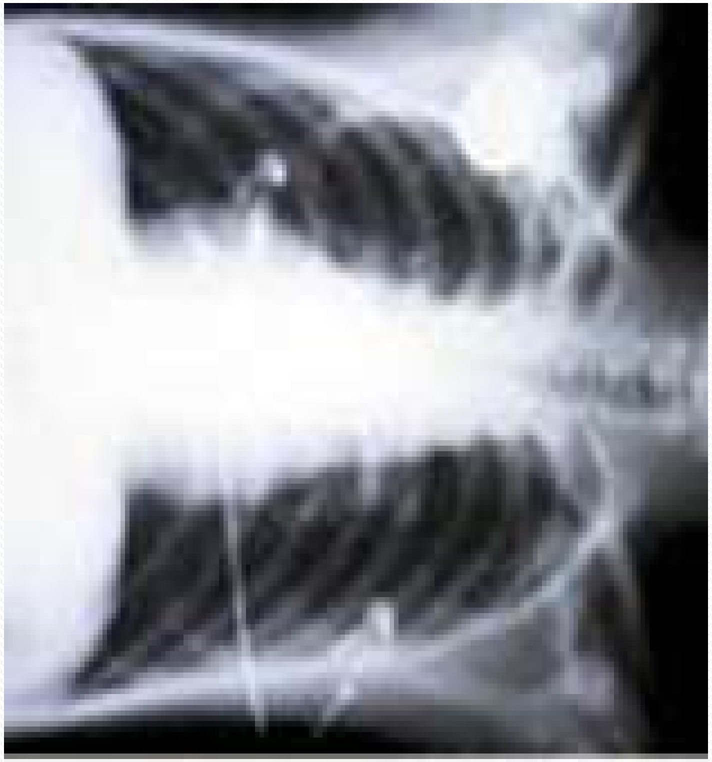


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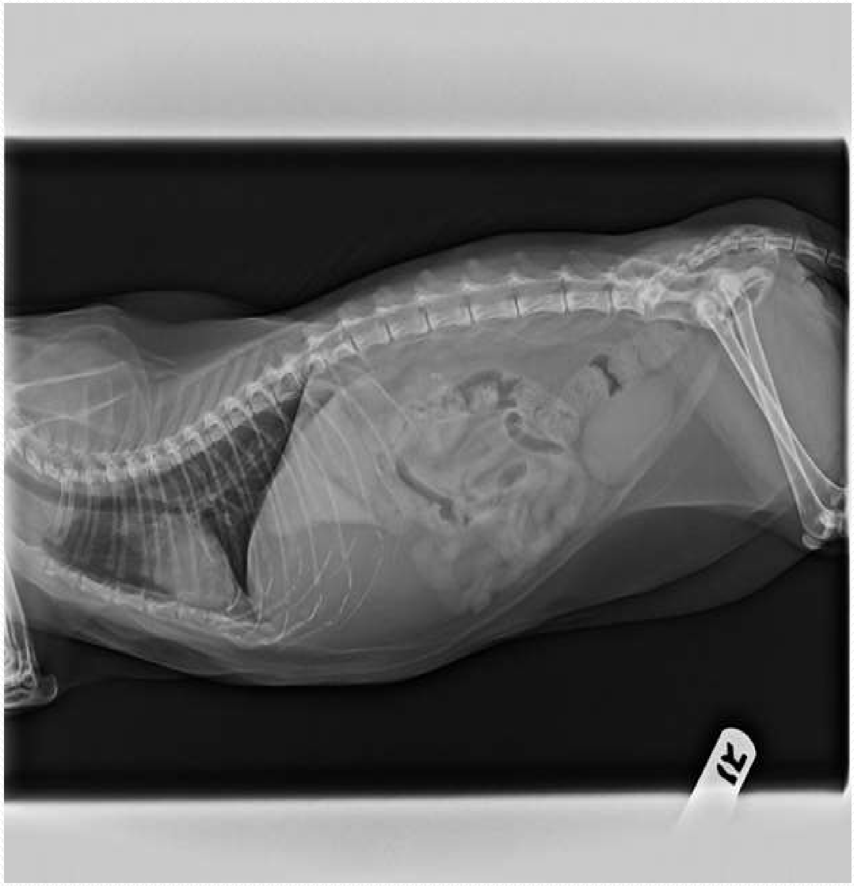

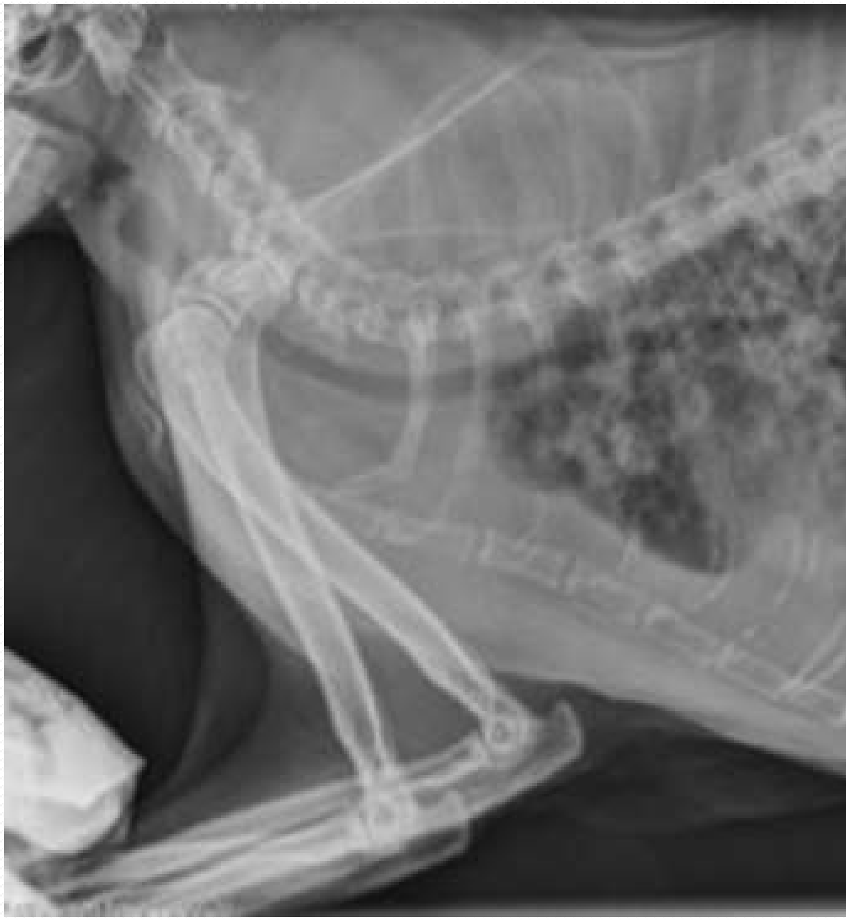
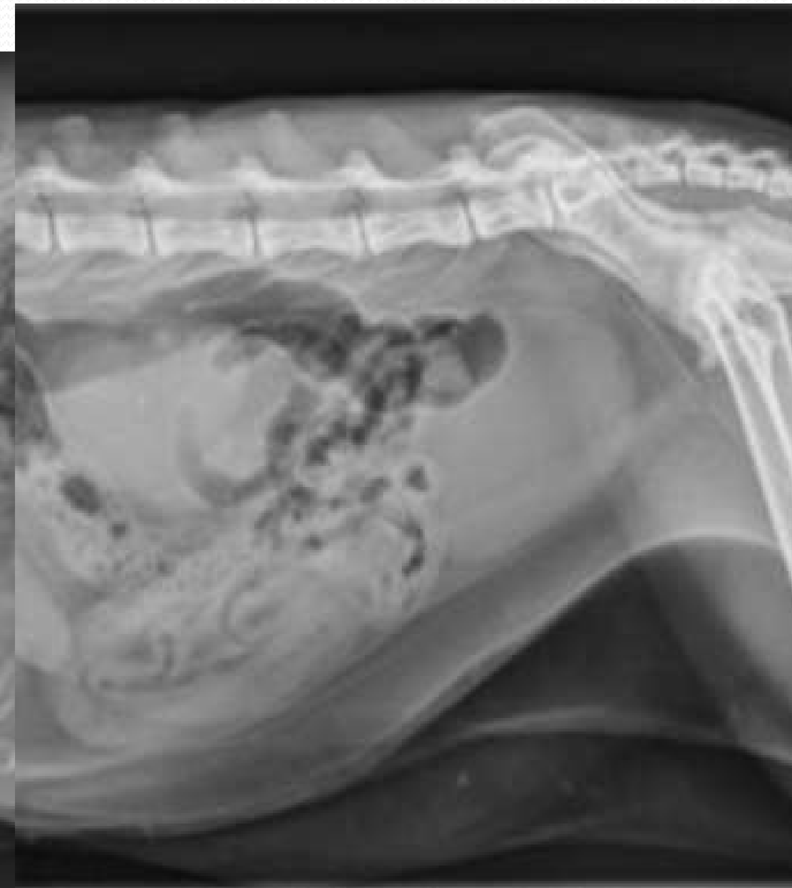

RADIATION SAFETY

Radiation exposure to man usually results from diagnostic as well as therapeutic radiation devices. Veterinary practice exposes veterinarians and their coworkers to definite risks. It is the responsibility of the veterinarian, to enforce radiation safety measures in the radiological section and to educate other personnel about the potential hazards of radiation.

I. Biological Effects of Radiation

The x-ray beam while traversing the tissue forces the electrons to be ejected from the atomic lattice. Once absorbed by the tissues, all types of radiation produce changes in the living cells. The cellular injury causes pathological and physiological changes leading to 'radiation sickness'

After transfer of radiant energy to the atoms and molecules in the form of excitation and ionization, direct and indirect effects of radiation are produced. The direct effect appears due to absorption of energy by the molecules. Indirect effects are caused by the products of radiation decomposition (radiolysis) of water and other solutes of the body.

After radiolysis of water in the cells, there is formation of ‘free radicals’ with ‘unpaired electrons’. These free radicals and the H_2O_2 formed by them are highly reactive and mutagenic. This may be one of the chief mechanism by which the damage is caused by the ionizing radiation, as 80% of the biological system is water.

Radiation sensitivity of body cells refers to the loss of reproductive capability of the proliferating cells. Since, the radiation damage is usually mitotic linked, cells regularly proliferating, such as stem cells of hemopoitic systems and cells of the gut, skin and testes are more radiosensitive. The cells which do not proliferate, such as nerve and muscle cells are relatively radioresistant.

II. Radiation Protection

X-rays are only dangerous if you are careless. Keeping in view of the magnitude of the radiation hazards, radiation safety has assumed greater significance in routine clinical practice. Sometimes radiation safety practices are neglected on the ground that too much time and effort is required. None of these excuses, however, justifies the unsafe use of radiation. X-rays can cause harm even though we do not see or feel them

III. Radiation Precautions

- Never hold the x-ray cassette with hands during an exposure. Cassette holders or general anesthesia should be used.
- Lead aprons and gloves should be worn by the individuals assisting x-ray examinations.
- Personnel not required for assistance should leave the immediate area.
- Lead aprons and gloves should be worn by the individuals assisting x-ray examinations

- X-ray beam should be collimated and a light beam diaphragm used to enable maximum collimation. No part of any attending person, even if covered with protective clothing, should be placed in the primary beam.
- Primary beam filtration should be done.

- Personnel used in radiographic work should be rotated at intervals, if possible.
- Pregnant women and persons under 18 years of age should not be involved in radiographic work.
- Fast speed screens (e.g. rare earth screens) may be used to reduce exposure factors.
- Correct x-ray exposures and proper dark room techniques should be used to avoid repeated unnecessary exposures.

- All personnel working with and around x-ray machines should be monitored using film batch system (Radiation safety monitoring badge).
- A notice should be posted prominently near the x-ray unit, indicating potential hazards of radiation and need to wear protective apparels.

- Radiation survey by qualified experts should be carried out at periodic intervals to check safety precautions and possible radiation leakage from the equipments.

ULTRASONOGRAPHY

- Ultrasonography means imaging with ultrasound.
- The sound waves are reflected by tissue interfaces to produce echoes, which are in turn detected by the transducer and converted into a signal to produce images.
- It is an interactive process involving the sonographer, patient, transducer, sonographic instrument and sonologist.
- ***Transducers*** convert electric into ultrasound energy and vice versa.

- Ultrasound is generally defined as an auditory frequency beyond perceived by the human ear.
- Most humans hear and emit sound in the frequency range 2 to 20 kHz, while in some animals ranges are much greater.
- Bats, dolphins, many rodents and some insects have ranges that extend as high as 120 kHz – well beyond the limit of human detection.
- Ultrasound, in the range of ***1 million to 10 million hertz***, is used in non-invasive diagnostic imaging of internal body structures.

- Ultrasound does not produce an image, as sharp and clear as CT, but it has four singular advantages.
  - It **does not employ ionizing radiation** and so no biological injury is produced.
  - It can be employed in transaxial plane or sagitally or at any chosen obliquity as required by the anatomic region being investigated.
  - It is far less expensive than CT or MRI.
  - It can even be performed portably at the bed side of very sick patients.

- The organs usually scanned are liver, kidney, urinary bladder, spleen, uterus, ovaries teat and udder.
- In ruminants and equines, a rectal linear scan head is used for the diagnosis of ovarian and uterine disorders. In small animal and equine practice ultrasound is routinely used as a diagnostic aid.

❑ Real – time scanning produces, moving images e.g. heart movements in a fetus.

Sonogram – Ultrasound scan.

Sonologist – Specialist in Ultrasonography.

- The ultrasound image is produced by interactions of ultrasound pulses with the anatomical structures within the animal body.
- The absorption of the ultrasound as it passes into and back out of the body is generally undesirable because it limits the depth of imaging, it adversely affects the amplitude of echoes that form the image, and can be the source of artifacts.

- The size of the ultrasound pulse at different depths within the imaged area determines the amount of blurring and image detail.
- Ultrasound pulses have several physical characteristics that should be considered by the user in order to adjust the imaging procedure for specific diagnostic applications.
- An understanding of the physical characteristics of ultrasound and how it interacts with the body enhances the ability to analyze images and make accurate diagnostic decisions.

- Sound is a physical phenomenon that transfers energy from one point to another.
- In this respect, it is similar to radiation. It differs from radiation, however, in that sound can pass only through matter and not through a vacuum as radiation can.
- This is because sound waves are actually vibrations passing through a material.
- If there is no material, nothing can vibrate and sound cannot exist.

- One of the most significant characteristics of sound is its frequency, which is the rate at which the sound source and the material vibrate.
- The basic unit for specifying frequency is the hertz, which is one vibration, or cycle, per second.
- Pitch is a term commonly used as a synonym for frequency of sound.

- The source of sound is a vibrating object, the piezoelectric transducer element.
- Since the vibrating source is in contact with the tissue, it is caused to vibrate.
- The vibrations in the region of tissue next to the transducer are passed on to the adjacent tissue.
- This process continues, and the vibrations, or sound, is passed along from one region of tissue to another.
- The rate at which the tissue structures vibrate back and forth is the frequency of the sound.
- The rate at which the vibrations move through the tissue is the velocity of the sound with an increased pressure.

- The sound in most diagnostic ultrasound systems is emitted in pulses rather than a continuous stream of vibrations.
- At any instant, the vibrations are contained within a relatively small volume of the material. It is the volume of vibrating material which is referred to as ***ultrasound pulse***.
- In soft tissue and fluid materials the direction of vibration is the same as the direction of pulse movement away from the transducer.

- This is characterized as longitudinal vibration as opposed to the transverse vibrations that occur in solid materials.
- As the longitudinal vibrations pass through a region of tissue, alternating changes in pressure are produced.

- The frequency of ultrasound pulses must be carefully selected to provide a proper balance between image detail and depth of penetration.
- In general, high frequency pulses produce higher quality images.
- The frequency of sound is determined by the source.
- The major element within the transducer is a crystal designed to vibrate with the desired frequency.

- A special property of the crystal material is that it is piezoelectric.
- This means that the crystal will deform if electricity is applied to it.
- If the transducer is activated by a single electrical pulse, the transducer will vibrate, or "ring," for a short period of time.
- This creates an ultrasound pulse as opposed to a continuous ultrasound wave.

- The ultrasound pulse travels into the tissue in contact with the transducer and moves away from the transducer surface.
- A given transducer is often designed to vibrate with only one frequency, called its *resonant frequency*.
- Therefore, the only way to change ultrasound frequency is to change transducers.
- This is a factor that must be considered when selecting a transducer for a specific clinical procedure.
- Certain frequencies are more appropriate for certain types of examinations than others.
- Some transducers are capable of producing different frequencies.
- For these the ultrasound frequency is determined by the electrical pulses applied to the transducer.

Factors Related to Ultrasound

Velocity

- The significance of ultrasound velocity is that it is used to determine the depth location of structures in the body.
- The velocity with which sound travels through a medium is determined by the characteristics of the material and not characteristics of the sound.

Material ---------------Velocity (m/s)

- Air ---------------------330
- Water ----------------1497
- Metal -----------------3000 - 6000
- Fat ---------------------1440
- Blood -----------------1570
- Soft tissue **-----------**1540

Wavelength

- It has an effect on image quality.
- The number of cycles within a pulse is determined by the damping characteristics of the transducer.
- Damping is what keeps the transducer element from continuing to vibrate and produce a long pulse.

Reflection

- The reflection of ultrasound pulses by structures within the body is the interaction that creates the ultrasound image.
- It occurs at the interface, or boundary, between two dissimilar materials.
- In order to form a reflection interface, the two materials must differ in terms of a physical characteristic known as ***acoustic impedance Z.***

- Acoustic impedance is a characteristic of a material related to its density and elastic properties.
- Since the velocity is related to the same material characteristics, a relationship exists between tissue impedance and ultrasound velocity.

The Ultrasound Imaging System

- The Principal Functional Components of an Ultrasound Imaging System:

Digital computer electronics

- To control most of the functions in the imaging process.

Transducer

- Is the component of the ultrasound system placed in direct contact with the patient's body.
- It alternates between two major functions:

  (1) Producing ultrasound pulses and

  (2) Receiving or detecting the returning echoes.
- Within the transducer there are one or more piezoelectric elements.
- When an electrical pulse is applied to the piezoelectric element it vibrates and produces the ultrasound.
- Also, when the piezoelectric element is vibrated by the returning echo pulse it produces a pulse of electricity.
- The transducer also focuses the beam of pulses to give it a specific size and shape at various depths within the body and also scans the beam over the anatomical area that is being imaged.


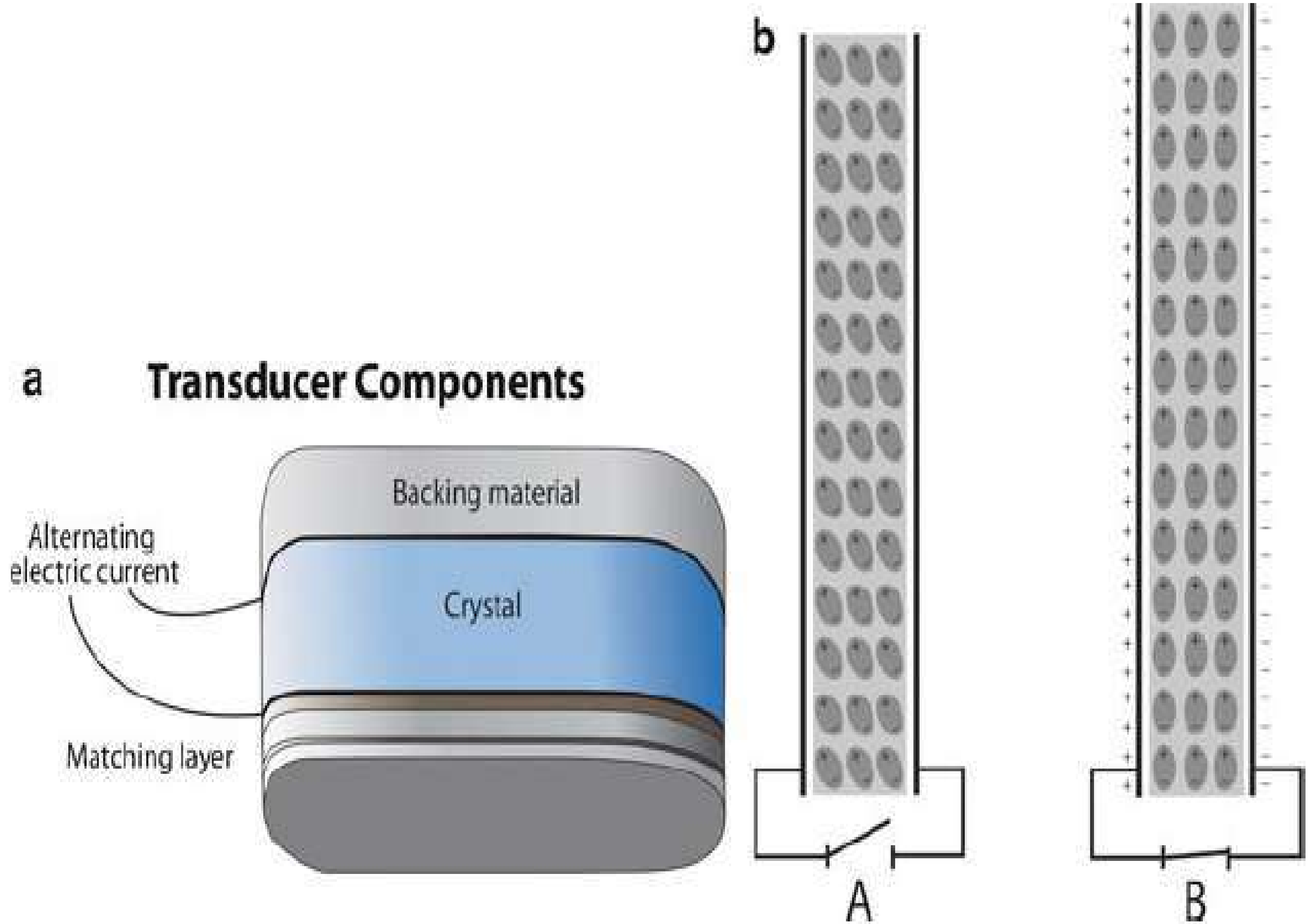

Fig. 2.3 (a) The transducer is comprised of piezoelectric crystals surrounded by insulating material and matching layers at the exit port which allow ideal transmission of the sound waves through the skin into the tissues. (b) Piezoelectric crystals elongate and shorten with realignment of the crystal dipoles in response to applied alternating current

Pulse Generator

- The pulse generator produces the electrical pulses that are applied to the transducer.
- For conventional ultrasound imaging the pulses are produced at a rate of approximately 1,000 pulses per second.

Amplification

- Is used to increase the size of the electrical pulses coming from the transducer after an echo is received.
- The principal control associated with the amplifier is the time gain compensation (TGC)

Scan Generator

- The scan generator controls the scanning of the ultrasound beam over the body section being imaged.
- This is usually done by controlling the sequence in which the electrical pulses are applied to the piezoelectric elements within the transducer.

Image Processor

- The digital image is processed to produce the desired characteristics for display.
- This includes giving it specific contrast characteristics and reformatting the image if necessary.

Display

- The digital ultrasound images are viewed on the equipment display (monitor) and usually transferred to the physician display or work station.
- One component of the ultrasound imaging system that is not shown is the ***digital storage device*** that is used to store images for later viewing if that process is used.

Echopattern	Visible color	Type of lesion
Hypoechoic or echo poor	Black color	Cystic mass
Hyperechoic or echogenic	White color	Solid mass
Mixed echogenicity	Gray color or areas of black & white color	Complex mass

ULTRASOUND MACHINE


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PHOTOACOUSTIC IMAGING

What is photoacoustic

- Conversion of photons to acoustic wave due to absorption and localized thermal excitation.
- Pulses of light is absorbed, energy will be radiated as heat.
- Heat causes detectable sound waves due to pressure variation.
- Mostly used in tumor detection

Endogenous PA contrast:

- Melanin
- Oxy Hemoglobin
- Deoxy Hemoglobin

Exogenous PA contrast (Highly sensitive to deeply situated tumors):

- Alexa Fluor
- Indocyanine Green

Advantages

1. Ability to detect deeply situated tumor and its vasculature
2. Monitors angiogenesis
3. High resolution
4. Compatible to Ultra Sound
5. High Penetration depth

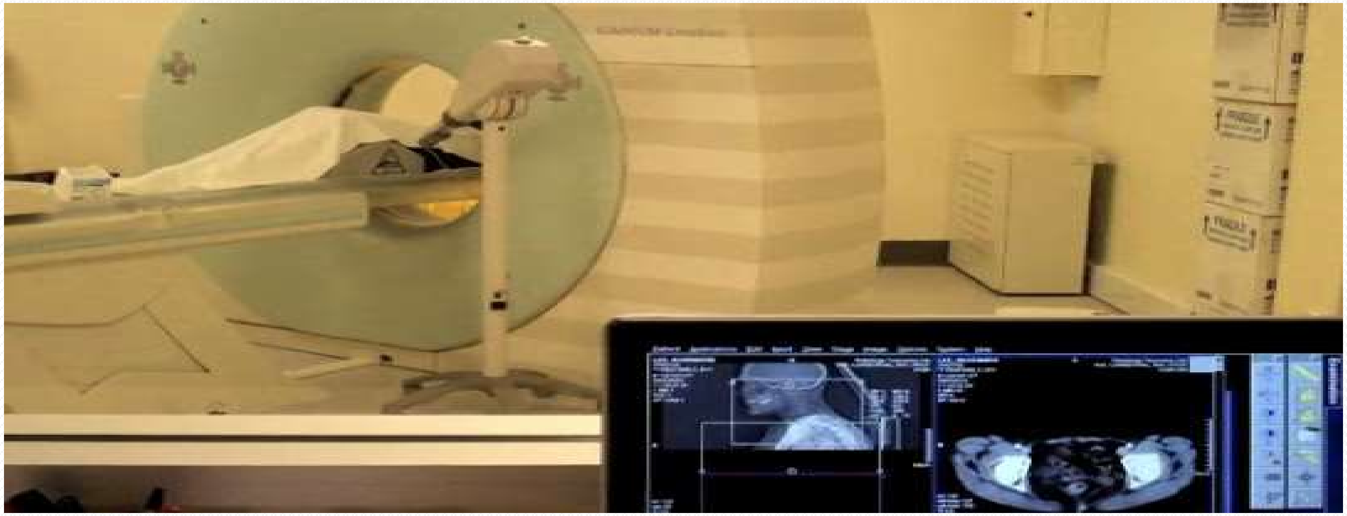
Disadvantages

1. Limited Path length
2. Temperature Dependence
3. Weak absorption at short wavelengths

Computed Tomography Scan (CT Scan)

Brief Overview

- CT Scan is used for diagnostics
- Doctors can't always make a diagnosis
- CT scan use radiation to take X-Rays (slices) of the body
- CT scans take slices and turn into 3D images



History

- (early 1900's) Alessandro Vallebona (Italy) had the idea of taking slices of the body for imaging (Tomography)
- (1971) First CT Scan performed
- (1974) CT Scanners installed
- The inventors of the CT scan are credited as Godfrey Hounsfield (Britain) and Allan Comrack (South Africa).

State of the Art

- Widely prevalent
- Over the past 20 years their use has increased greatly
- 3D imaging, and better clarity

CT vs MRI

- CT Scans are usually cheaper
- CT Scans are typically better at showing bones than MRI, but less effective at showing the soft tissue
- CT scans take around 5 minutes, MRI's usually take 30 minutes
- CT scans can be harmful to the patient, while MRI's have no known biohazards
- Both used for for detecting cancer

Limitations

- In order for better clarity, more exposure to radiation is necessary
- Human error in reading scans
- Not very good at depicting soft tissue
- In order to change the image plane you have to move the patient, unlike with MRI.

Future of CT Scans

- Discovery CT750
- Clearer Imaging due to Garnet detector material
- Less radiation exposure
- Faster

Positron Emission Tomography (P.E.T)

What is PET

- PET is a noninvasive, diagnostic imaging technique for measuring the metabolic activity of cells.
- It was developed in the mid 1970s and
- It was the first scanning method to give functional information about the brain.
- Existence first postulated in 1928 by Paul Dirac
- First observed in 1932 by Carl D. Anderson, who gave the positron its name.

What is a Positron?

- A Positron is an anti-matter electron, it is identical in mass but has an apposite charge of +1.
- Positron can come from different number of sources, but for PET they are produced by nuclear decay.
- Nuclear decay is basically when unstable nuclei are produced in a cyclotron by bombarding the target material with protons, and as a result a neutron is released.
- In PET the target material is chosen so that the product of the bombardment decays to a more stable state isotope by emitting a positron.

What happens after the positron is obtained?

- Left over energy from the nuclear decay process is shared between the positron and the departing neutrino (a particle smaller than an atom without charge).
- Because of conservation of energy and momentum the positron is forced to stay and thus become useful.
- Positron begins its activity in colliding with other particles and gradually losing its kinetic energy and thus slowing down.

Annihilation of a positron and electron

- The positron will encounter an electron and completely annihilate each other resulting in converting all their masses into energy.
- This is the result of two photons, or gamma rays.
- Because of conservation of energy and momentum, each photon has energy of 511keV (kilo electric volt) and head in an almost 180 degrees from each other.
- 511keV is the ideal rest state annihilation value.

How do we detect photons (gamma rays)?

- PET detects these photons with a PET camera which allows to determine where they came from, where the nucleus was when it decayed, and also knowing where the nucleus goes in the body.

What are some of the uses for PET

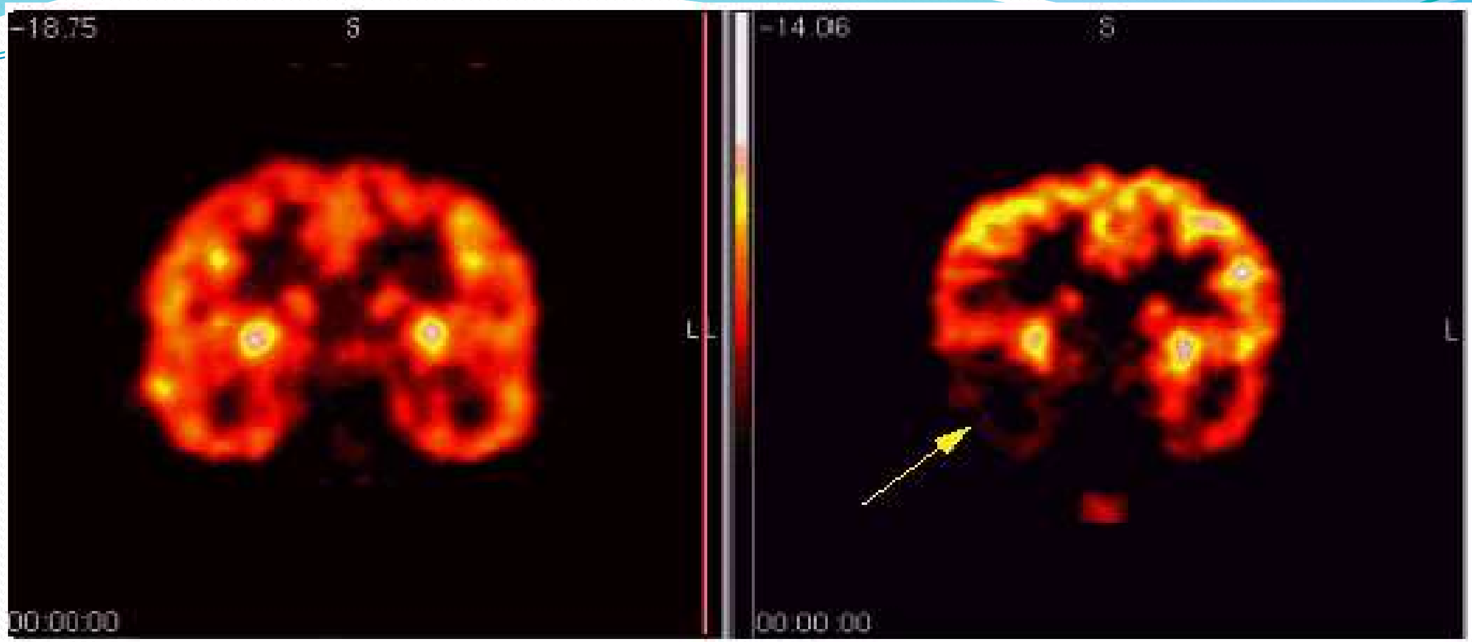
- Patients with conditions affecting the brain
- Heart
- Certain types of Cancer
- Alzheimer's disease
- Some neurological disorders

Htt://www.nucmed.buffalo.edu/petdef.htm

Patients with brain disorders

- PET scans of the brain are used to evaluate patients who have memory disorders of an undetermined cause, suspected or proven brain tumors or seizure disorders that are not responsive to medical therapy and are therefore candidates for surgery.

http://www.radiologyinfo.org/content/petomography.htm



Normal brain

Image of the brain of a 9 year old female with a history of seizures poorly controlled by medication. PET imaging identifies the area (indicated by the arrow) of the brain responsible for the seizures. Through surgical removal of this area of the brain, the patient is rendered "seizure-free".

Htt://www.nucmed.buffalo.edu/petdef.htm

Heart Conditions

- PET scans of the heart are used to determine blood flow to the heart muscle and help evaluate signs of coronary artery disease. PET scans of the heart can also be used to determine if areas of the heart that show decreased function are alive rather than scarred as a result of a prior heart attack, called a myocardial infarction. Combined with a myocardial perfusion study, PET scans allow differentiation of nonfunctioning heart muscle from heart muscle that would benefit from a procedure, such as coronary bypass for instance.

http://www.radiologyinfo.org/content/petomography.htm

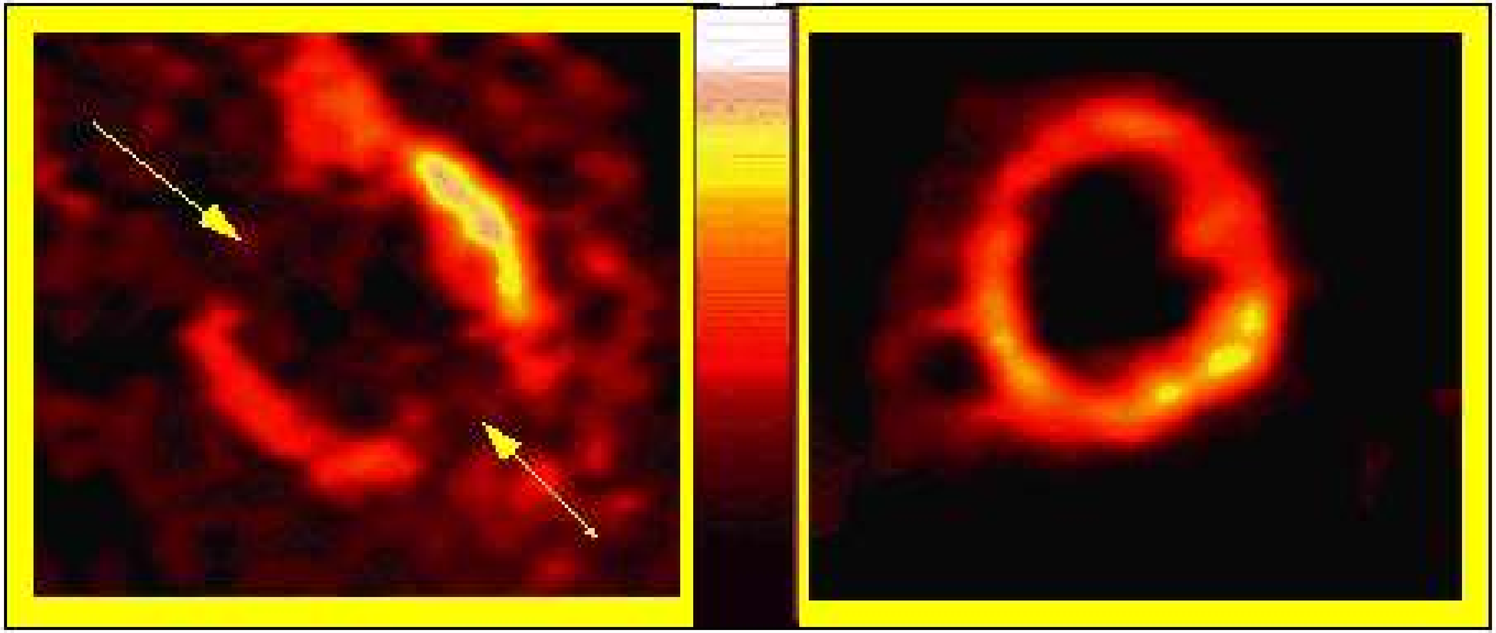


Image of heart which has had a mycardial infarction (heart attack). The arrow points to areas that have been damaged by the attack, indicating "dead" myocardial tissue. Therefore, the patient will not benefit from heart surgery, but may have other forms of treatment prescribed.

Normal heart

Htt://www.nucmed.buffalo.edu/petdef.htm

Cancer Patients

- Used to determine if there are new or advancing cancers by analysis of biochemical changes.
- It is used to examine the effects of cancer therapy by characterizing biochemical changes in the cancer. PET scans can be performed on the whole body.

http://www.radiologyinfo.org/content/petomography.htm

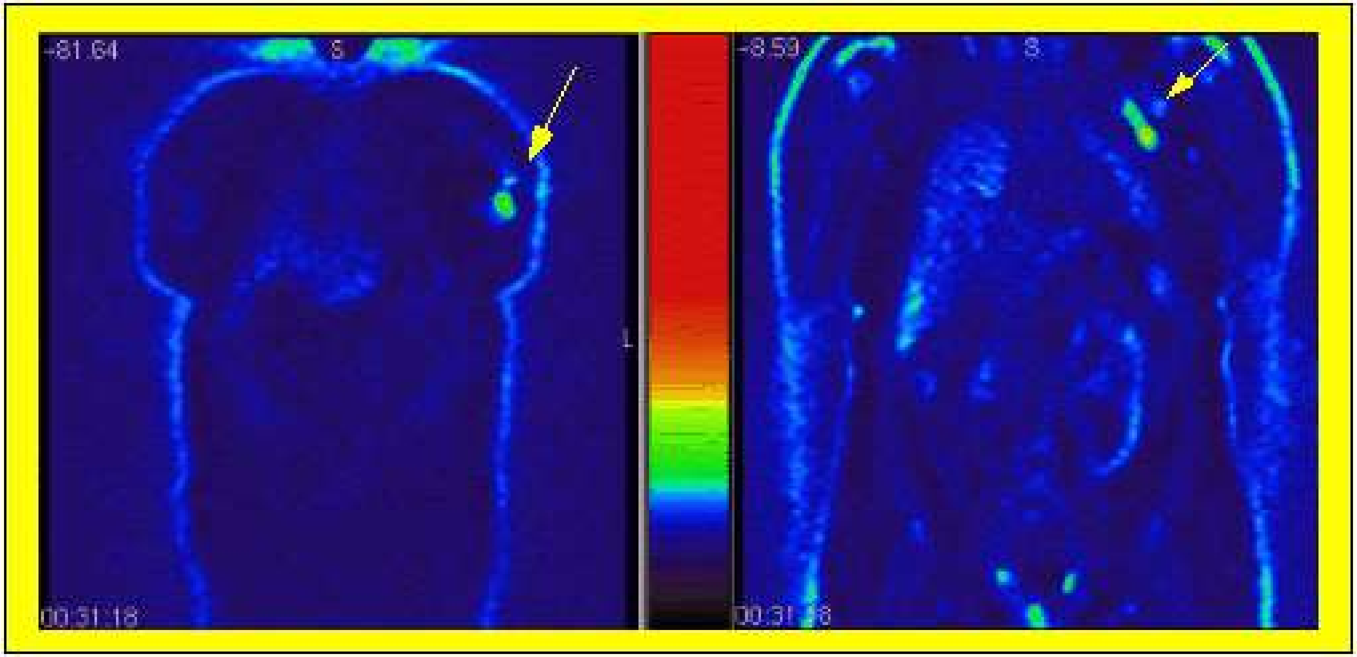


Image showing malignant breast mass that was not revealed by conventional imaging techniques such as CT, MRI, and mammogram.

Image of same patient with enlarged left axillary lymph nodes (indicated by arrows), which through biopsy were found to be metastatic (spread from another location). The whole body scan reveals a mass in the left breast (indicated by arrow), that was malignant and subsequently removed.

Htt://www.nucmed.buffalo.edu/petdef.htm

Alzheimer’s disease

- With Alzheimer’s disease there is no gross structural abnormality, but PET is able to show a biochemical change.

Neurological disorders

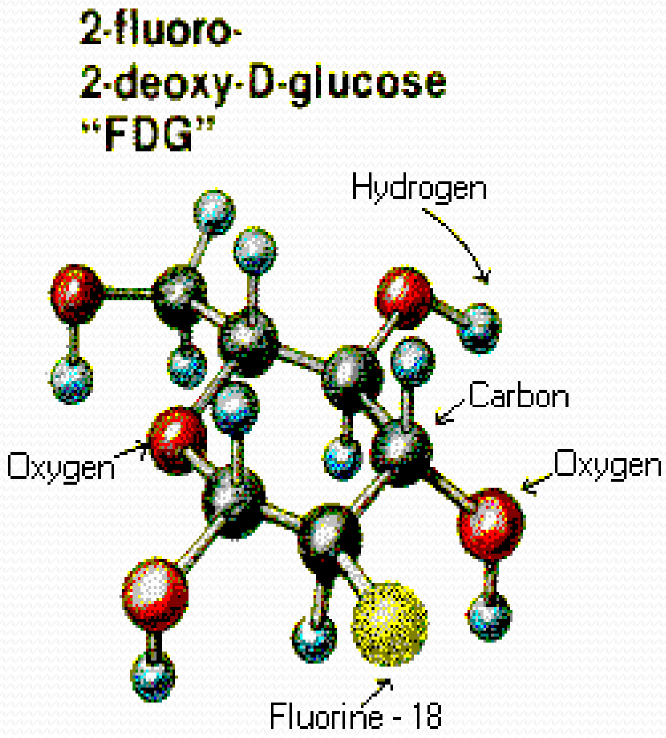
- Positron emission tomography (PET) imaging has recently been shown to aid in the diagnosis of particular neurological syndromes associated with cancer.
- Before their cancer is even diagnosed, patients can develop problems with the brain, spinal cord or nerves, though the cancer has not spread to the nervous system. Called "paraneoplastic neurological disorders," these neurological problems occur as the body's immune system begins to fight the cancer cells, but accidentally attacks the brain or nerves as well. These problems are uncommon, difficult to diagnose, and usually appear in patients whose primary cancer is extremely difficult to find. Abnormal antibodies in the blood or spinal fluid are often associated with these disorders, though they cannot help identify the primary tumor.

http://interactive.snm.org/index.cfm?PageID=2367&RPID=535

How does it work?

- Before the examination begins, a radioactive substance is produced in a machine called a cyclotron and attached, or tagged, to a natural body compound, most commonly glucose, but sometimes water or ammonia. Once this substance is administered to the patient, the radioactivity localizes in the appropriate areas of the body and is detected by the PET scanner.

- Different colors or degrees of brightness on a PET image represent different levels of tissue or organ function. For example, because healthy tissue uses glucose for energy, it accumulates some of the tagged glucose, which will show up on the PET images. However, cancerous tissue, which uses more glucose than normal tissue, will accumulate more of the substance and appear brighter than normal tissue on the PET images.



http://www.radiologyinfo.org/content/petomography.htm

Labeling

- Chemical compounds we'd like to follow through the body are labeled with radioactive atoms that decay by emitting positrons. Labeling is a process of attaching some kind of identifying tag to the compound you want to follow which will later let you identify where the compound has gone. In PET the compounds that can be labeled are limited only by the imagination of the investigators and the physical half-life of the positron emitting label. One of the big advantages of PET is that the atoms which can be labeled (turned into positron emitters) are the same atoms which naturally comprise the organic molecules utilized in the body. These atoms include oxygen, carbon and nitrogen to name a few. Since these atoms occur naturally in organic compounds, replacing the naturally occurring atoms in a compound with a labeled atom leaves you a compound that is chemically and biologically identical to the original (so it will behave in a manner identical to its unlabeled sibling) and that is traceable. In addition to naturally occurring compounds such as neurotransmitters, sugars, etc., it is also possible to label synthesized compounds (such as drugs) and follow them as well.

http://www.nucmed.buffalo.edu/petdef.htm

Tracers

- A second important attribute of PET is that it can follow labeled compounds in *trace* quantities. This means that the labeled compounds can be introduced into the body without affecting the normal processes of the body. For example, labeling a pound of sugar and ingesting that sugar would be a good example of a *non-trace* quantity of labeled compound. At these quantities, blood chemistry would be altered (e.g. insulin produced in response to rising blood sugar levels). Often you want to follow the time course of a compound in the body by introducing trace quantities of a compound that will behave the same as the unlabeled compound *without altering* the ongoing physiological state of chemical processes of the body. PET is sensitive enough to detect trace amounts of labeled compound and so is well suited to this kind of investigation.

http://www.nucmed.buffalo.edu/petdef.htm

How is it performed?

- A nurse or technologist will take you into a special injection room, where the radioactive substance is administered as an intravenous injection (although in some cases, it will be given through an existing intravenous line or inhaled as a gas). It will then take approximately 30 to 90 minutes for the substance to travel through your body and accumulate in the tissue under study. During this time, you will be asked to rest quietly and avoid significant movement or talking, which may alter the localization of the administered substance. After that time, scanning begins. This may take 30 to 45 minutes.
- Some patients, specifically those with heart disease, may undergo a stress test in which PET scans are obtained while they are at rest and again after undergoing the administration of a pharmaceutical to alter the blood flow to the heart.
- Usually, there are no restrictions on daily routine after the test, although you should drink plenty of fluids to flush the radioactive substance from your body.

http://www.radiologyinfo.org/content/petomography.htm

What are the benefits vs. risks?

- Because PET allows study of body function, it can help physicians detect alterations in biochemical processes that suggest disease before changes in anatomy are apparent with other imaging tests, such as CT or MRI.
- Because the radioactivity is very short-lived, your radiation exposure is low. The substance amount is so small that it does not affect the normal processes of the body.
- PET imaging has been shown to improve detection of a variety of cancers, and earlier tests have suggested this technique may be useful in identifying small tumors in patients with paraneoplastic neurological disorders.
- The radioactive substance may expose radiation to the fetus in patients who are pregnant or the infants of women who are breast-feeding. The risk to the fetus or infant should be considered in relation to the potential information gain from the result of the PET examination. If you are pregnant, you should inform the PET imaging staff before the examination is performed.

http://www.radiologyinfo.org/content/petomography.htm

Things to consider

- You will remain still for a long time.
- Claustrophobic persons may feel some anxiety.
- Even though you may feel the desire to feel something due to the radioactivity, you will be disappointed, unless they mistakenly inject you plutonium gas.

Limitations

- PET can give false results if a patient's chemical balances are not normal. Specifically, test results of diabetic patients or patients who have eaten within a few hours prior to the examination can be adversely affected because of blood sugar or blood insulin levels.
- Also, because the radioactive substance decays quickly and is effective for a short period of time, it must be produced in a laboratory near the PET scanner. It is important to be on time for the appointment and to receive the radioactive substance at the scheduled time. PET must be done by a radiologist who has specialized in nuclear medicine and has substantial experience with PET. Most large medical centers now have PET services available to their patients. Medicare and insurance companies cover many of the applications of PET, and coverage continues to increase.
- Finally, the value of a PET scan is enhanced when it is part of a larger diagnostic work-up. This often entails comparison of the PET scan with other imaging studies, such as CT or MRI.

http://www.radiologyinfo.org/content/petomography.htm

Relevant information

- But PET imaging is not yet widely available, and clear indicators of clinically meaningful outcomes using PET are essential to warrant use with this patient population.
- "Accurately defining the role of this technique for these patients is critical," comments study author Steven Allder, MD, of the department of Neurology, Royal Hallamshire Hospital in Sheffield, United Kingdom. Toward this end, Adler and colleagues studied the use of PET imaging in 32 patients with suspected paraneoplastic neurological disorders who had not yet been diagnosed with cancer.
- With each patient, all relevant investigations had been performed prior to PET imaging resulting in no diagnostic conclusions. Each patient then underwent PET imaging from neck to pelvis. All patients were then prospectively followed-up, with the results of all further investigation collected. Final diagnosis was determined, and the sensitivity and specificity of the results of the initial PET scan were calculated.
- "This particular PET scanning in our patient population successfully yielded a high proportion of relevant lesions that were undetectable by alternative diagnostic means," reports Allder. Results of this study indicate that PET is an appropriate, promising tool for patients with undiagnosed paraneoplastic neurological disorders.

http://interactive.snm.org/index.cfm?PageID=2367&RPID=535

Summary of P.E.T

- PET produces images of the body by detecting the radiation emitted from radioactive substances. These substances are injected into the body, and are usually tagged with a radioactive atom (C-11, Fl-18, O-15 or N-13) that has short decay time. These radioactive atoms are formed by bombarding normal chemicals with neutrons to create short-lived radioactive isotopes. PET detects the gamma rays given off at the site where a positron emitted from the radioactive substance collides with an electron in the tissue. The results are evaluated by a trained expert.

http://science.howstuffworks.com/nuclear-medicine2.htm

Modern Imaging Technologies

- Diagnostic techniques are considered as an integral part of all the methods available for the diagnosis of pathological conditions.
- A wide variety of pathological lesions can be diagnosed by radiography and other specialized techniques such as diagnostic ultrasound, computed tomography and magnetic resonance imaging are becoming more popular now.

Fluoroscopy

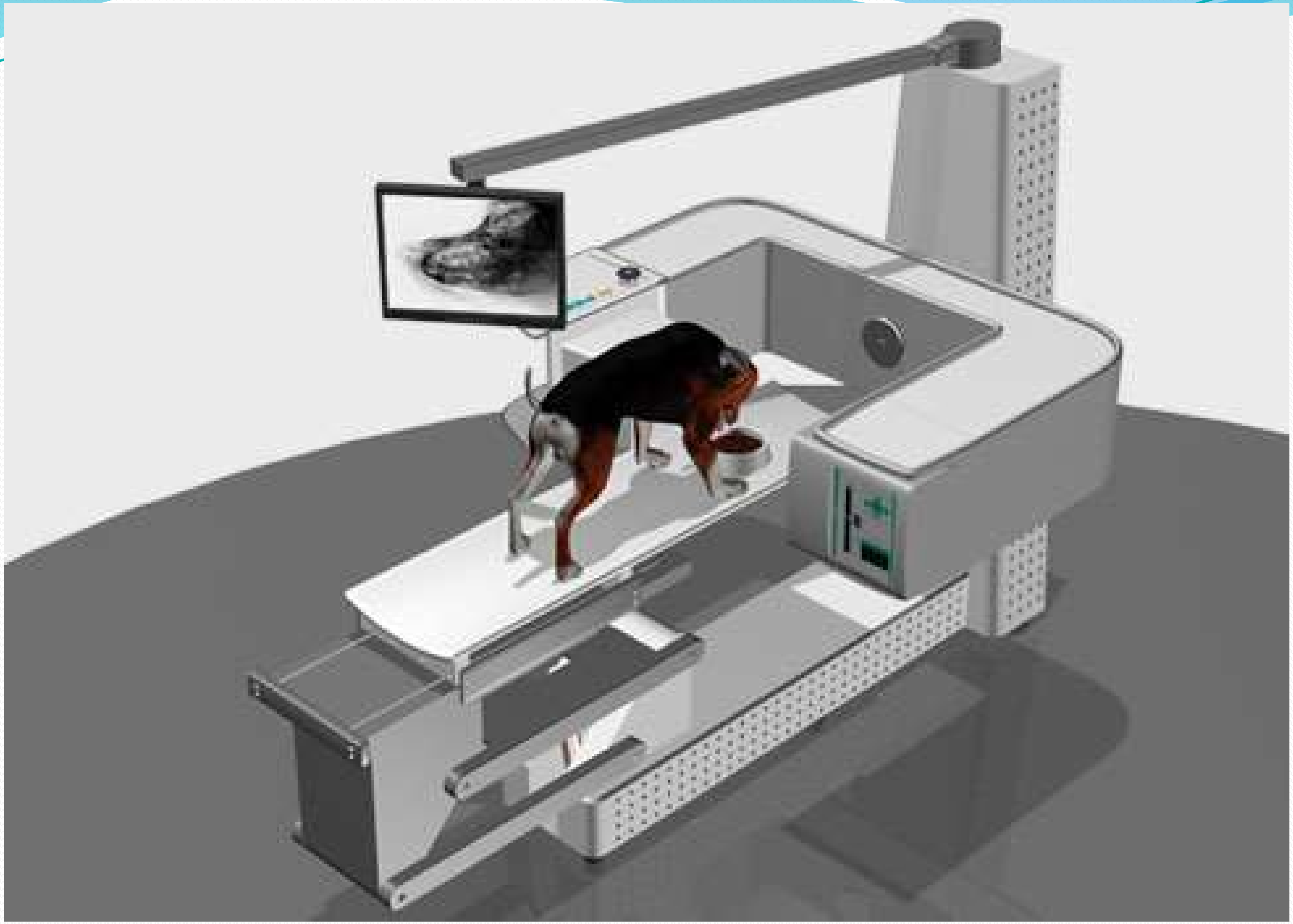
- Is one where the image is displayed on a television screen having been ‘intensified’ from an initial image, produced on a fluorescent screen.
- The simplest type of fluoroscopic unit consists of an x-ray tube, a fluoroscopic table and a fluorescent screen, which resembles an intensifying screen.
- The provision of a closed circuit television system reduces the dose of radiation
- The advantages of fluoroscopy are for the immediate visualization of the radiographic image on the screen.

- It also saves time and expenses of exposing and developing x-ray film.
- The greatest contribution of fluoroscopy is that it permits clinical evaluation of the dynamics of the body such as the peristalsis and movements of the joints.
- It helps veterinarians to thoroughly evaluate the esophageal obstruction or diverticulum using barium meal (contrast media).
- It is a valuable aid in positioning of catheter in the heart and great blood vessels for the examination of the circulatory system.

The shortcomings are:

- The radiation hazards that are greater in fluoroscopy than in conventional radiography, even after adapting all preventive measures.
- Permanent records of dynamic images cannot be kept.
- The fluoroscopist should never be used as a substitute for non-motion radiographic examination.

- The fluoroscopy and other staff must wear the film batches to monitor the x-ray exposure dose.




BURBANK BEYOND

Magnetic Resonance Imaging (MRI)

- Is a highly sensitive and noninvasive technique providing accurate and detailed anatomic images with good contrast and spatial resolution.
- However, in veterinary medicine MRI is still in its infancy and its use is infrequent.
- MRI has been used in developed countries in clinical cases as well as a research tool especially for CNS diseases in small animals.

- MRI has a wide spectrum of application.
- It can be used for imaging all body regions in small animals, but only the extremities and the head can be imagined in large animals.
- It is useful in answering many questions related to the musculoskeletal diseases in animals such as understanding the pathogenesis of navicular disease, traumatic arthritis and osteochondrosis in equines and wobbler syndrome in dogs.

- The newer applications of MRI are magnetic resonance angiography and MR spectroscopy.
- It is especially used to differentiate an inflammatory process from a neoplastic mass, tumors from peritumoral oedema.
- It is more specific and sensitive in detecting localizing and differentiating osteomyelitis, cellulites and abscess.
- However, its use is contraindicated in pregnancy.

- MRI, like ultrasound **does not use ionizing radiation** as diagnostic radiography and CT do.
- The rapid development of MRI makes it essential to have some idea of its uses in clinical medicine as well as a better visualization of anatomic structures in the living patients.
- The technique for imaging places the patient, within a bore of a powerful magnet and passes radio waves through the body in a particular sequence of very short pulses.
- Each pulse causes responding pulse of radio waves to be emitted from the patient's tissues and is recorded by a computer which then produces a two-dimensional picture as a slice of the patient.

- In addition to the transverse sections of the body, the magnetic resonance imaging can be carried out in the sagittal and coronal planes as well as in various degrees of obliquity.
- Tissues which emit strong MR signals appear white in MR scans, whereas those emitting little or no signal appear black.
- In general, air and cortical bone as well as rapidly moving fluid (blood) will appear black, whereas fat will appear white.


Vet-MR


T

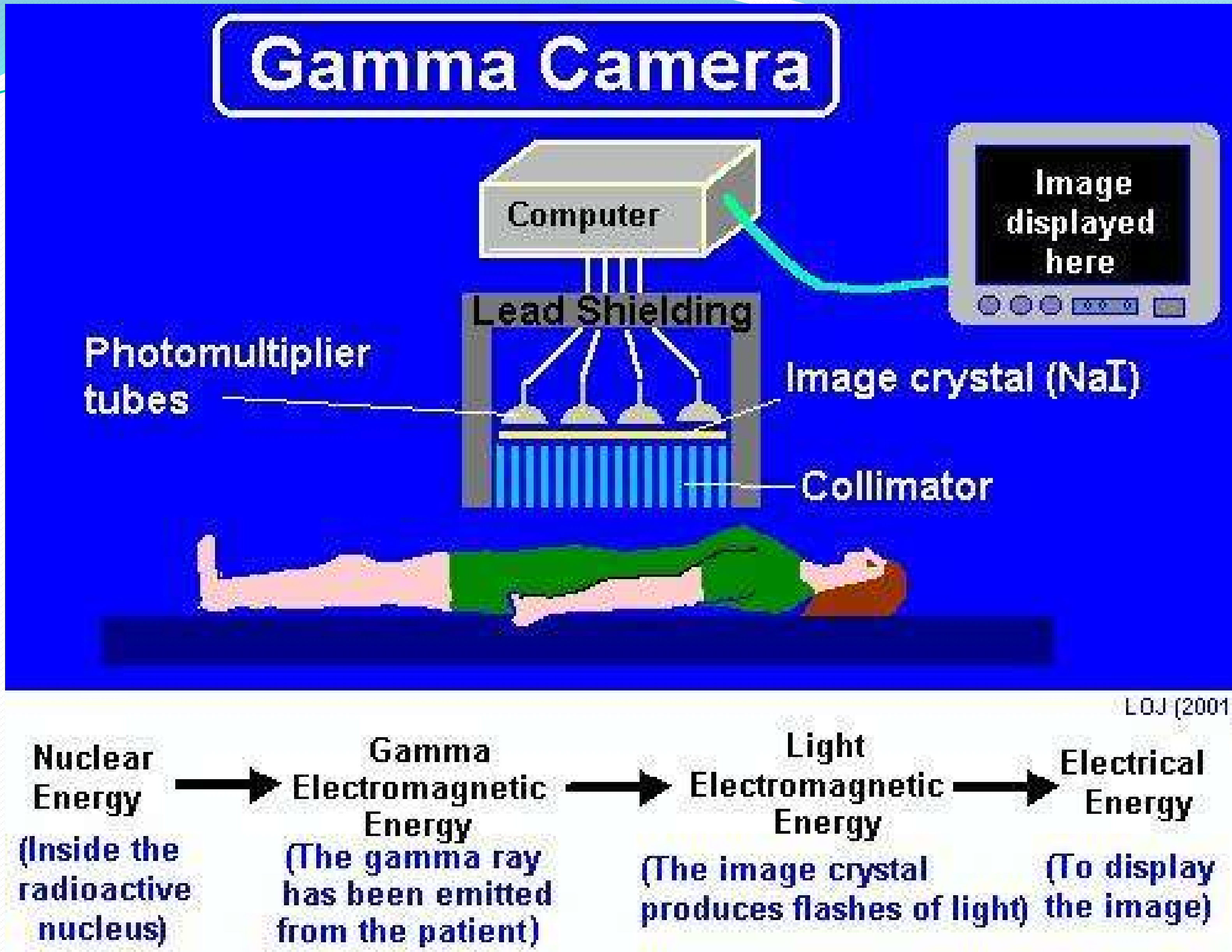
Nuclear Medicine

- A diagnostic technique in which a two dimensional picture of internal body tissue is produced through the detection of radiation emitted by a radioactive substance administered in to the body.
- Nuclear medicine or radioneucleotide imaging is another branch of radiology, offers physiologic information of importance in modern medicine.
- This branch of radiology is based on the visualization of particular living organs and tissues.

- It is a highly sensitive advanced procedure in which radioisotopes are used to detect the functional abnormalities of the body system.
- The interpretation is based on the appearance of the increased (hot spots) or decreased (cold spots) radioactivity regions.
- An active process is indicated by a hot spot while a dull process like lack of perfusion is indicated by cold spot.
- It has been used to detect functional disorders of the kidney, liver, lungs, GI tract, thyroid gland and many other organs.
- It is very useful in the diagnosis of occult lameness, lung perfusion and ventilation and patency of the ureter in both large and small animals.
- Also used for vertebral column imaging and monitoring the progress of fracture healing and in tumor detection

- An image is obtained because; the radioactive isotope emits gamma rays for a brief period.
- The emitted rays are recorded by a gamma camera during the period of gamma emission.
- Within an acceptably short period of time, the isotope will stop emitting detectable rays, as it return to a stable

- The nuclear medicine gives, less precise anatomic information, but much more important physiological information, which will help to understand metabolic process, both normal and abnormal.


Gamma Camera
Computer
Image displayed here
Lead Shielding
Photomultiplier tubes
Image crystal (NaI)
Collimator
LOJ (2001)
Nuclear Energy
(Inside the radioactive nucleus)
Gamma Electromagnetic Energy
(The gamma ray has been emitted from the patient)
Light Electromagnetic Energy
(The image crystal produces flashes of light)
Electrical Energy
(To display the image)

- In ***linear tomography*** the X-ray tube is moved in a straight line in one direction while the film moves in the opposite direction.
- As these shifts occur, the X-ray tube continues to emit radiation so that most structures in the part of the body under examination are blurred by motion.
- Only those objects lying in a plane coinciding with the pivot point of a line between the tube and the film are in focus.

- A somewhat more complicated technique known as ***multidirectional tomography*** or ***poly tomography*** produces an even sharper image by moving the film and X-ray tube in a circular or elliptical pattern.
- As long as both tube and film move in synchrony, a clear image of objects in the focal plane can be produced.
- These tomographic approaches have been used to study the kidneys and other abdominal structures that are surrounded by tissues of nearly the same density and so cannot be differentiated by conventional X-ray techniques.
- They have also been employed to examine the small bones and other structures of the ear, which are surrounded by relatively dense temporal bone.

Endoscopy

- Is used to visualize the interior part of an organ or other area, that otherwise cannot be examined without surgery.
- ***Flexible Endoscopy*** uses an endoscope, which is flexible and designed to bend to look and move around corners.
- ***Rigid Endoscopy*** uses a plastic or metal scope that cannot be bent.
- ***Flexible endoscope*** will have an umbilical cord to attach the scope to the light source; a handle and a flexible insertion tube to introduce into the animal.

- The endoscopes most often used in veterinary practice are:
  - Gastrodudenoscopes
  - Bronchoscopes
  - Colonoscopes
- Rigid endoscopes are of variable size and length that have an obturator and light source.
- Various types of endoscopes are;
  - Laryngoscope
  - Laparoscopes
  - Throcoscopes
  - Cystoscopes (for examining the urinary bladder)
  - Rhinoscopes (for examining the cavities and passages of the nose)
  - Arthroscopes.

- Minimally invasive surgery is increasingly becoming an accepted diagnostic and therapeutic tool in veterinary practices.
- The different endoscopic techniques are **Gastrodudenoscopy, Colonoscopy, Bronchoscopy, Cystoscopy and Vaginoscopy** according to the organs examined.

❖**Laparoscopy** is endoscopy of the peritoneal cavity and may be diagnostic or interventional (minimally invasive surgery).

❖**Arthroscopy**

  - Is the technique of endoscopy of a joint.
  - Are always used through specially designed cannulas for removal of loose bodies (e.g. cartilage fragments), joint lavage for asepsis, topical management of osteoarthritis etc.

- The **endoscopic technique** is valuable only when it eliminates the need for more invasive surgery.
- Endoscopy of alimentary and respiratory tract is occasionally performed for the following purposes.
  - ❑To dilate stricture (benign esophageal stricture)
  - ❑To control hemorrhage,
  - ❑To remove part or all of an organ (ovariohysterectomy)
  - ❑To insert a tube (gastrotomy feeding tube)
  - ❑To removal of foreign bodies.

Procedure for Endoscopic removal of foreign body

- Each FB must be considered individually because an ill-planned endoscopic removal may be more damaging to the patient (e.g. perforation).
- Always radiograph the animal shortly before anesthesia since, the FB might have passed out of reach of the scope, just before procedure.
- Appropriate retrieval forceps may be selected for firmest grip on the FB.
- Do not just grip the FB and pull it immediately.
- Reposition or turn the FB to obtain the best grasp.
- It will make it easier to pull through the sphincters.
- If inappropriate resistance is noted, better release the object and perform surgery.

- There are both advantages and disadvantages and disadvantages in this procedure.

Advantages

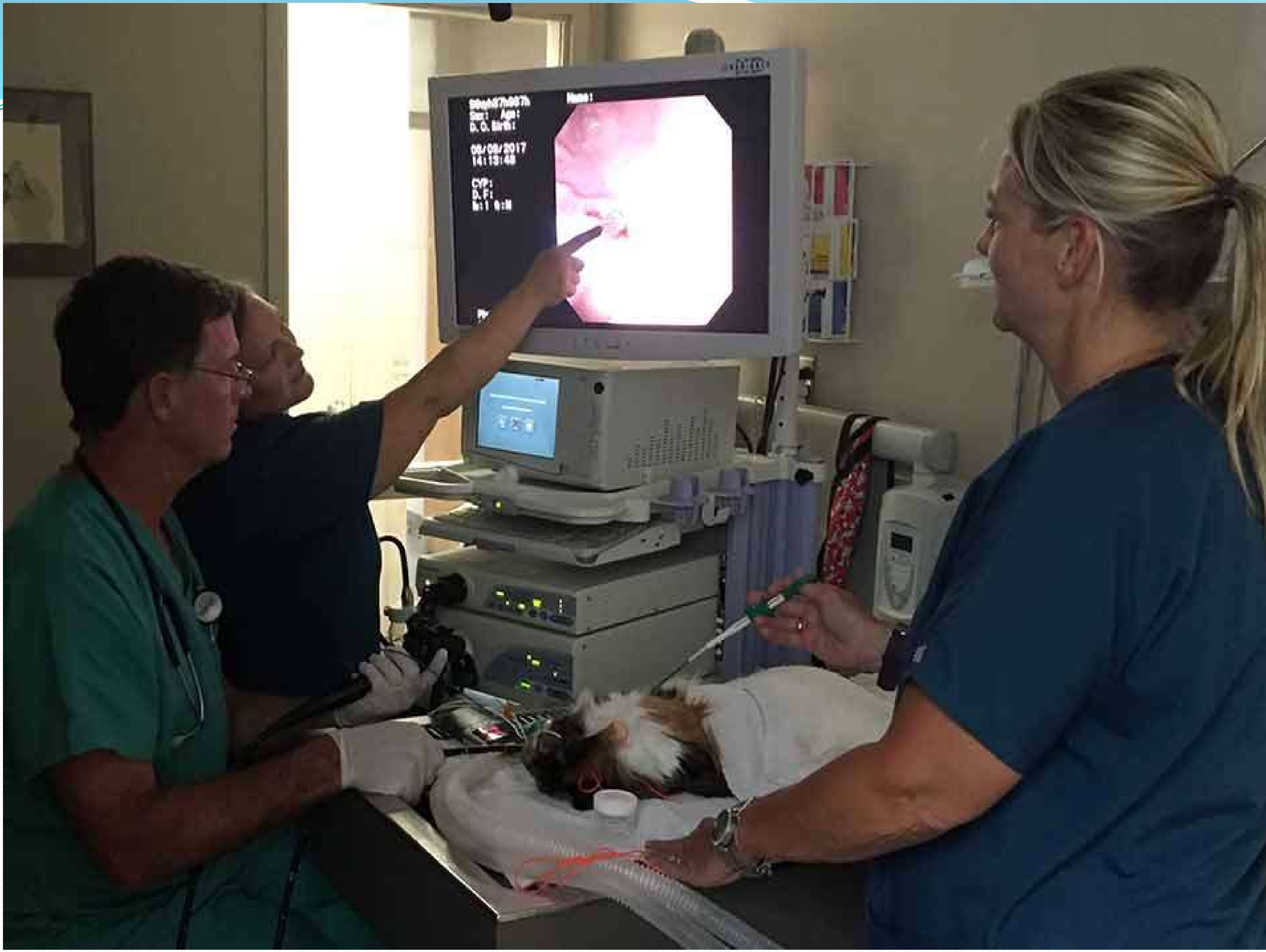
- Often much quicker than regular surgery
- Often less stressful to the patient
- Reduced tissue trauma, morbidity and recovery time.

Disadvantages

  - Cannot remove all types of objects
  - Careless techniques can hurt the animal
  - Requires an assortment of expensive FB retrieval forceps.

- Primary use of endoscopy in veterinary medicine is to visualize and obtain tissue or cytological samples of mucosa.
- Rectal and gastric polyps can be removed endoscopically (polypectomy).


SHOULD UNDERGO THE
APPROPRIATE INFECTION
CONTROL PROCEDURES PRIOR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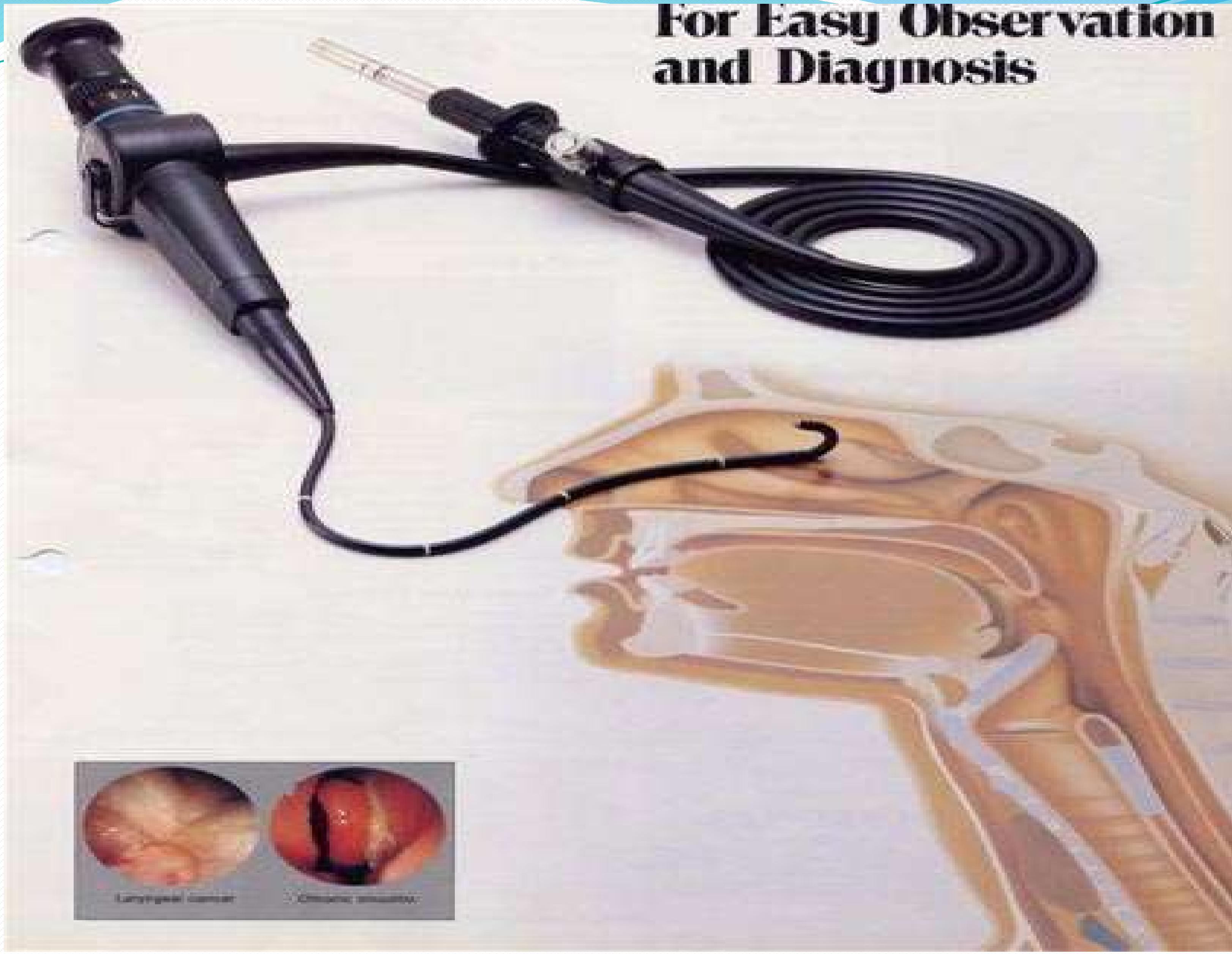
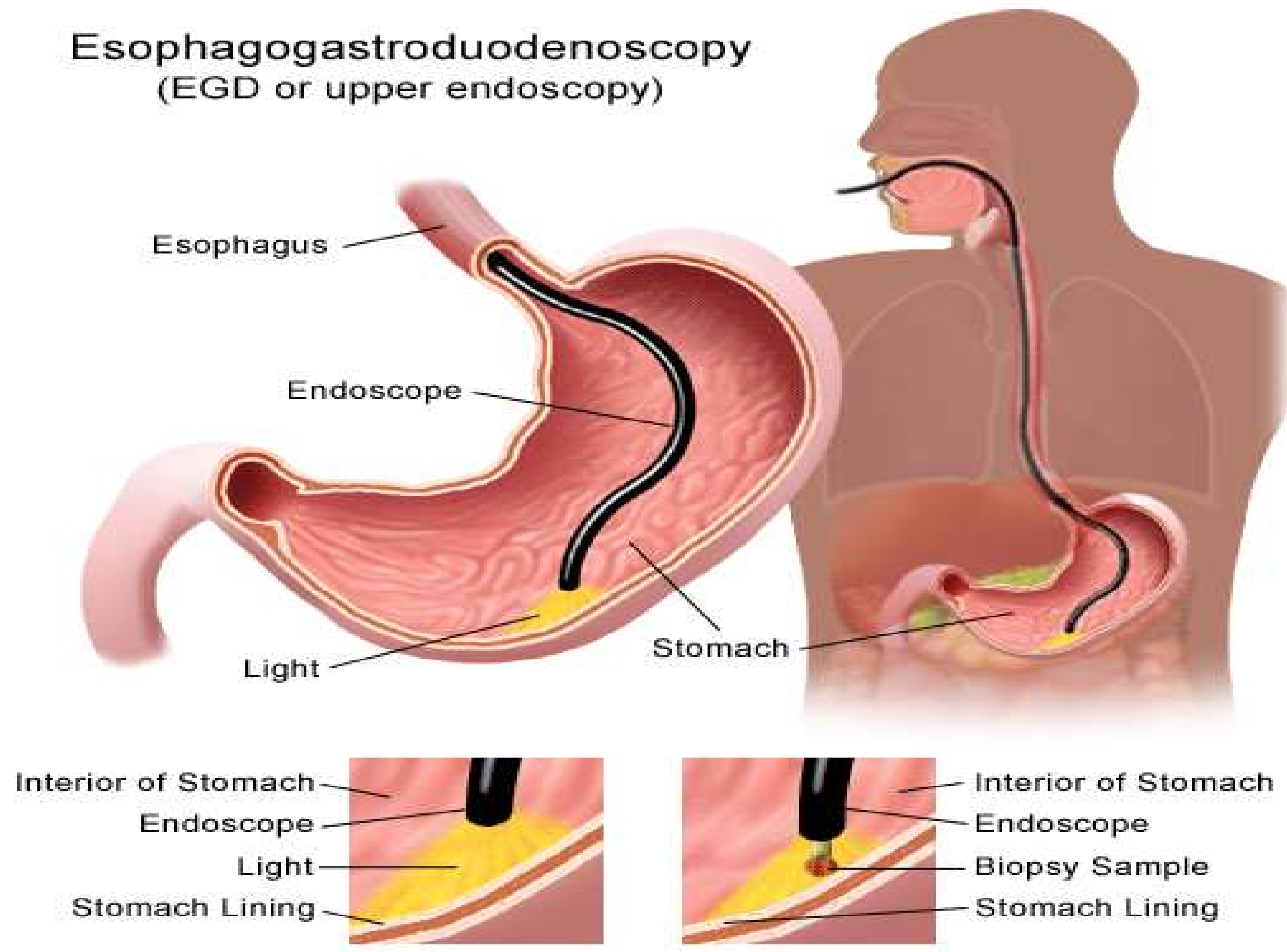

For Easy Observation
and Diagnosis


Esophagogastroduodenoscopy
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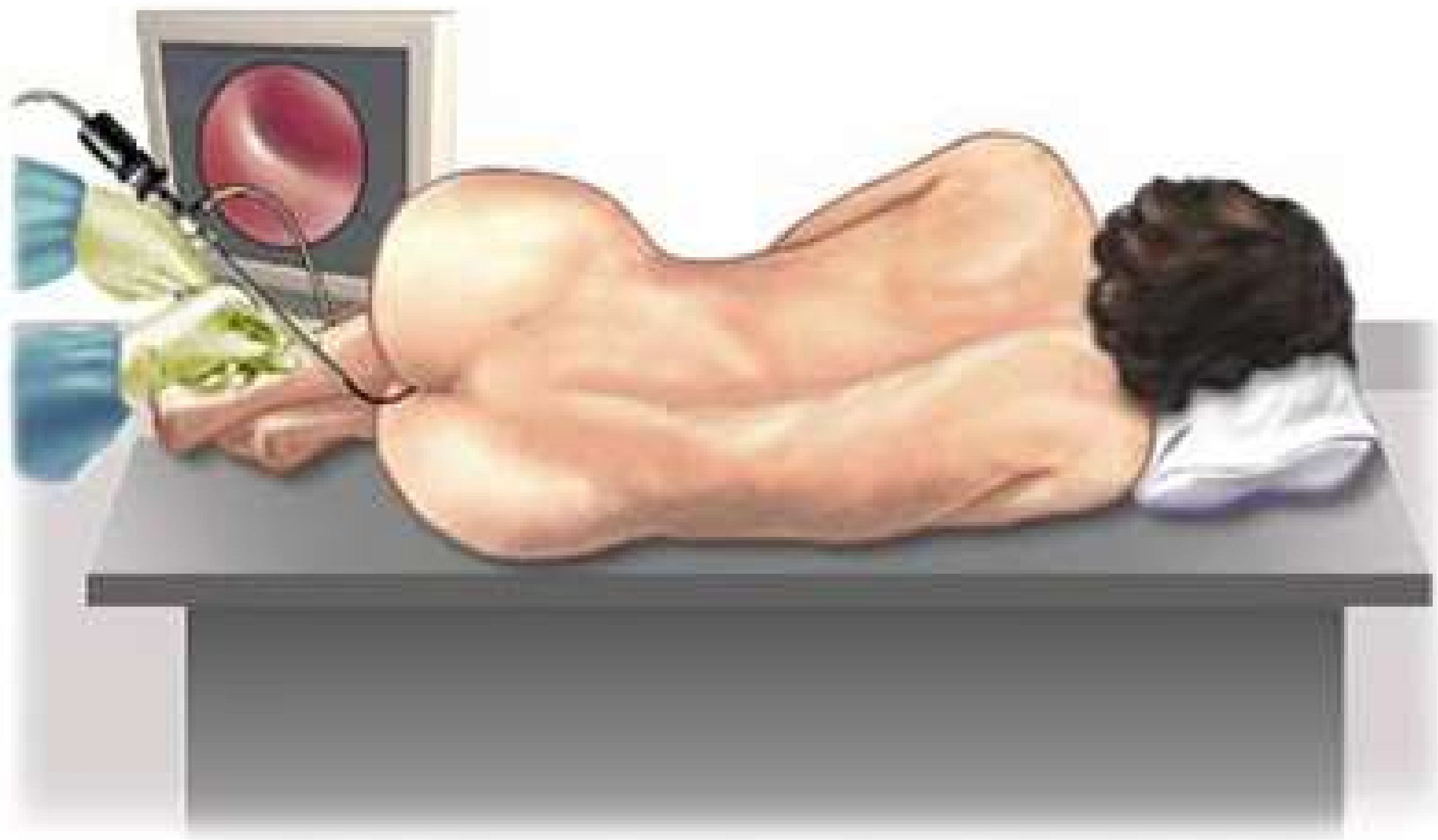
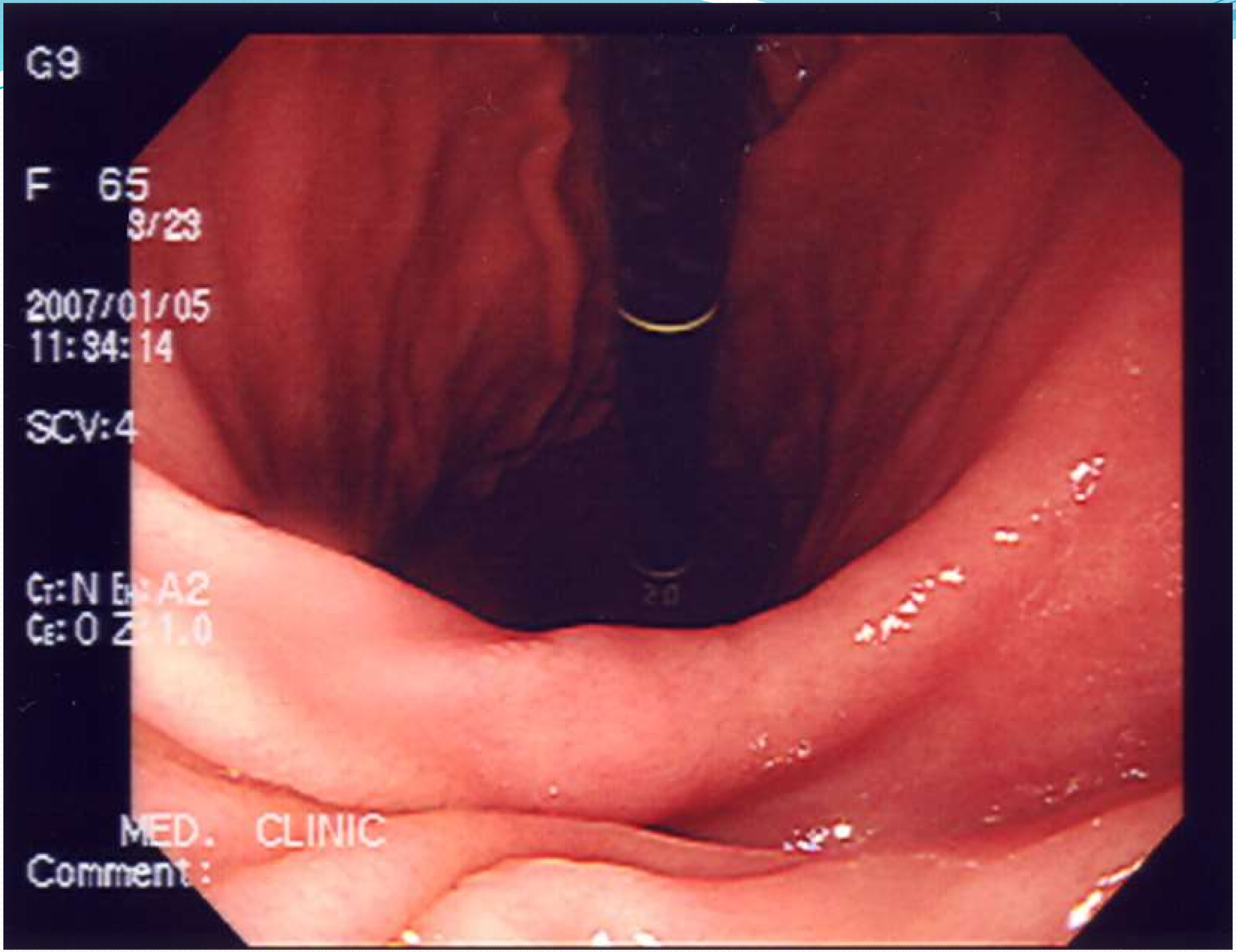
Stomach Lining

Lower endoscopy

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