Reading Material for

Radiography Technique – II

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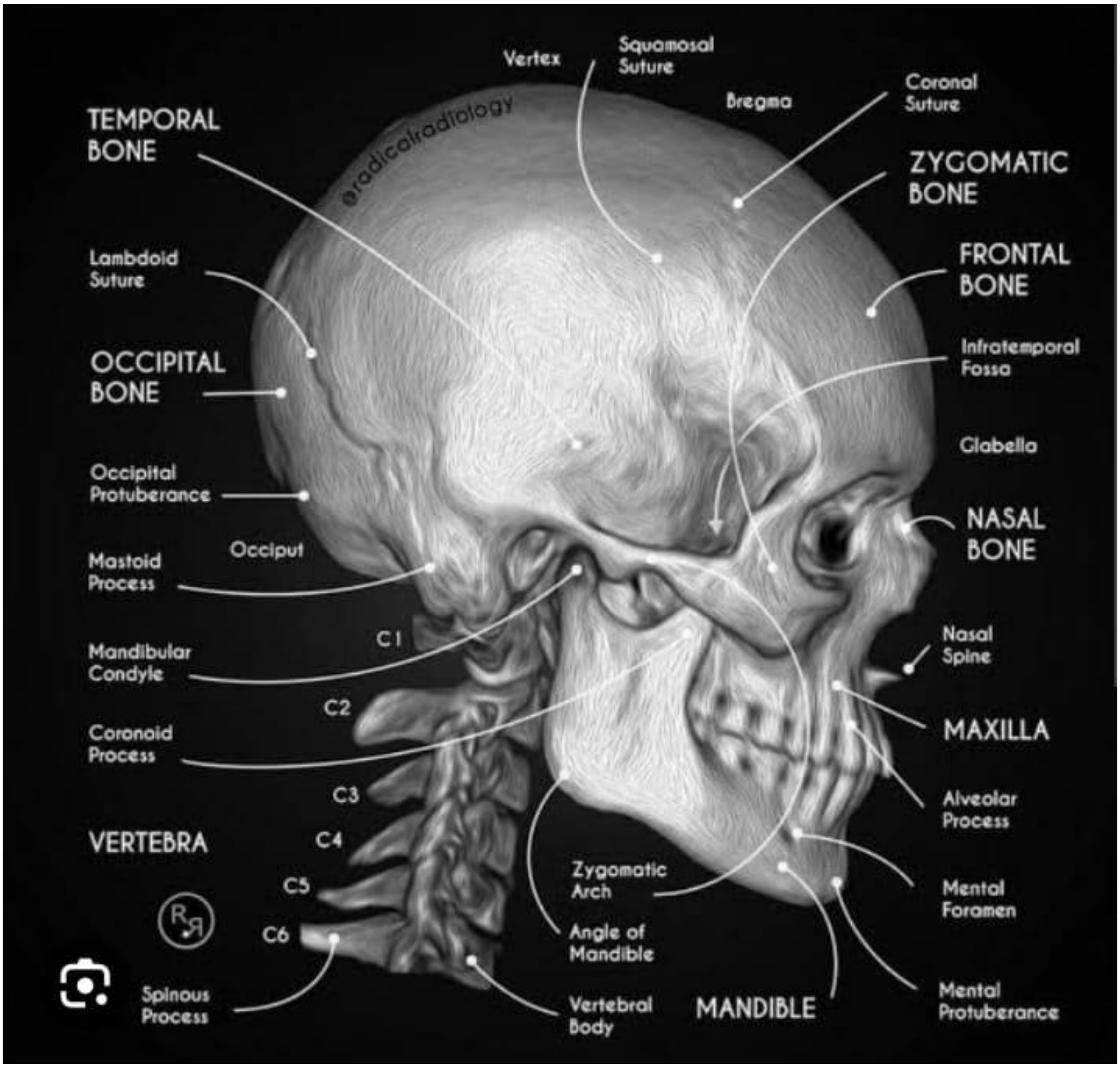
RADIOGRAPHIC ANATOMY



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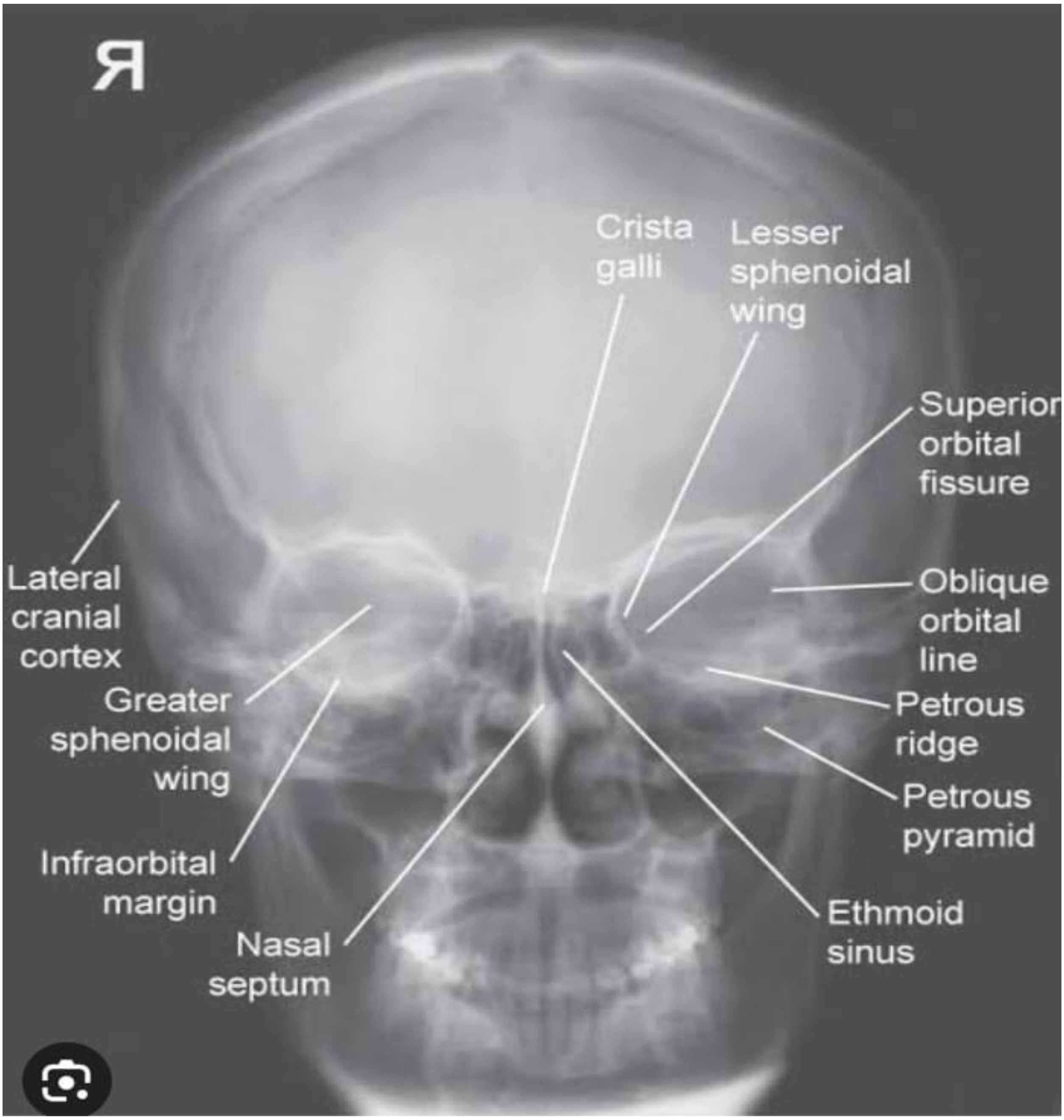

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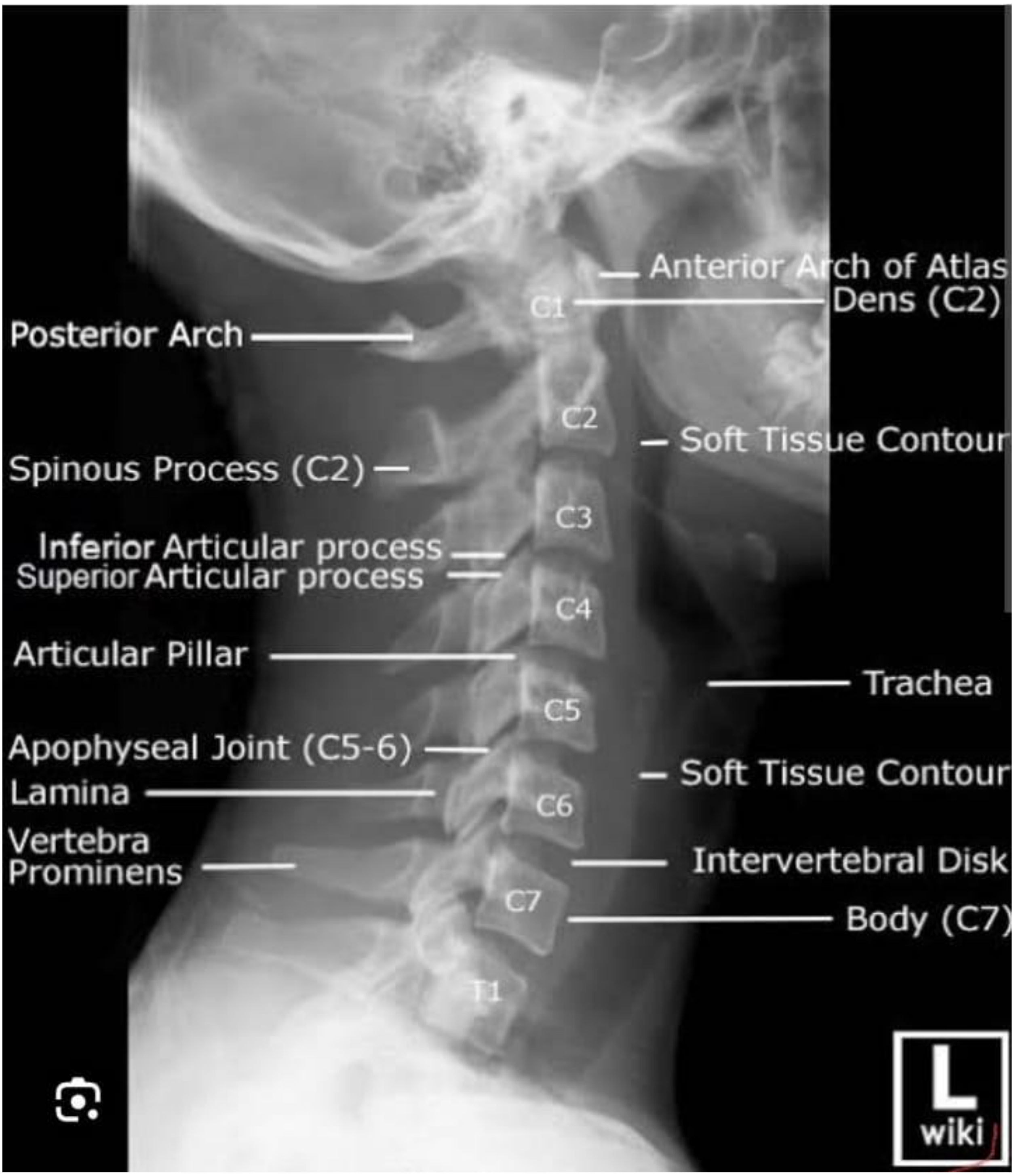

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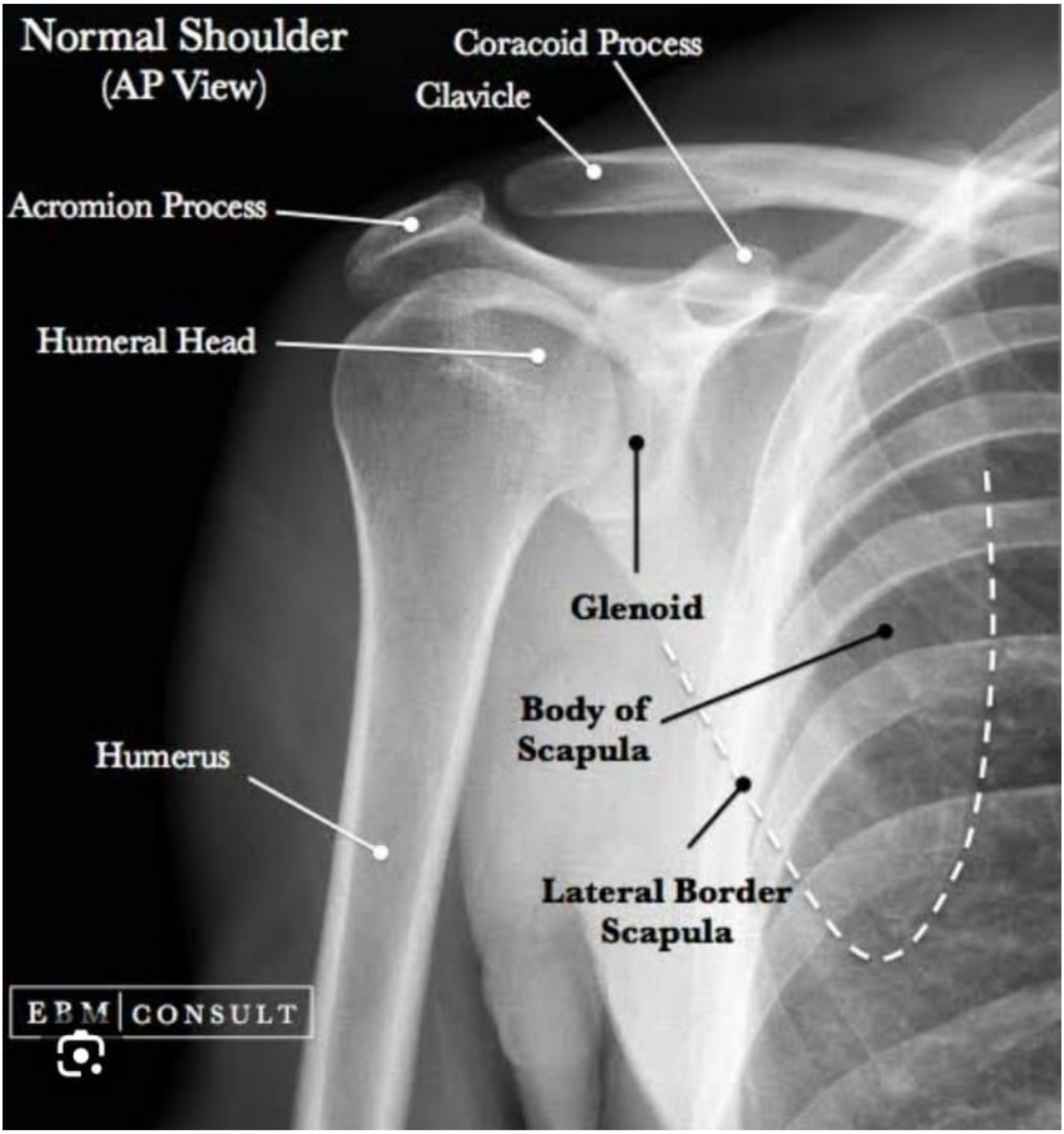

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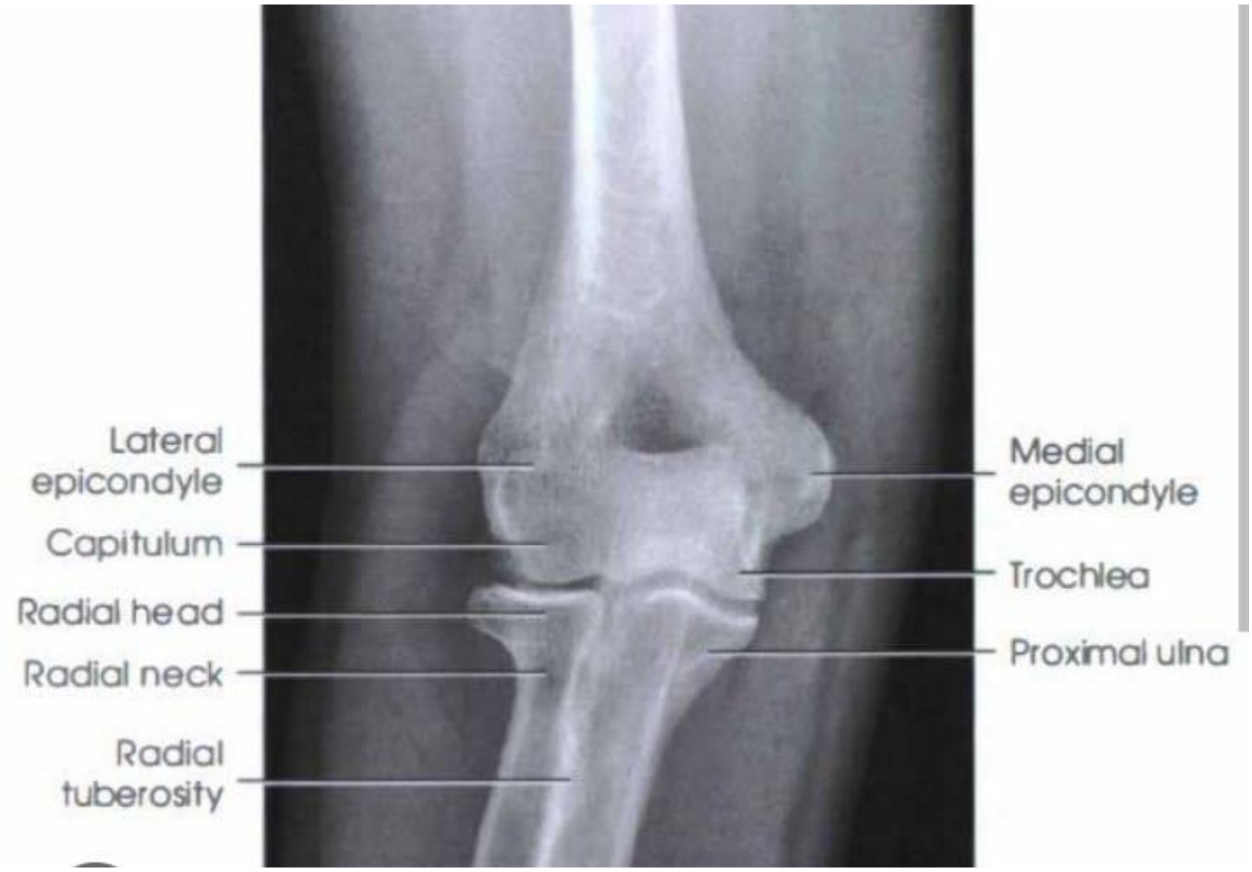

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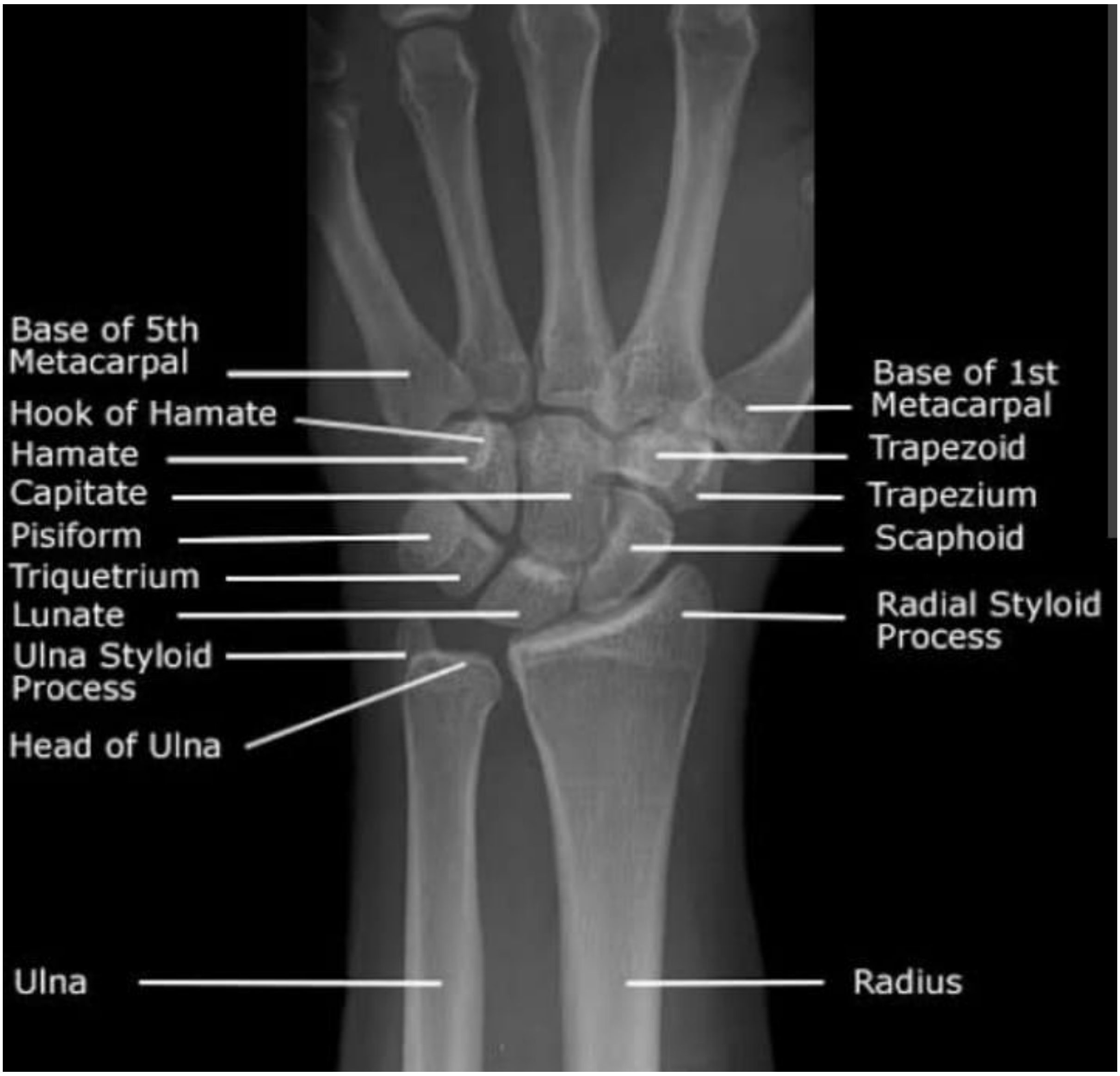

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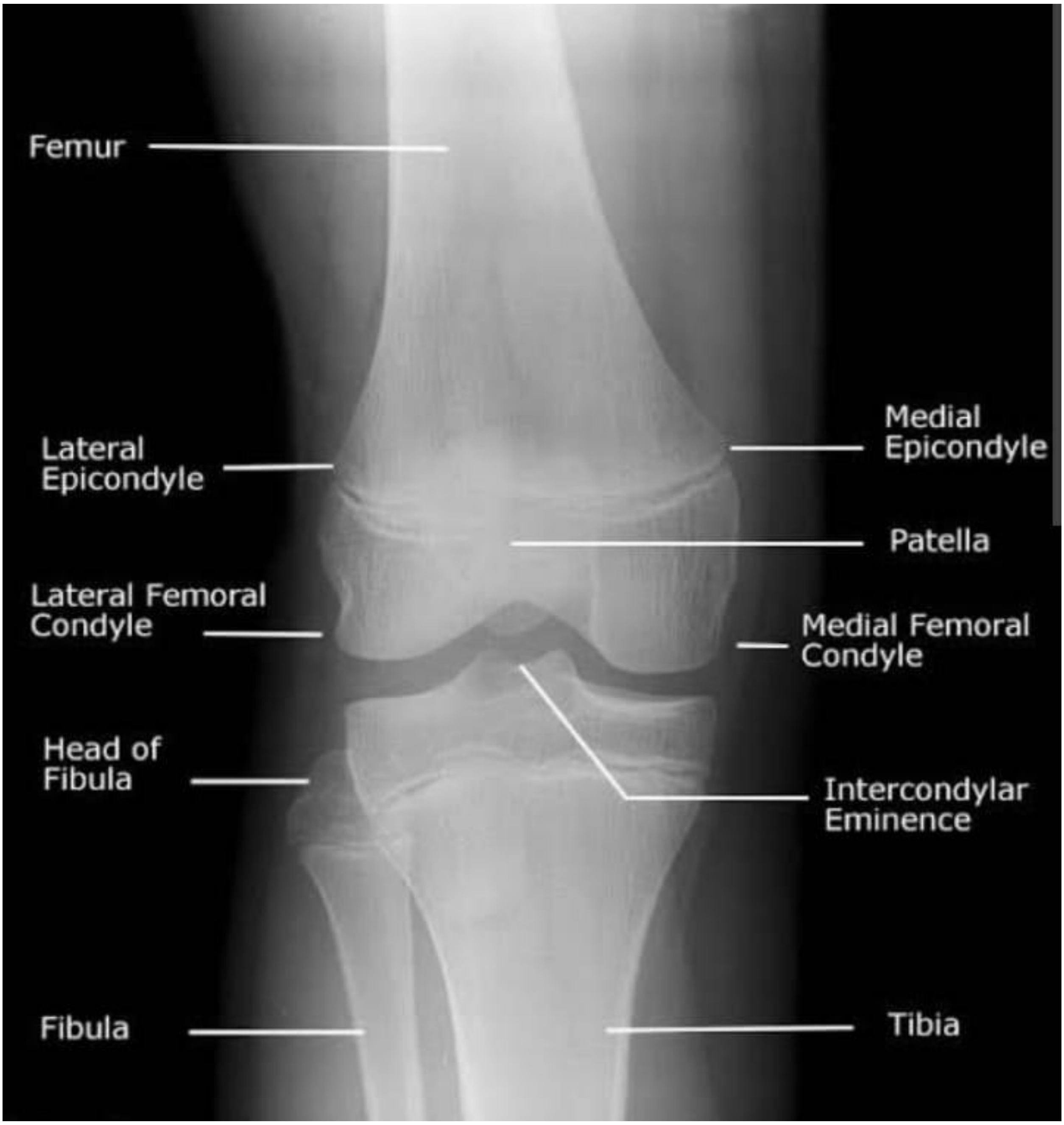
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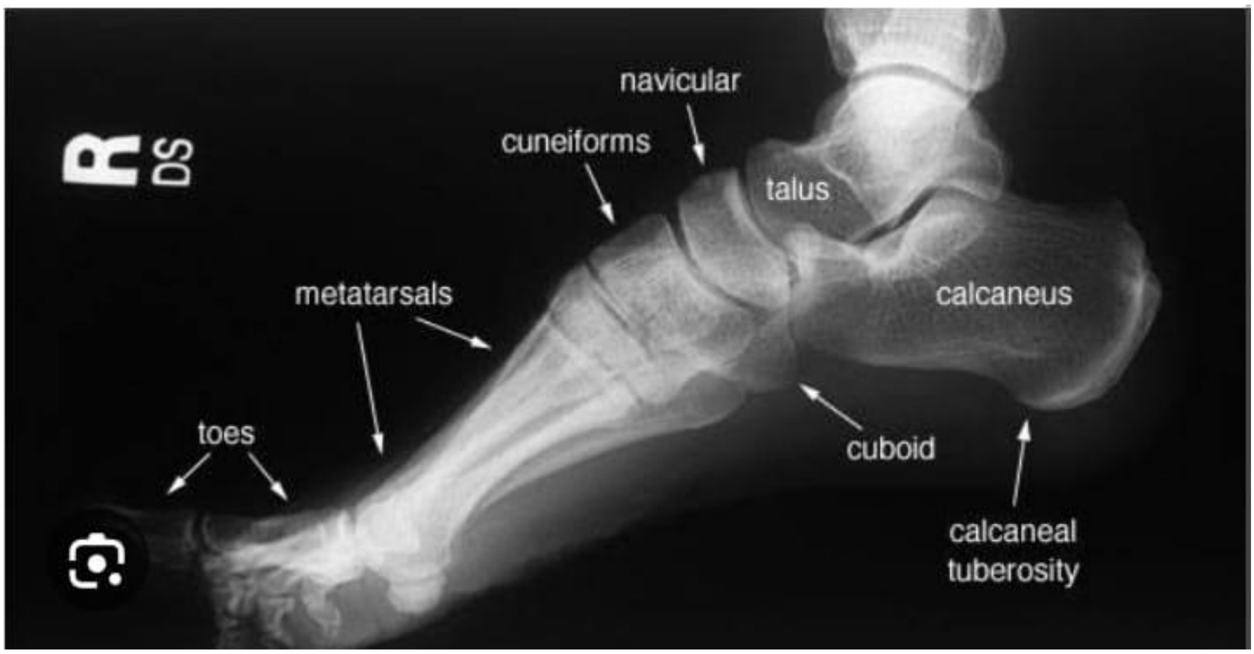

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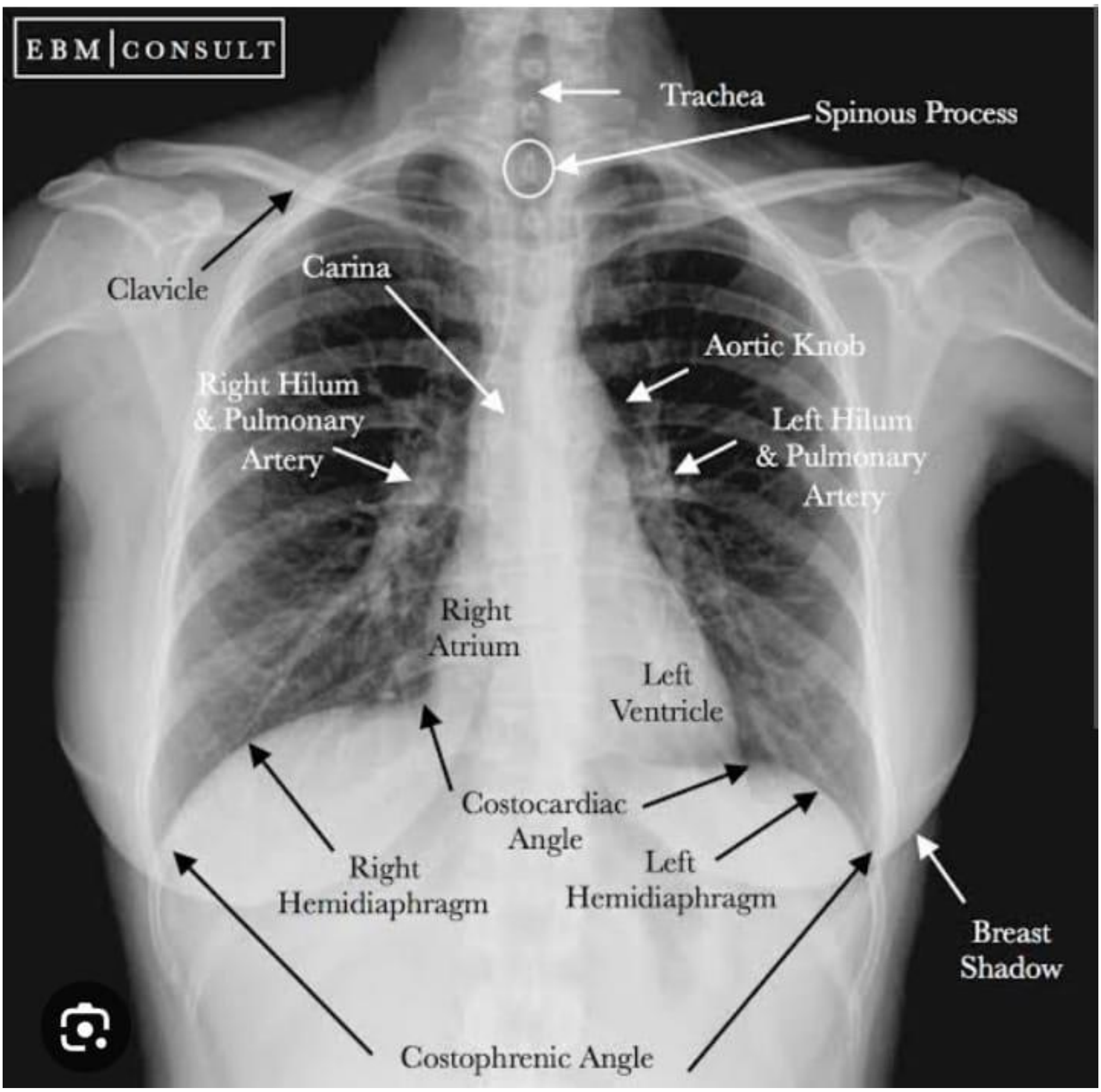


CHEST XRAY PA (POSTERIOR ANTERIOR) VIEW

References:

Pocket Atlas of radiographic anatomy by Moeller

CHAPTER 2

RADIOGRAPHIC POSITIONING

2.1 HAND

2.1.1 Basic projections

It is common practice to obtain two projections, a posteroanterior and an anterior oblique, on one 24 x 30-cm cassette. If possible use a cassette with high-resolution scier oblique, on rubber mask may be used to mask off the half of the film not in use.

2.1.2 Postero-anterior-dorsi-palmar

Position of patient and cassette

The patient is seated alongside the table with the affected arm nearest to the table.

The forearm is pronated and placed on the table with the palmer surface of the hand in contact with the cassette.

The fingers are separated and extended but relaxed to ensure that they remain in contact with the cassette.

The wrist is adjusted so that the radial and ulnar styloid processes are equidistant from the cassette.

A sandbag is placed over the lower forearm for immobilization.

Direction and centering of the X-ray beam

The vertical central ray is centered over the head of the third metacarpal.

Essential image characteristics

The image should demonstrate all the phalanges, including the soft-tissue fingertips, the carpal and metacarpal bones, and the distal ends of the radius and ulna.

The inter-phalangeal and metacarpo-phalangeal and carpometacarpal joints should be demonstrated clearly.

No rotation.

2.1.3 Anterior oblique - dorsi-palmar oblique

Position of patient and cassette

From the basic postere anterior position, the hand is externally rotated 45 degrees with the fingers extended.

The fingers should be separated slightly and the hand supported on a 45-degree non- opaque pad. A sandbag is placed over the lower end of the forearm for immobilization.

Direction and centering of the X-ray beam

The vertical central ray is centered over the head of the fifth metacarpal.

The tube is then angled so that the central ray passes through the head of the third metacarpal, enabling a reduction in the size of the field.

Essential image characteristics

The image should demonstrate all the phalanges, including the soft-tissue of the fingertips, the carpal and metacarpal bones, and the distal ends of the radius and ulna. The correct degree of rotation has been achieved when the heads of the first and second metacarpals are seen separated whilst those of the fourth and fifth are just superimposed.

2.1.4 Posterior oblique - both hands (ball catcher's or Norgaard projection)

This projection may be used in the diagnosis of rheumatoid arthritis. It can also be used to demonstrate a fracture of the base of the fifth metacarpal.

2.1.5 Position of patient and cassette

Ideally, the patient is seated alongside the table. However, if this is not possible due to the patient's condition, the patient may be seated facing the table.

Both forearms are supinated and placed on the table with the dorsal surface of the hands in contact with the cassette.

From this position, both hands are rotated internally (medially) 45 degrees into a 'ball-catching' position.

The fingers and thumbs are separated and extended but relaxed to ensure that they remain in contact with the cassette.

The hands may be supported using 45-degree non-opaque pads.

A sandbag is placed over the lower forearms for immobilization.

Direction and centering of the X-ray beam

The vertical central ray is centered to a point midway between the hands at the level of the fifth metacarpo-phalangeal joints.

Essential image characteristics

The image should demonstrate all the phalanges, including the soft-tissue of the fingertips, the carpal and metacarpal bones, and the distal ends of the radius and ulna.

The exposure factors selected must produce a density and contrast that optimally demonstrate joint detail.

The heads of the metacarpals should not be superimposed.

Radiation protection

If it has been necessary to position the patient facing the table, it is essential to provide radiation protection for the lower limbs and gonads. This may be achieved by placing a lead- rubber sheet on the table underneath the cassette to attenuate the primary beam.

2.2 SCAPHOID

2.2.1 Postero-anterior - ulnar deviation

Imaging of the carpal bones is most commonly undertaken to demonstrate the scaphoid. The projections may also be used to demonstrate other carpal bones, as indicated below.

Four projections may be taken to demonstrate all the carpal bones using a 24 X 30-cm cassette, each quarter being used in turn, with the other three-quarters masked off using lead rubber. For scaphoid fractures, three projections are normally taken: postero-anterior, anterior oblique and lateral.

2.2.2 Position of patient and cassette

The patient is seated alongside the table with the affected side nearest the table.

The arm is extended across the table with the elbow flexed and the forearm pronated

If possible, the shoulder, elbow and wrist should be at the level of the tabletop.

The wrist is positioned over one-quarter of the cassette and the hand is adducted (ulnar deviation).

Ensure that the radial and ulnar styloid processes are equidistant from the cassette.

The hand and lower forearm are immobilized using sandbags.

Direction and centering of the X-ray beam

The vertical central ray is centered midway between the radial and ulnar styloid processes.

Essential image characteristics

The image should include the distal ends of the radius and ulna and the proximal end of the metacarpals.

The joint space around the scaphoid should be demonstrated clearly.

2.3 WRIST

<u>Postero-anterior view of wrist</u>

2.3.1 Position of patient and cassette

The patient is seated alongside the table, with the affected side nearest to the table.

The elbow joint is flexed to 90 degrees and the arm is abducted, such that the anterior aspect of the forearm and the palm of the hand rest on the cassette.

If the mobility of the patient permits, the shoulder joint should be at the same height as the forearm.

The wrist joint is placed on one half of the cassette and adjusted to include the lower part of the radius and ulna and the proximal two-thirds of the metacarpals.

The fingers are flexed slightly to bring the anterior aspect of the wrist into contact with the cassette.

The wrist joint is adjusted to ensure that the radial and ulnar styloid processes are equidistant from the cassette.

The forearm is immobilized using a sandbag.

Direction and centering of the X-ray beam

The vertical central ray is centered to a point midway between the radial and ulnar styloid processes.

Essential image characteristics

The image should demonstrate the proximal two-thirds of the metacarpals, the carpal bones, and the distal third of the radius and ulna.

There should be no rotation of the wrist joint.

2.4 Lateral view of wrist

2.4.1 Position of patient and cassette

From the postero-anterior position, the wrist is externally rotated through 90 degrees, to bring the palm of the hand vertical.

The wrist joint is positioned over the unexposed half of the cassette to include the lower part of the radius and ulna and the proximal two-thirds of the metacarpals.

The hand is rotated externally slightly further to ensure that the radial and styloid processes are superimposed.

The forearm is immobilized using a sandbag.

Direction and centering of the X-ray beam

The vertical central ray is centered over the styloid process of the radius.

Essential image characteristics

The exposure should typoide adequate penetration to visualize the carpal bones. The radial and ulnar styloid processes should be superimposed.t

The image should demonstrate the proximal two-thirds of the metacarpals, the carpal bones, and the distal third of the radius and ulna.

2.5 Anterior oblique view of wrist

2.5.1 Position of patient and cassette

The patient is seated alongside the table, with the affected side nearest to the table.

The elbow joint is flexed to 90 degrees and the arm is abducted, such that the anterior aspect of the forearm and the palm of the hand rest on the tabletop.

If the mobility of the patient permits, then the shoulder joint should be at the same height as the forearm.

The wrist joint is placed on the cassette and adjusted to include the lower part of the radius and ulna and the proximal two-thirds of the metacarpals.

The hand is externally rotated through 45 degrees and supported in this position using a non-opaque pad.

The forearm is immobilized using a sandbag.

Direction and centering of the X-ray beam

The vertical central ray is centered midway between the radial and ulnar styloid processes.

Essential image characteristics

The exposure should provide adequate penetration to visualize the carpal bones.

The image should demonstrate the proximal two-thirds of the metacarpals, the carpal bones, and the distal third of the radius and ulna.

Notes

This projection results in an additional oblique projection of the metacarpals, the carpal bones and lower end of the radius. To obtain an additional projection of the lower end of the ulna, it is necessary to rotate the humerus.

The three projections, postero-anterior, lateral and oblique, may all be taken on the same cassette using lead rubber to mask off all but the one-third of the cassette being used.

Radiological considerations

Fracture of the distal radius can be undisplaced, dorsally angulated (Colles' fracture) or ventrally angulated (Smith's fracture). The importance of Smith's fracture lies in the fact that it is less stable than Colles' fracture.

Dislocations of the carpus are uncommon, but again they carry potential for serious disability. One manifestation of lunate dislocation is an increased gap between it and the scaphoid, which will be missed if the wring is rotated on the posteroanterior projection.

2.6 ELBOW

2.6.1 Antero-posterior view of elbow

Position of patient and cassette

From the lateral position, the patient's arm is externally rotated.

The arm is then extended fully, such that the posterior aspect of the entire limb is in contact with the tabletop and the palm of the hand is facing upwards.

The unexposed half of the cassette is positioned under the elbow joint, with its short axis parallel to the forearm.

The arm is adjusted such that the medial and lateral epicondyles are equidistant from the cassette.

The limb is immobilized using sandbags.

Direction and centering of the X-ray beam

The vertical central ray is centered through the joint space 2.5 cm distal to the point midway between the medial and lateral epicondyles of the humerus.

Essential image characteristics

The central ray must pass through the joint space at 90 degrees to the humerus to provide a satisfactory view of the joint space.

The image should demonstrate the distal third of humerus and the proximal third of the radius and ulna.

Notes

Care should be taken when a supracondylar fracture of the humerus is suspected. In such cases, no attempt should be made to extend the elbow joint, and a modified technique must be employed.

When the patient is unable to extend the elbow to 90 degrees, a modified technique is used for the antero-posterior projection.

If the limb cannot be moved, two projections at right-angles to each other can be taken by keeping the limb in the same position and rotating the X-ray tube through 90 degrees.

If the patient is unable to extend the elbow fully, the positioning for the antero posterior projection may be modified. If the main area of interest is the proximal end of the radius and ulna, then the posterior aspect of the forearm should be in contact with the cassette. If the main area of interest is the distal ends of the humerus, then the posterior aspect of the humerus should be in contact with the cassette.

If the elbow is immobilized in the fully flexed position, then an axial projection must be used instead of the antero-posterior projection. (In both of the above cases, gross injury and general alignment can be demonstrated).

2.6.2 Lateral (basic)

Positioning of Patient and Film

The patient is seated at the side of the table with the arm abducted, the elbow flexed to. 90 degrees and the palm of the hand at 90 degrees to the table. The shoulder should be at the same horizontal level as the elbow and wrist so that the medial aspect of the entire limb is in contact with the table. The half of the film being used is placed under the elbow with its centre to the elbow joint and its long axis parallel to the forearm. Check that the shoulder is well down and that the palm of the hand is at right angles to the table before immobilising the limb with sandbags.

Direction and Centering of the X-ray Beam

The vertical central ray is directed to the lateral epicondyle of the humerus. (A common error is in not lowering the shoulder sufficiently so that the upper arm is not fully in contact with the table. The vertical central ray will not then pass through the joint space at right angles to the humerus.)

2.7 HUMERUS - SHAFT

2.7.1 Antero-posterior view of humeral shaft

Position of patient and cassette

The cassette is placed in an erect cassette holder.

The patient sits or stands with their back in contact with the cassette.

The patient is rotated towards the affected side to bring the posterior aspect of the shoulder, upper arm and elbow into contact with the cassette.

The position of the patient is adjusted to ensure that the medial and lateral epicondyles of the humerus are equidistant from the cassette.

Direction and centering of the X-ray beam

The central ray is directed at right-angles to the shaft of the humerus and centered midway between the shoulder and elbow joints.

2.7.2 Lateral view of humeral shaft

If the arm is immobilized in order to obtain a true lateral projection, i.e. one that is at right-angles to the antero-posterior, then it will be necessary to have the patient's median sagittal plane parallel to the cassette and the lateral aspect of the injured arm in contact with the cassette, and to direct the horizontal central ray through the thorax to the injured arm. This has the disadvantage that the ribs and lungs will be superimposed on the humerus, obscuring details of the injury and signs of healing and adding to the radiation dose to the patient. The position described, although not fully at right-angles to the antero-posterior projection, avoids this superimposition.

Position of patient and cassette

The cassette is placed in an erect cassette holder.

From the anterior position, the patient is rotated through 90 degrees until the lateral aspect of the injured arm is in contact with the cassette.

The patient is now rotated further until the arm is just clear off the rib cage but still in contact with the cassette.

Direction and centering of the X-ray beam

The horizontal central ray is directed at right-angles to the shaft of the humerus and centered midway between the shoulder and elbow joint.

Essential image characteristics

The exposure should be adjusted to ensure that the area of interest is clearly visualized.

2.8 HUMERUS - NECK

The most common reason for radiography of the neck of the humerus is suspected fracture, either pathological or traumatic.

Depending on the condition of the patient, the examination may be undertaken with the patient erect, providing adequate immobilization is used, supine on the X-ray table, or, in cases of multiple trauma, on a trolley.

The exposure is made on arrested respiration.

A 24 x 30-cm cassette fitted with a regular-speed screen is used.

2.8.1 Antero-posterior of humerus neck

Position of patient and cassette

The patient stands or lies supine facing the X-ray tube.

The patient is rotated towards the affected side to bring the posterior aspect of the injured shoulder into contact with the midline of the cassette.

The cassette is positioned to include the acromion process and the proximal half of the humerus.

Direction and centering of the X-ray beam

The central ray is directed at right-angles to the humerus and centered to the head of the humerus.

Essential image characteristics

The image should include the acromion process and proximal half of the shaft of the humerus.

The exposure should demonstrate adequately the neck of the humerus clear off the thorax.

Notes

Exposure should be made on arrested respiration.

The patient should immobilize the affected forearm by supporting its weight with the other arm. If the patient is supine, a sandbag should be placed over the forearm.

2.9 ACROMIOCLAVICULAR JOINTS

2.9.1 Antero-posterior of acromioclavicular joint

An antero-posterior projection of the joint in question is all that is normally required. In certain circumstances, subluxation of the joint may be confirmed with the patient holding a heavy weight.

An 18 x 24-cm cassette is placed in a vertical cassette holder.

Position of patient and cassette

The patient stands facing the X-ray tube, with the arms relaxed to the side. The posterior aspect of the shoulder being examined is placed in contact with the cassette and the patient is then rotated approximately 15 degrees towards the side being examined to bring the acromioclavicular joint space at right angles to the film.

Th cassette is positioned so that the acromion process is in the centre of the film.

Direction and centering of the X-ray beam

The horizontal central ray is centered to the palpable lateral end of the clavicle at the acromioclavicular joint.

To avoid superimposition of the joint on the spine of the scapula, the central ray can be angled 25 degrees cranially before centering to the joint.

Essential image characteristics

The image should demonstrate the acromioclavicular joint and the clavicle projected above the acromion process.

The exposure should demonstrate soft tissue around the articulation.

Notes

The normal joint is variable (3-8 mm) in width. The normal difference between the sides should be less than 2-3 mm (Manaster 1997).

The inferior surfaces of the acromion and clavicle should normally be in a straight line.

2.10 Weight-bearing antero-posterior projection of acromioclavicular joint

The acromioclavicular joint has a weak joint capsule and is vulnerable to trauma. Subluxation may be difficult to diagnose in the standard antero-posterior image, because the width of the joint can be variable and may look widened in a normal joint.

To prove subluxation, it may be necessary to do weight-bearing comparison projections of both acromioclavicular joints (separate joint images).

The positions of the patient and cassette are as described above.

It is advisable to 'strap' the weights used for the procedure around the lower arms rather than getting the patient to hold on to them, as the biomechanics involved may lead to a false negative appearance.

2.11 CLAVICLE

2.11.1 Postero-anterior - erect (basic) for clavicle

Although the clavicle is demonstrated on the antero-posterior 'survey' image, it is desirable to have the clavicle as close to the cassette as possible to give optimum bony detail. The posteroanterior position also reduces the radiation dose to the thyroid and eyes, an important consideration in follow-up fracture images. Alternatively, the patient may be supine on the table or trolley for the antero-posterior projection in which immobility and movement are considerations.

A 24 x 30-cm cassette is placed transversely in an erect cassette holder (or a vertical Bucky if the patient is particularly large).

Position of patient and cassette

The patient sits or stands facing an erect cassette holder.

The patient's position is adjusted so that the middle of the clavicle is in the centre of the cassette.

The patient's head is turned away from the side being examined and the affected shoulder rotated slightly forward to allow the affected clavicle to be brought into close contact with the Bucky.

Direction and centering of the X-ray beam

The horizontal central ray is directed to the centre of the clavicle and the centre of the image, with the beam collimated to the clavicle.

Essential image characteristics

The entire length of the clavicle should be included on the image.

The lateral end of the clavicle will be demonstrated clear off the thoracic cage.

There should be no foreshortening of the clavicle.

The exposure should demonstrate both the medial and the lateral ends of the clavicle.

Note

Exposure is made on arrested respiration to reduce patient movement.

2.12 SCAPULA

The position of the scapula relative to the thorax changes as the arm moves through abduction, adduction, flexion, extension and rotation. When the shoulders are pressed back, the medial borders for the scapulae are parallel to and near the vertebral column, so that most of the scapula would be superimposed on the thoracic cage in the antero-posterior projection of the scapula. With the arm in full medial rotation, the scapula glides laterally over the ribs, allowing more of the body of the scapula to be shown clearly against the rib cage.

A 24 x 30-cm cassette is used, placed vertically in an erect cassette holder or a Bucky if the patient is large.

2.12.1 Antero-posterior (basic) - erect for scapula

The scapula can be shown on the antero-posterior basic survey projection of the shoulder but with the arm in medial rotation. It is preferable for the patient to be examined in the erect position when there is suspected injury as it is more comfortable. There may also be underlying rib fractures.

Position of patient and cassette

The patient stands with the affected shoulder against a cassette and rotated slightly to bring the plane of the scapula parallel with the cassette.

The arm is slightly abducted away from the body and medially rotated.

The cassette is positioned so that its upper border is at least 5 cm above the shoulder to ensure that the oblique rays do not project the shoulder off the cassette.

Direction and centering of the X-ray beam

The horizontal ray is directed to the head of the humerus.

Note

A long exposure time may be chosen and the patient allowed to continue quiet breathing during the exposure, so that images of overlying lung and rib are blurred in cases of non- trauma.

Essential image characteristics

The entire scapula should be demonstrated on the image.

The medial border of the scapula should be projected clear off the mediastinum.

The medial border of the scapula should be projected clear off the ribs.

2.13 FOOT

Basic projections

It is common practice to obtain two projections, a dorsi-plantar and a dorsi-plantar oblique using a 24 x 30-cm high-resolution cassette. A lead-rubber mask is used to mask off each half of the cassette not in use.

2.13.1 Dorsi-plantar view of foot

To ensure the tarsal and tarso-metatarsal joints are demonstrated, the foot is X-rayed with the foot flat on the cassette and with the X-ray tube angled 15 degrees cranially. Alternatively, the foot is raised on a 15-degree non-opaque pad using a vertical central beam. The angulation compensates for the inclination of the longitudinal arch and reduces overshadowing of the tarsal bones.

Position of patient and cassette

The patient is seated on the X-ray table, supported if necessary, with the affected hip and knee flexed.

The plantar aspect of the affected foot is placed on the cassette and the lower leg is supported in the vertical position by the other knee.

Alternatively, the cassette can be raised on a 15-degrees foam pad for ease of positioning.

Direction and centering of the X-ray beam

The central ray is directed over the cuboid-navicular joint, midway between the palpable navicular tuberosity and the tuberosity of the fifth metatarsal.

The X-ray tube is angled 15 degrees cranially when the cassette is flat on the table.

The X-ray tube is vertical when the cassette is raised on a 15-degree pad.

Essential image characteristics

The tarsal and tarso-metatarsal joints should be demonstrated when the whole foot is examined.

The kVp selected should reduce the difference in subject contrast between the thickness of the toes and the tarsus to give a uniform radiographic contrast over the range of foot densities.

Note

A wedge filter can be used to compensate for the difference in tissue thickness.

2.13.2 Lateral view of foot

This is used in addition to the routine dorsi-plantar projection to locate a foreign body. It may also be used to demonstrate a fracture or dislocation of the tarsal bones, or base of metatarsal fractures or dislocation.

Position of patient and cassette

From the dorsi-plantar position, the leg is rotated outwards to bring the lateral aspect of the foot in contact with the cassette.

A pad is placed under the knee for support.

The position of the foot is adjusted slightly to bring the plantar aspect perpendicular to the cassette.

Direction and centering of the X-ray beam

The vertical central ray is centered over the navicular cuneiform joint.

Essential image characteristics

If examining for a suspected foreign body, the kVp selected should be adequate to show the foreign body against the soft tissue structures.

Note

A metal marker placed over the puncture site is commonly used to aid localization of the foreign body.

2.14 ANKLE JOINT

Basic projections

Two projections are routinely taken, an antero-posterior and a lateral, using an 18 x 24-cm high-resolution cassette. A lead-rubber mask can be used to mask off the half of the film not in use.

2.14.1 Antero-posterior (Mortice projection) for ankle.

Position of patient and cassette

The patient is either supine or seated on the X-ray table with both legs extended.

A pad may be placed under the knee for comfort.

The affected ankle is supported in dorsiflexion by a firm 90-degree pad placed against the plantar aspect of the foot. The limb is rotated medially (approximately 20 degrees) until the medial and lateral malleoli are equidistant from the cassette.

The lower edge of the cassette is positioned just below the plantar aspect of the heel.

Direction and centering of the X-ray beam

Centre midway between the malleoli with the vertical central ray at 90 degrees to an imaginary line joining the malleoli.

Essential image characteristics

The lower third of the tibia and fibula should be included.

A clear joint space between the tibia, fibula and talus should be demonstrated (commonly called the Mortice view).

Common faults and remedies

Insufficient dorsiflexion results in the calcaneum being superimposed on the lateral malleolus.

Insufficient medial rotation causes overshadowing of the tibiofibular joint with the result that the joint space between the fibula and talus is not demonstrated clearly.

If internal rotation of the limb is difficult, then the central ray is angled to compensate, making sure that it is still at 90 degrees to the imaginary line joining the malleoli.

2.14.2 Lateral view of ankle joint

A 15-degree pad is placed under the lateral border of the forefoot and a pad is placed under the knee for support. The lower edge of the cassette is positioned just below the plantar aspect of the heel.

Direction and centering of the X-ray beam

Centre over the medial malleolus, with the central ray at right-angles to the axis of the tibia.

Essential image characteristics

The lower third of the tibia and fibula should be included.

The medial and lateral borders of the trochlear articular surface of the talus should be superimposed on the image.

Common faults and remedies

Over-rotation causes the fibula to be projected posterior to the tibia and the medial and lateral borders of the trochlear articulations are not superimposed.

Under-rotation causes the shaft of the fibula to be superimposed on the tibia and the medial and lateral borders of the trochlear articulations are not superimposed.

The base of the fifth metatarsal and the navicular bone should be included on the image to exclude fracture.

Radiological considerations

Inversion injury of the ankle is common and may result in fracture of the lateral malleolus or the base of the fifth metatarsal. Investigation of the injury should therefore cover both areas.

Tear of the collateral ligaments without bone fracture may make the ankle unstable, despite a normal radiograph. Stress projections may clarify this problem and ultrasound or MRI may be useful. Complex injuries may occur with fracture of both malleoli, rendering the ankle mortise very unstable, especially if associated with fracture of the posterior tibia - the so called trimalleolar fracture - and/or disruption of the distal tibio-fibular synchondrosis. These injuries frequently require surgica fixation.

Position of patient and cassette

With the ankle dorsiflexed, the patient turns on to the affected side until the malleoli superimposed vertically and the tibia is parallel to the cassette.

2.15 CALCANEUM

Basic projections

It is common practice to take two projections, a lateral and an axial, using an 18 x 24 cm cassette fitted with high-resolution intensifying screens. A lead-rubber mask may be used to mask off each half of the film not in use.

2.15.1 Lateral view of calcaneum

Position of patient and cassette

From the supine position, the patient rotates on to the affected side.

The leg is rotated until the medial and lateral malleoli are superimposed vertically.

A 15-degree pad is placed under the anterior aspect of the knee and the lateral border of the forefoot for support.

The cassette is placed with the lower edge just below the plantar aspect of the heel.

Direction and centering of the X-ray beam

Centre 2.5 cm distal to the medial malleolus, with the vertical central ray perpendicular to the cassette.

Essential image characteristics

The adjacent tarsal bones should be included in the lateral projection, together with the ankle joint.

Note

This projection is used to demonstrate calcaneal spurs. For comparison, a radiograph of both heels in the lateral position may be necessary.

2.15.2 Axial view of calcaneum

Position of patient and cassette

The patient sits or lies supine on the X-ray, table with both limbs extended.

The affected leg is rotated medially until both malleoli are equidistant from the film.

The ankle is dorsiflexed. The position is maintained by using a bandage strapped around the forefoot and held in position by the patient.

The cassette is positioned with its lower edge just distal to the plantar aspect of the heel.

Direction and centering of the X-ray beam

Centre to the plantar aspect of the heel at the level of the tubercle of the fifth metatarsal.

The central ray is directed cranially at an angle of 40 degrees to the plantar aspect of the heel.

Essential image characteristics

The subtalar joint should be visible on the axial projection.

2.16 KNEE JOINT

Basic projections

Two projections are taken routinely: an antero-posterior and a lateral. Each image is normally equired using a 18 x 24-cm cassette with standard-speed intensifying screens.

2.16.1 Antero-posterior of knee joint

Position of patient and cassette

The patient is either supine or seated on the X-ray table, with both legs extended. The affected limb is rotated to centralize the patella between the femoral condyles, and sandbags are placed against the ankle to help maintain this position.

The cassette should be in close contact with the posterior aspect of the knee joint, with its centre level with the upper borders of the tibial condyles.

Direction and centering of the X-ray beam

Centre 2.5 cm below the apex of the patella through the joint space, with the central ray at 90 degrees to the long axis of the tibia.

Essential image characteristics

The patella must be centralized over the femur.

Note

To enable correct assessment of the joint space, the central ray must be at 90 degrees to the long axis of the tibia and, if necessary, angled slightly cranially. If the central ray is not perpendicular to the long axis of the tibia, then the anterior and posterior margins of the tibial plateau will be separated widely and assessment of the true width of the joint space will be difficult.

If the central ray is too high, then the patella is thrown down over the joint space and the joint space appears narrower.

If the knee joint is flexed and the patient is unable to extend the limb, then the cassette may be raised on pads to bring it as close as possible to the posterior aspect of the knee.

2.16.2 Lateral view of knee joint

Position of patient and cassette

The patient lies on the side to be examined, with the knee flexed at 45 or 90 degrees (see below).

The other limb is brought forward in front of the one being examined and supported on a sandbag.

A sandbag is placed under the ankle of the affected side to bring the long axis of the tibia parallel to the cassette.

The position of the limb is now adjusted to ensure that the femoral condyles are superimposed vertically.

The centre of the cassette is placed level with the medial tibial condyle.

Direction and centering of the X-ray beam

Centre to the middle of the superior border of the medial tibial condyle, with the central ray at 90 degrees to the long axis of the tibia.

Essential image characteristics

The patella should be projected clear off the femur.

The femoral condyles should be superimposed.

The proximal tibio-fibular joint is not clearly visible.

Additional projections of knee joint

Further projections are used to demonstrate fracture of the patella and the intercondylar notch. Stress views may also be taken in suspected ligamental tears.

A lateral projection of the knee and tibial tubercle may be useful in Osgood Schlatter's disease, although this is primarily a clinical diagnosis and radiography is reserved for exclusion of other pathology in cases of doubt. Ultrasound may also be useful in this clinical situation.

2.16.3 Lateral view of knee joint - horizontal beam

This projection replaces the conventional lateral in all cases of gross injury and suspected fracture of the patella.

Position of patient and cassette

The patient remains on the trolley / bed, with the limb gently raised and supported on pads.

If possible, the leg may be rotated slightly to centralize the patella between the femoral condyles.

The film is supported vertically against the medial aspect of the knee,

The centre of the cassette is level with the upper border of the tibial condyle.

Direction and centering of the X-ray beam

The horizontal central ray is directed to the upper border of the lateral tibial condyle, at 90 degrees to the long axis of the tibia.

Notes

By using a horizontal beam, fluid levels may be demonstrated, indicating lipohaemarthrosis.

2.17 PATELLA

The optimum retro-patellar joint spacing occurs when the knee is flexed approximately 30-45 degrees. Further flexion pulls the patella into the intercondylar notch, reducing the joint spacing; as flexion increases, the patella tracks over the lateral femoral condyle. The patella moves a distance of 2 cm from full extension to full flexion.

2.17.1 Conventional infero-superior projection

The procedure is undertaken using an 18 x 24-cm cassette.

Position of patient and cassette

The patient sits on the X-ray table, with the knee flexed 30-45 degrees and supported on a pad placed below the knee.

A cassette is held by the patient against the anterior distal femur and supported using a non-opaque pad, which rests on the anterior aspect of the thigh.

Direction and centering of the X-ray beam

The tube is lowered. Avoiding the feet, the central ray is directed cranially to pass through the apex of the patella parallel to the long axis.

The beam should be closely collimated to the patella and femoral condyles to limit scattered radiation to the trunk and head.

Radiation protection

Examination of the individual single knee is recommended, rather than including both knees in one exposure when both knees are requested.

The total radiation field can be reduced, thus limiting the scattered radiation.

A lead-rubber apron is worn for protection, with additional lead-rubber protection placed over the gonads.

2.18 SHAFT OF FEMUR

Basic projections

Two projections are taken routinely, preferably with both the knee and hip joints included on the image. If this is impossible to achieve, then the joint nearest the site of injury should be included.

A large cassette is placed in the table Bucky so that the effects of scatter are reduced. However, should only an image of the distal aspect of the femur be required, then the use of the Bucky can be eliminated in order to reduce patient dose.

2.18.1 Shaft of femur Antero-posterior

Position of patient and cassette

The patient lies supine on the X-ray table, with both legs extended.

The affected limb is rotated to centralize the patella over the femur.

Sandbags are placed below the knee to help maintain the position.

The cassette is positioned in the Bucky tray immediately under the limb, adjacent to the posterior aspect of the thigh to include both the hip and the knee joints.

Alternatively, the cassette is positioned directly under the limb, against the posterior aspect of the thigh to include the knee joint.

Direction and centering of the X-ray beam

Centre to the middle of the cassette, with the vertical central ray at 90 degrees to an imaginary line joining both femoral condyles.

Notes

In cases of suspected fracture, the limb must not be rotated.

If both joints are not included on one film, then a single anteroposterior projection of the joint distal to the fracture site must be taken. This ensures that no fracture is missed and allows assessment of any rotation at the fracture site.

Remember that the divergent beam will project the hip cranially and the knee caudally, and therefore care must be taken when positioning the cassette to ensure that the joint will be on the top/bottom of the film.

2.18.2 Lateral view of shaft of femur

Position of patient and cassette

From the antero-posterior position, the patient rotates on to the affected side, and the knee is slightly flexed.

The pelvis is rotated backwards to separate the thighs.

The position of the limb is then adjusted to vertically superimpose the femoral condyles.

Pads are used to support the opposite limb behind the one being examined.

The cassette is positioned in the Bucky tray under the lateral aspect of the thigh to include the knee joint and as much of the femur as possible.

Alternatively, the cassette is positioned directly under the limb, against the lateral aspect of the thigh, to include the knee joint.

Direction and centering of the X-ray beam

Centre to the middle of the cassette, with the vertical central ray parallel to the imaginary line joining the femoral condyles.

2.18.3 Additional projection for femoral shaft - lateral horizontal beam

This projection replaces the conventional lateral in all cases of gross injury and suspected fracture.

Position of patient and cassette

The patient remains on the trolley / bed. If possible, the leg may be slightly rotated to centralize the patella between the femoral condyles.

The cassette is supported vertically against the lateral aspect of the thigh, with the lower border of the cassette level with the upper border of the tibial condyle.

The unaffected limb is raised above the injured limb, with the knee flexed and the lower leg supported on a stool or specialized support

Direction and centering of the X-ray beam

Centre to the middle of the cassette, with the beam horizontal.

Note

If the injury involves only the lower two-thirds of femur, then place the cassette vertically against the medial aspect of the thigh, directing the beam from the lateral aspect of the limb to the middle of the cassette.

Radiation protection during the radiographs of femur

In all cases, the beam must be well collimated.

Gonad protection must be applied in all non-trauma cases, as extra-focal radiation and scattered radiation will irradiate the gonads if not protected.

In trauma cases, gonad protection is not used in the first instance as it may obscure injury. In subsequent follow-up radiographs, gonad protection must be used.

2.19 HIP JOINT

2.19.1 Antero-posterior - single hip

Position of patient and cassette

The patient is positioned as described for the basic pelvis and basic bilateral hip projections.

The patient lies supine and symmetrical on the X-ray table, with the median sagittal plane perpendicular to the tabletop.

To avoid pelvic rotation, the anterior superior iliac spines must be equidistant from the tabletop:

The affected limb is internally rotated to bring the neck of the femur parallel to the tabletop, and is then supported by sandbags.

Direction and centering of the X-ray beam

The vertical central ray is directed 2.5 cm distally along the perpendicular bisector of a line joining the anterior superior iliac spine and the symphysis pubis over the femoral pulse.

The primary beam should be collimated to the area under examination and gonad protection applied where appropriate.

2.20 SACRO-ILIAC JOINTS

2.20.1 Antero-posterior view

The antero-posterior projection shows both sacro-iliac joints on one image and can be done when the patient is unable to turn prone.

The positions of the patient and the film and the direction of the beam are the same as those described for the anteroposterior projection of the sacrum.

The sacro-iliac joints are included routinely on the anteroposterior projection of the lumbar spine in some protocols, as some pathologies can give rise to lower back pain.

Position of patient and cassette

The patient lies supine and symmetrical on the X-ray table, with the median sagittal plane perpendicular.

The midline of the patient must coincide with the centered primary beam and the table Bucky mechanism.

To avoid rotation, the anterior superior iliac spines must be equidistant from the tabletop.

A 24 x 30-cm cassette, placed transversely in the Bucky tray, is centered at a level to coincide with the central ray.

The shoulders are raised over a pillow to eliminate the lumbar arch.

The knees should be flexed over foam pads for comfort.

Direction and centering of the X-ray beam

Centre in the midline at a level midway between the anterior superior iliac spines and the superior border of the symphysis pubis.

The central ray is directed between 5 and 15 degrees cranially, depending on the sex of the patient. The female requires greater caudal angulation of the beam.

The primary beam is collimated to the area of interest.

2.21 CERVICAL VERTEBRAE

Basic projections Many centres perform an antero-posterior and a lateral projection, with the addition of a further image to demonstrate the C 1/2 region if the patient has a history of trauma. 18 x 24-cm cassettes are employed routinely, but 24 x 30-cm cassettes are often used in difficult cases.

2.21.1 Cervical spine lateral (erect)

Position of patient and cassette

The patient stands or sits with either shoulder against the cassette.

The median sagittal plane should be adjusted such that it is parallel with the cassette.

The head should be flexed or extended such that the angle of the mandible is not superimposed over the upper anterior cervical vertebra or the occipital bone does not obscure the posterior arch of the atlas.

To aid immobilization, the patient should stand with the feet slightly apart and with the shoulder resting against the cassette stand.

In order to demonstrate the lower cervical vertebra, the shoulders should be depressed, as shown in the photograph. This can be achieved by asking the patient to relax their shoulders downwards. The process can be aided by asking the patient to hold a weight in each hand (if they are capable) and making the exposure on arrested expiration.

Direction and centering of the X-ray beam

The horizontal central ray is centered to a point vertically below the mastoid process at the level of the prominence of the thyroid cartilage.

Essential image characteristics

The whole of the cervical spine should be included, from the atlanto-occipital joints to the top of the first thoracic vertebra.

The mandible or occipital bone does not obscure any part of the upper vertebra.

Angles of the mandible and the lateral portions of the floor of the posterior cranial fossa should be superimposed.

Soft tissues of the neck should be included.

The contrast should produce densities sufficient to demonstrate soft tissue and bony detail.

Radiological considerations

Atlanto-axial subluxation is seen on the lateral projection, especially in flexion (where appropriate). Care is needed in making this diagnosis in children, in whom the normal space is larger (adults <2 mm, children 3-5 mm).

Visualization of the margins of the foramen magnum can be difficult but is necessary for diagnosis of various skull-base abnormalities, such as basilar invagination. It will be obscured by incorrect exposure or the presence of earrings.

A secondary sign of a vertebral injury is swelling of the soft tissues anterior to the vertebral body (normal thickness is less than the depth of a normal vertebral body). This can be mimicked by flexion of the neck - always try to obtain films in the neutral position.

Common faults and remedies

Failure to demonstrate C7 / T1: if the patient cannot depress the shoulders, even when holding weights, then a swimmers' projection should be considered. Care should be taken with the position of the lead name blocker. Important anatomy may easily be obscured, especially when using a small cassette.

Notes

The large object-to-film distance (OFD) will increase geometric unsharpness. This is overcome by increasing the focus-to-film distance (FFD) to 150 cm.

An air gap between the neck and the film eliminates the need to employ a secondary radiation grid to attenuate scatter.

Radiation protection

Care should be taken when collimating to avoid including the eyes within the primary beam.

2.21.2 Cervical spine lateral (supine)

For trauma cases, the patient's condition usually requires the examination to be performed on casualty trolley. The lateral cervical spine projection is taken first, without moving the patient. The resulting radiograph must be examined by a medical officer to establish whether the patient's neck can be moved for other projections.

Position of patient and cassette

The patient will normally arrive in the supine position.

It is vitally important for the patient to depress the shoulders (assuming no other injuries to the arms).

The cassette can be either supported vertically or placed in the erect cassette holder, with the top of the cassette at the same level as the top of the ear.

To further depress the shoulders, one or two suitably qualified individuals can apply caudal traction to the arms. NB: refer to departmental local rules for staff working within a controlled area.

Common faults and remedies

Failure to demonstrate C7 / T1: if the patient's shoulders are depressed fully, then the application of traction will normally show half to one extra vertebra inferiorly. Should the cervical thoracic junction still remain undemonstrated, then a swimmers' lateral or oblique projections should be considered.

Radiological considerations

This projection is part of the Advanced Trauma and Life Support (ATLS) primary

Clear demonstration of the C7/T1: junction is essential, as this is a common site of jury and is associated with major neurological morbidity. It is often not covered Tully on the initial trauma screen and must always be demonstrated in the setting of trauma, by supplementary projections if necessary.

2.21.3 Antero-posterior - first and second cervical vertebrae (open mouth)

Position of patient and cassette

The patient lies supine on the Bucky table or, if erect positioning is preferred, sits or stands with the posterior aspect of the head and shoulders against the vertical Bucky.

The medial sagittal plane is adjusted to coincide with the midline of the cassette, such that it is at right-angles to the cassette.

The neck is extended, if possible, such that a line joining the tip of the mastoid process and the inferior border of the upper incisors is at right-angles to the cassette. This will superimpose the upper incisors and the occipital bone, thus allowing clear visualization of the area of interest.

The cassette is centered at the level of the mastoid process.

Direction and centering of the X-ray beam

Direct the perpendicular central ray along the midline to the centre of the open mouth.

If the patient is unable to flex the neck and attain the position described above, then the beam must be angled, typically five to ten degrees cranially or caudally, to superimpose the upper incisors on the occipital bone.

The cassette position will have to be altered slightly to allow the image to be centered after beam angulation.

Essential image characteristics

The inferior border of the upper central incisors should be superimposed over the occipital bone.

The whole of the articulation between the atlas and the axis must be demonstrated clearly.

Ideally, the whole of the dens, the lateral masses of the atlas and as much of the axis as possible should be included within the image.

Common faults and remedies

Failure to open the mouth wide enough: the patient can be reminded to open their mouth as wide as possible just before the exposure.

A small degree of rotation may result in superimposition of the lower molar over the lateral section of the joint space. Check for rotation during positioning.

If the front teeth are superimposed over the area of interest (top left photograph), then the image should be repeated with the chin raised or with an increased cranial angulation of the tube.

If the occipital bone is superimposed, then the chin should be lowered or a caudal angulation should be employed.

It is worth noting that some individuals have a very prominent maxilla. It will be very difficult to produce an image without some degree of superimposition in these cases, so an alternative projection or modality should be considered.

2.21.4 Antero-posterior third to seventh cervical vertebrae

Position of the Patient

With the patient supine the neck is extended so that the base line is an angle of 20° to the vertical.

Direction and centering of X-ray beam The tube is angled at 10° towards the head centre the midline at the level of 4th cervical vertebra.

Radiological considerations

A unifacet dislocation can be diagnosed by loss of continuity of the line of spinous processes (or a line bisecting the bifid processes). This is made more difficult if the patient is rotated or the image is underexposed.

Common faults and remedies

Failure to demonstrate the upper vertebra: an increase in the tube angle or raising the chin should provide a solution.

2.22 THORACIC VERTEBRAE

2.22.1 Antero- posterior view of thoracic spine

Position of patient and cassette

The patient is positioned supine on the X-ray table, with the median sagittal plane perpendicular to the tabletop and coincident with the midline of the Bucky.

The upper edge of a cassette, which should be at least 40 cm long for an adult, should be at a level just below the prominence of the thyroid cartilage to ensure that the upper thoracic vertebrae are included.

Make exposure on arrested inspiration. This will cause the diaphragm to move down over the upper lumbar vertebra, thus reducing the chance of a large density difference appearing on the image from superimposition of the lungs.

Direction and centering of the X-ray beam

Direct the central ray at right-angles to the cassette and towards a point 2.5 cm below the sternal angle.

Collimate tightly to the spine.

Essential image characteristics

The image should include the vertebrae from C7 to L 1.

The image density should be sufficient to demonstrate bony detail for the upper as well as the thoracic lower vertebrae.

Radiological considerations

The presence of intact pedicles is an important sign in excluding metastatic disease. Pedicles are more difficult to see on an underexposed or rotated film.

Common faults and remedies

The cassette and beam are often centered too low, thereby excluding the upper thoracic vertebrae from the image.

The lower vertebrae are also often not included. L 1 can be identified easily by the fact that it usually will not have a rib attached to it.

High radiographic contrast (see below) causes high density over the upper vertebrae and low density over the lower vertebra.

2.22.2 Lateral view of thoracic vertebrae

Position of patient and cassette

Usually undertaken with the patient in the lateral decubitus position on the X-ray table, although this projection can also be performed erect.

The median sagittal plane should be parallel to the cassette and the midline of the axilla coincident with the midline of the table or Bucky.

The arms should be raised well above the head.

The head can be supported with a pillow, and pads may be placed between the knees for the patient's comfort.

The upper edge of the cassette should be at least 40 cm in length and should be positioned 3-4 cm above the spinous process of C7.

Direction and centering of the X-ray beam

The central ray should be at right-angles to the long axis of the thoracic vertebrae. This may require a caudal angulation.

Centre 5 cm anterior to the spinous process of T6/7. This is usually found just below the inferior angle of the scapula (assuming the arms are raised), which is easily palpable.

Essential image characteristics

The upper two or three vertebrae may not be demonstrated due to the superimposition of the shoulders.

Look for the absence of a rib on L 1 at the lower border of the image. This will ensure that T12 has been included within the field.

The posterior ribs should be superimposed, thus indicating that the patient was not rotated too far forwards or backwards.

The trabeculae of the vertebrae should be clearly visible, demonstrating an absence of movement unsharpness.

The image density should be adequate for diagnosis for both the upper and lower thoracic vertebrae. The use of a wide latitude imaging system / technique is therefore desirable,

2.23 LUMBAR VERTEBRAE

2.23.1 Antero-posterior view of lumber spine

Position of patient and cassette

The patient lies supine on the Bucky table, with the median sagittal plane coincident with, and at right-angles to, the midline of the table and Bucky.

The anterior superior iliac spines should be equidistant from the tabletop.

The hips and knees are flexed and the feet are placed with their plantar aspect on the tabletop to reduce the lumbar arch and bring the lumbar region of the vertebral column parallel with the cassette.

The cassette should be large enough to include the lower thoracic vertebrae and the sacro-iliac joints and is centered at the level of the lower costal margin.

The exposure should be made on arrested aspiration, as this will cause the diaphragm to move superiorly. If the X-ray is done during inspiration, the air within the lungs would otherwise cause a large difference in density and poor contrast between the upper and lower lumbar vertebrae.

Direction and centering of the X-ray beam

Direct the central ray towards the midline at the level of the lower costal margin (L3).

Essential image characteristics

The image should include from T12 down, to include all of the sacro-iliac joints.

Rotation can be assessed by ensuring that the sacro-iliac joints are equidistant from the spine.

The exposure used should produce a density such that bony detail can be discerned throughout the region of interest.

Radiological considerations

The same considerations apply as to the thoracic spine.

Common faults and remedies

The most common fault is to miss some or all of the sacroiliac joint. An additional projection of the sacra-iliac joints should be performed.

2.23.2 Lumbar vertebrae lateral horizontal beam

A patient with a suspected fracture to the lumbar vertebrae should not be moved from the casualty trolley without medical supervision. Similarly, the patient should not be moved into the lateral decubitus position in these circumstances. This will necessitate the use of a horizontal beam technique in order to obtain the second projection required for a complete examination.

Position of patient cassette

The trauma trolley is placed adjacent to the vertical Bucky.

Adjust the position of the trolley so that the lower costal margin of the patient coincides with the vertical central line of the Bucky and the median sagittal plane is parallel to the cassette.

The Bucky should be raised or lowered such that the patient's mid-coronal plane is coincident with the midline of the cassette within the Bucky, along its long axis.

If possible, the arms should be raised above the head.

Direction and centering of the X-ray beam

Direct the horizontal central ray parallel to a line joining the anterior superior iliac spines and towards a point 7.5 cm anterior to the third lumbar spinous process at the level of the lower costal margin.

Essential image characteristics

Refer to lateral lumbar spine.

Extreme care must be taken if using the automatic exposure control. The chamber selected must be directly in line with the vertebrae, otherwise an incorrect exposure will result.

If a manual exposure is selected, a higher exposure will be required than with routine lateral. This is due to the effect of gravity on the internal organs, causing them to lie on either side of the spine.

2.23.3 Right or left posterior oblique views of lumbar vertebrae

These projections demonstrate the pars interarticularis and the apophyseal joints on the side nearest the cassette. Both sides are taken for comparison.

Position of patient and cassette

The patient is positioned supine on the Bucky table and is then rotated 45 degrees to the right and left sides in turn. The patient's arms are raised, with the hands resting on the pillow.

The hips and knees are flexed and the patient is supported with a 45-degree foam pad placed under the trunk on the raised side.

The cassette is centered at the lower costal margin.

Direction and centering of the X-ray beam

Direct the vertical central ray towards the midclavicular line on the raised side at the level of the lower costal margin.

Essential image characteristics

The degree of obliquity should be such that the posterior elements of the vertebra are aligned in such as way as to show the classic 'Scottie dog' appearance (see diagram)

Radiological considerations

A defect in the pars interarticularis can be congenital or due to trauma. It is a weakness in the mechanism that prevents one vertebra slipping forward on the one below (spondylolisthesis) and can be a cause of back pain. If bilateral, a spondylolisthesis is more likely. The defect appears as a 'collar' on the 'Scottie dog', hence the importance of demonstrating the 'dog'.

Common faults and remedies

A common error is to centre too medially, thus excluding the posterior elements of the vertebrae from the image.

2.23.4 Lumbo-sacral junction lateral

Position of patient and cassette

The patient lies on either side on the Bucky table, with the arms raised and the hands resting on the pillow. The knees and hips are flexed slightly for stability.

The dorsal aspect of the trunk should be at right-angles to the cassette. This can be assessed by palpating the iliac crests or the posterior superior iliac spines.

The coronal plane running through the centre of the spine should coincide with, and be perpendicular to, the midline of the Bucky.

The cassette is centered at the level of the fifth lumbar spinous process.

Non-opaque pads may be placed under the waist and knees, as necessary, to bring the vertebral column parallel to the cassette.

Direction and centering of the X-ray beam

Direct the central ray at right-angles to the lumbo-sacral region and towards a point 7.5 cm anterior to the fifth lumbar spinous process. This is found at the level of the tubercle of the iliac crest or midway between the level of the upper border of the iliac crest and the anterior superior iliac spine.

If the patient has particularly large hips and the spine is not parallel with the tabletop, then a five-degree caudal angulation may be required to clear the joint space.

Essential image characteristics

The area of interest should include the fifth lumbar vertebra and the first sacral segment.

A clear joint space should be demonstrated.

Radiation protection

This projection requires a relatively large exposure so should not be undertaken as a routine projection. The lateral lumbar spine should be evaluated and a further projection for the L5/S 1 junction considered if this region is not demonstrated to diagnostic standard.

2.24 SACRUM

2.24.1 Antero-posterior / postero-anterior

The sacrum may be either imaged antero-posteriorly or postero-anteriorly. If imaged postero anteriorly, there will be various advantages, including a lower dose to the gonads and better demonstration of the sacro-iliac joints, as the joint spaces will be more parallel with the divergent central ray. The anteroposterior position may be a more realistic option when the patient is infirm or injured and therefore would find it difficult to maintain the prone position.

Position of patient and cassette

The patient lies supine or prone on the Bucky table, with the median sagittal plane coincident with, and at right-angles to, the midline of the Bucky.

The anterior superior iliac spines should be equidistant from the tabletop.

If the patient is examined supine (antero-posteriorly), the knees can be flexed over a foam pad for comfort. "This will also reduce the pelvic tilt.

The cassette is displaced cranially for antero-posterior projection, or caudally for postero-anterior projections, such that its centre coincides with the angled central ray.

Direction and centering of the X-ray beam

Antero-posterior: direct the central ray 10-25 degrees cranially from the vertical and towards a point midway between the level of the anterior superior iliac spines and the superior border of the symphysis pubis.

The degree of angulation of the central ray is normally greater for females than for males and will be less for a greater degree of flexion at the hips and knees.

Postero-anterior: palpate the position of the sacrum by locating the posterior superior iliac spine and coccyx. Centre to the middle of the sacrum in the midline.

The degree of beam angulation will depend on the pelvic tilt.

Palpate the sacrum and then simply apply a caudal angulation, such that the central ray is perpendicular to the long axis of the sacrum.

Radiological considerations

The sacrum is a thin bone. Problems with exposure can easily lead to important pathologies such as fractures and metastases being missed.

2.24.2 Sacrum lateral view

Position of patient and cassette

The patient lies on either side on the Bucky table, with the arms raised and the hands resting on the pillow. The knees and hips are flexed slightly for stability.

The dorsal aspect of the trunk should be at right-angles to the cassette. This can be assessed by palpating the iliac crests or the posterior superior iliac spines.

The coronal plane running through the centre of the spine should coincide with, and be perpendicular to, the midline of the Bucky.

The cassette is centered to coincide with the central ray at the level of the midpoint of the sacrum.

Direction and centering of the X-ray beam

Direct the central ray at right-angles to the long axis of the sacrum and towards a point in the midline of the table at a level midway between the posterior superior iliac spines and the sacro-coccygeal junction.

Radiological considerations

Fractures are easily missed if the exposure is poor or a degree of rotation is present.

Common faults and remedies

If using an automatic exposure control, centering too far posteriorly will result in an underexposed image.

2.25 COCCYX

2.25.1 Antero-posterior view of coccyx

Position of patient and cassette

The patient lies supine on the Bucky table, with the median sagittal plane coincident with, and at right-angles to, the midline of the Bucky.

The anterior superior iliac spines should be equidistant from the tabletop.

The knees can be flexed over a foam pad for comfort and to reduce the pelvic tilt.

The cassette is displaced caudally so that its centre coincides with the central ray.

Direction and centering of the X-ray beam

Direct the central ray 15 degrees caudally towards a point in the midline 2.5 cm superior to the symphysis pubis.

Radiological considerations

Anatomy of the coccyx is very variable (number of segments, angle of inclination, etc.).

This is a high dose investigation with little yield unless the patient is to have a coccyxectomy.

2.25.2 Lateral view of coccγx

Position of patient and cassette

The patient lies on either side on the Bucky table, with the palpable coccyx in the midline of the Bucky. The arms are raised, with the hands resting on the pillow. The knees and hips are flexed slightly for stability.

The dorsal aspect of the trunk should be at right-angles to the cassette. This can be assessed by palpating the iliac crests or the posterior superior iliac spines. The median sagittal plane should be parallel with the Bucky.

The cassette is centered to coincide with the central ray at the level of the coccyx. Direction and centering of the X-ray beam

Direct the central ray at right-angles to the long axis of the sacrum and towards the palpable coccyx.

Common faults and remedies

Care must be taken when using an automatic exposure control, as underexposure can easily result if the chamber is positioned slightly posterior to the coccyx.

2.26 THORAX: THORACIC INLET (INCLUDING TRACHEA)

Plain radiography is requested to investigate the presence of soft-tissue swellings in the neck and the upper thorax and to demonstrate the effects on the air passages, e.g. the presence of retrosternal goitre.

Consideration should also be given to the fact that radiography in the lateral position will involve exposure of the neck and the relatively thicker upper thorax. A high-kilovoltage tech nique should therefore be employed to demonstrate the full length of the trachea on one image.

Two projections, an antero-posterior and a lateral, are taken using a moving grid technique. A cassette size is selected that will include the full length of the trachea.

2.26.1 Antero-posterior of thoracic inlet and trachea

Position of patient and cassette

The patient lies supine, with the median sagittal plane adjusted to coincide with the central long axis of the imaging couch.

The chin is raised to show the soft tissues below the mandible and to bring the radiographic baseline to an angle of 20 degrees from the vertical.

The cassette is centered at the level of the sternal notch.

Direction and centering of the X-ray beam

Direct the vertical ray in the midline at the level of the sternal notch.

Exposure is made on forced expiration.

Essential image characteristics

The beam should be collimated to include the full length of the trachea.

2.26.2 Thoracic inlet lateral view

Image acquisition is best performed with the patient erect, thus enabling the patient to position the shoulders away from the area of interest.

Position of patient and cassette

The patient stands or sits with either shoulder against a vertical Bucky.

The median sagittal plane of the trunk and head are parallel to the cassette.

The cassette should be large enough to include from the lower pharynx to the lower end of the trachea at the level of the sternal angle.

The shoulders are pulled well backwards to enable the visualization of the trachea.

This position is aided by the patient clasping their hands behind the back and pulling their arms backwards.

The cassette is centered at the level of the sternal notch.

Direction and centering of the X-ray beam

The horizontal central ray is directed to the cassette at the level of the sternal notch.

The exposure is made on forced expiration.

Note

The full length of the trachea can be demonstrated on a single image using a high-kilovoltage technique, which reduces the contrast between the neck and the denser upper thorax.

Radiological considerations

This projection is sometimes helpful in confirming retrosternal extension of the thyroid gland. Most assessments of the trachea itself will be by bronchoscopy and/or CT (especially multislice CT with MPR reconstructions and virtual bronchoscopy).

An anterior mediastinal mass (e.g. retrosternal thyroid) causes increased density of the anterior mediastinal window. This can also be mimicked by superimposed soft tissue if the patient's arms are not pulled backwards sufficiently away from the area of interest.

2.27 LUNGS

2.27.1 Postero-anterior-erect

A 35 x 43-cm or 35 x 35-cm cassette is selected, depending on the size of the patient Orientation of the larger cassette will depend on the width of the thorax.

Position of patient and cassette

The patient is positioned facing the cassette, with the chin extended and centered to the middle of the top of the cassette.

The feet are paced slightly apart so that the patient is able to remain steady.

The median sagittal plane is adjusted at right-angles to the middle of the cassette. The shoulders are rotated forward and pressed downward in contact with the cassette, This is achieved by placing the dorsal aspect of the hands behind and below the hips, with the elbows brought forward, or by allowing the arms to encircle the cassette.

Direction and centering of the X-ray beam

The horizontal central beam is directed at right-angles to the cassette at the level of the eighth thoracic vertebrae (i.e. spinous process of T7), which is coincident with the lung midpoint (Unett and Carver 2001).

The surface marking of T7 spinous process can be assessed by using the inferior angle of the scapula before the shoulders are pushed forward.

Exposure is made in full normal arrested inspiration.

In a number of automatic chest film-changer devices, the central beam is centered automatically to the middle of the film.

Essential image characteristics

The ideal postero-anterior chest radiograph should demonstrate the following:

Full lung fields with the scapulae projected laterally away from the lung fields.

The clavicles symmetrical and equidistant from the spinous processes and not obscuring the lung apices.

The lungs well inflated, i.e. it should be possible to visualize either six ribs anteriorly or ten ribs posteriorly.

The costophrenic angles and diaphragm outlined clearly.

The mediastinum and heart central and defined sharply.

The fine demarcation of the lung tissues shown from the hilum to the periphery.

2.28 Expiration technique

Aradiograph may be taken on full expiration to confirm the presence of a pneumothorax This has the effect of increasing intrapleural pressure, which results in the compressmothorax lung, making a pneumothorax bigger. The technique is useful in demonstrating a small pneumothorax and is also used to demonstrate the effects of air-trapping associated with an inhaled foreign body obstructing the passage of air into a segment of lung, and the extent of diaphragmatic movement.

2.28.1 Lungs antero-posterior - semi-erect

This semi-recumbent position is adopted as an alternative to the antero-posterior erect projection when the patient is too ill to stand or sit erect without support.

Position of patient and cassette

The patient is supported in a semi-recumbent position, facing the X-ray tube. The degree to which they can sit erect will depend on their medical condition.

A cassette is supported against the back, using pillows or a large 4S-degree foam pad, with its upper edge above the lung fields.

Care should be taken to ensure that the cassette is parallel to the coronal plane.

The median sagittal plane is adjusted at right-angles to, and in the midline of, the cassette.

Rotation of the patient is prevented by the use of foam pads.

The arms are rotated medially, with the shoulders brought forward to bring the scapulae clear off the lung fields.

Direction and centering of the X-ray beam

The central ray is directed first at right-angles to the cassette and towards the sternal notch.

The central ray is then angled until it is coincident with the middle of the film, thus avoiding unnecessary exposure to the eyes.

Notes

If the patient is unable to sit erect, fluid levels are demonstrated using a horizontal ray with the patient adopting the lateral decubitus or dorsal decubitus position.

Sick patients may be unable to support their own head in the erect position, resulting in superimposition of the chin over the upper thorax. Care should be taken to avoid or minimize this if at all possible as apical lesions will be obscured.

2.28.2 Lungs lateral view

A supplementary lateral projection may be useful in certain clinical circumstances for localizing the position of a lesion and demonstrating anterior mediastinal masses not shown on the postero-anterior projection. Lateral radiographs, however, are not taken as part of a routine examination of the lung fields, because of the additional radiation patient dose.

The FFD may be reduced to 150 cm to maintain a short exposure time.

Position of patient and cassette

The patient is turned to bring the side under investigation in contact with the cassette.

The median sagittal plane is adjusted parallel to the cassette.

The arms are folded over the head or raised above the head to rest on a horizontal bar.

The mid-axillary line is coincident with the middle of the film, and the cassette is adjusted to include the apices and the lower lobes to the level of the first lumbar vertebra.

Direction and centering of the X-ray beam

Direct the horizontal central ray at right-angles to the middle of the cassette at the mid- axillary line.

Radiological considerations

Insufficient elevation of the arms will cause the soft tissues of the upper arms to obscure the lung apices and thoracic inlet, and even the retrosternal window, leading to masses or other lesions in these areas being missed.

Rotation will also partially obscure the retrosternal window, masking anterior mediastinal masses. It will also render the sternum less distinct, which may be important in the setting of trauma when sternal fracture may be overlooked.

2.29 Lungs apices

Opacities obscured in the apical region by overlying ribs or clavicular shadows may be demonstrated by modification of the postero-anterior and antero-posterior projections.

2.29.1 Direction and centering of the X-ray beam

With the patient in the position for the postero-anterior projection, the central ray is angled 30 degrees caudally towards the seventh cervical spinous process coincident with the sternal angle.

With the patient in the position for the antero-posterior projection, the central ray is angled 30 degrees cephalad towards the sternal angle.

2.30 Lungs-fluid levels

Patients who are too ill to sit erect may be examined whilst lying down. The use of a horizontal central ray is essential to demonstrate fluid levels, e.g. hydropneumothorax

2.30.1 Postero-anterior or antero-posterior lung (lateral decubitus)

This projection is used to confirm the presence of fluid. Moving the patient into a different position causes movement of free fluid, so that loculation is also detected. It may also be used to demonstrate the lateral chest wall of the affected side clear off fluid, and to unmask any underlying lung pathology.

Position of patient and cassette

The patient is turned on to the unaffected side and, if possible, raised on to a supporting foam pad.

A cassette is supported vertically against the anterior chest wall, and the median sagittal plane is adjusted at right-angles to the cassette.

The patient's arms are raised and folded over the head to clear the chest wall.

Direction and centering of the X-ray beam

Centre to the level of the eighth thoracic vertebra, with the central ray horizontal and directed at right-angles to the cassette.

Alternatively, an antero-posterior projection may be taken, with the cassette supported against the posterior aspect of the patient.

2.30.2 Lung lateral (dorsal decubitus)

This projection will show as much as possible of the lung fields, clear off a fluid level, when the patient is unable to turn on their side.

Position of patient and cassette

The patient lies supine and, if possible, is raised off the bed on a supporting foam pad.

The arms are extended and supported above the head.

A cassette is supported vertically against the lateral aspect of the chest of the affected side and adjusted parallel to the median sagittal plane.

Direction and centing of the X-ray beam

Centre to the axilla, with the central ray horizontal and directed at right-angles to the cassette.

2.31 CRANIUM

2.31.1 Cranium Lateral - erect

This position may be used for a cooperative patient. Variations from the supine horizontal beam technique are noted below, but all other imaging criteria remain the same.

Position of patient and cassette

The patient sits facing the erect Bucky and the head is then rotated, such that the median sagittal plane is parallel to the Bucky and the inter-orbital line is perpendicular to it.

The shoulders may be rotated slightly to allow the correct position to be attained. The patient may grip the Bucky for stability.

Position the cassette transversely in the erect Bucky, such that its upper border is 5 cm above the vertex of the skull.

A radiolucent pad may be placed under the chin for support.

Direction and centering of the X-ray beam

The X-ray tube should have been centered previously to the Bucky.

Adjust the height of the Bucky / tube so that the patient is comfortable (NB: do not decentre the tube from the Bucky at this point).

Centre midway between the glabella and the external occipital protuberance to a point approximately 5 cm superior to the external auditory meatus.

Common faults and remedies

This is not an easy position for the patient to maintain. Check the position of all planes immediately before exposure, as the patient probably will have moved.

Notes

This projection can also be performed with the patient prone on a floating-top table.

The projection may be performed usefully on babies in the supine position, with the head rotated to either side.

An air/fluid level in the sphenoid sinus (an indicator for a base-of-skull fracture) will not be visible if the patient is imaged with a vertical central ray. This is not relevant in young babies, as the sinus is not developed fully.

2.31.2 Cranium - Occipito-frontal

Occipito-frontal projections can be employed with different degrees of beam angulation. The choice of projection will depend upon departmental protocol and the anatomy that the be demonstrated.

Position of patient and cassette

This projection may be undertaken erect or in the prone position. The erect projection will be described, as the prone projection is uncomfortable for the patient and will usually be carried out only in the absence of a vertical Bucky.

The patient is seated facing the erect Bucky, so that the median sagittal plane is coincident with the midline of the Bucky and is also perpendicular to it.

The neck is flexed so that the orbito-meatal base line is perpendicular to the Bucky. This can usually be achieved by ensuring that the nose and forehead are in contact with the Bucky.

Ensure that the mid-part of the frontal bone is positioned in the centre of the Bucky.

The patient may place the palms of each hand either side of the head (out of the primary beam) for stability.

A 24 x 30-cm cassette is placed longitudinally in the Bucky tray. Ensure that the lead name blocker will not interfere with the final image.

Direction and centering of the X-ray beam

Occipito-frontal

The central ray is directed perpendicular to the Bucky along the median sagittal plane.

A collimation field should be set to include the vertex of the skull superiorly, the region immediately below the base of the occipital bone inferiorly, and the lateral skin margins. It is important to ensure that the tube is centered to the middle of the Bucky.

Occipito-frontal caudal angulation:

10, 15 and 20 degrees

The technique used for these three projections is similar to that employed for the occipito-frontal projection, except that a caudal angulation is applied. The degree of angulation will depend on the technique, e.g. for an OF20° projection, a 20-degree caudal angulation will be employed.

Ensure that the central ray is always centered to the middle of the Bucky once the tube angulation has been applied and not before.

Essential image characteristics

All the cranial bones should be included within the image, including the skin margins.

It is important to ensure that the skull is not rotated. This can be assessed by measuring the distance from a point in the midline of the skull to the lateral margin. If this is the same on both sides of the skull, then it is not rotated.

The degree of beam angulation can be evaluated from an assessment of the position of the petrous ridges within the orbit:

- Occipito-frontal: the petrous ridges should be completely superimposed within the orbit, with their upper borders coincident with the upper third of the orbit.

-OF10°: the petrous ridges appear in the middle third of the orbit.

- OF15°: the petrous ridges appear in the lower third of the orbit.

- OF20°: the petrous ridges appear just below the inferior orbital margin.

Common faults and remedies

Rotation: ensure that the patient's head is straight immediately before the exposure is made.

Incorrect beam angulation: it is worth remembering that greater beam angulations will result in the petrous ridges appearing further down the orbit. If an OF20° is undertaken and the petrous bones appear in the middle third of the orbit, then a greater angle should have been applied, in this case a further 10 degrees.

Cranium - Occipito-frontal 30-degree cranial angulation - reverse Towne's projection

Position of patient and cassette

This projection is usually undertaken with the patient in the erect position and facing the erect Bucky, although it may be performed prone.

Initially, the patient is asked to place their nose and forehead on the Bucky table. The head is adjusted to bring the median sagittal plane at right-angles to the cassette and so it is coincident with its midline.

The orbito-meatal baseline should be perpendicular to the cassette.

The patient may place their hands on the Bucky for stability.

Direction and centering of the X-ray beam

The central ray is angled cranially so its makes an angle of 30 degrees to the orbito- meatal plane.

Adjust the collimation field, such that the whole of the occipital bone and the parietal bones up to the vertex are included within the field. Avoid including the eyes in the primary beam. Laterally, the skin margins should also be included within the field.

Essential image characteristics

The sella turcica of the sphenoid bone is projected within the foramen magnum.

The image must include all of the occipital bone and the posterior parts of the parietal bone, and the lambdoidal suture should be visualized clearly.

The skull should not be rotated. This can also be assessed by ensuring that the sella turcica appears in the middle of the foramen magnum.

Radiological considerations

The foramen magnum should be seen clearly on this projection. The margins may be obscured by incorrect angulation, thus hiding important fractures.

The zygoma may be seen well on this projection. If fractured, this gives a clue to the presence of associated facial injury.

Common faults and remedies

See Half-axial, fronto-occipital 30 degrees caudad - Towne's projection.

2.32 Cranium - Submento-vertical

Position of patient and cassette

The patient may be imaged erect or supine. If the patient is unsteady, then a supine technique is advisable.

2.32.1 Supine

The patient's shoulders are raised and the neck is hyperextended to bring the vertex of the skull in contact with the grid cassette or table.

The head is adjusted to bring the external auditory meatuses equidistant from the cassette.

The median sagittal plane should be at right-angles to the cassette along its midline.

2.32.2 Erect

The orbito-meatal plane should be as near as possible parallel to the cassette.

The patient sits a short distance away from a vertical Bucky.

The neck is hyperextended to allow the head to fall back until the vertex of the skull makes contact with the centre of the vertical Bucky.

The remainder of the positioning is as described for the supine technique.

Direction and centering of the X-ray beam

The central ray is directed at right-angles to the orbito-meatal plane and centered midway between the external auditory meatuses.

Essential image characteristics

A correct projection will show the angles of the mandible clear off the petrous portions of the temporal bone.

The foramina of the middle cranial fossa should be seen symmetrically either side of the midline.

Radiological considerations

Erosion of the bony margins of the skull-base foramina is an important indicator of destruction by tumour. Under-tilt, over-tilt and rotation reduce the visibility of these foramina.

This is now an uncommon projection, as CT demonstrates more completely the bony detail of the skull base in axial and coronal planes. MRI offers multiplanar imaging with superb detail of the soft tissues as well as the skull base.

Common faults remedies

This projection involves positioning that is very uncomfortable for the patient. It is well worth ensuring that the equipment is prepared fully before commencing the examination. so that the patient needs to maintain the position for only a minimum period,

The position is achieved much more easily if a skull unit is used, since the object table and tube can be adjusted to minimize hyperextension of the neck.

2.33 CRANIUM - SELLA TURCICA: LATERAL

2.33.1 Position of patient and cassette

The patient sits facing the erect Bucky and the head is then rotated, such that the median sagittal plane is parallel to the Bucky and the inter-orbital line is perpendicular to the Bucky.

The shoulders may be rotated slightly to allow the correct position to be attained. The patient may grip the Bucky for stability.

The head and Bucky heights are adjusted so that the centre of the Bucky is 2.5 cm vertically above a point 2.5 cm along the baseline from the external auditory meatus.

A radiolucent pad may be placed under the chin and face for support. Direction and centering of the X-ray beam

A well-collimated beam is centered to a point 2.5 cm vertically above a point mid way between glabella and external occipital protuberance, (2.5 cm along the baseline from the auditory meatus nearer the X-ray tube).

Radiological considerations

This examination is increasingly uncommon, as in the presence of good clinical or biochemical evidence of a pituitary tumour MRI or CT will be the test of choice. If these modalities are unavailable, then evidence of sella expansion by a large lesion may be obtained from plain image radiography. A double floor to the sella turcica may be a sign of smaller intra-pituitary tumour, but it can also be a normal variant due to a slope of the sella floor, this may be resolved by use of a well-collimated OF20° down projection.

2.34 CRANIUM-MASTOID-PROFILE

2.34.1 Position of patient and cassette

The patient lies supine on the table, with the orbito-meatal baseline perpendicular to the table top.

From a position with the median sagittal plane perpendicular to the table, the head is rotated through an angle of 35 degrees away from the side under examination, such that the median sagittal plane now makes an angle of 55 degrees to the table.

The vertical tangent to the skull should now be at the level of the middle of the mastoid process under examination, so that the mastoid process is in profile.

Finally, the head is moved transversely across the table so that the mastoid process being examined is in the midline of the table.

Direction and centering of the X-ray beam

The central ray is angled caudally so that it makes an angle of 25 degrees to the orbito-meatal plane and is centered to the middle of the mastoid process on the side under examination.

Collimate tightly around the mastoid process.

Notes

Both sides are often imaged for comparison.

A small lead side-marker should be included within the collimation field.

2.35 CRANIUM - PETROUS BONE: ANTERIOR OBLIQUE (STENVER'S)

2.35.1 Position of patient and cassette

The patient may be prone or may be more comfortable being examined erect and facing a vertical Bucky.

The middle of the supra-orbital margin on the side being examined is centered to the middle of the Bucky.

The neck is flexed so that the nose and forehead are in contact with the table and the orbito-meatal line is perpendicular to the table.

From a position where the median sagittal plane is perpendicular to the table, the head is rotated toward the side under examination, such that the median sagittal plane is now at an angle of 45 degrees to the table. This brings the petrous part of the temporal bone parallel to the cassette.

The neck is extended so that the orbito-meatal line is raised five degrees from horizontal.

An 18 x 24-cm cassette is placed transversely in the Bucky and is centered at a level to coincide with the central ray.

Direction and centering of the X-ray beam

A 12-degree cephalad beam angulation is employed, i.e. at an angle of seven degrees to the orbito-meatal plane, to separate the occiput from the petrous bone.

Centre midway between the external occipital protuberance and the external auditory meatus farthest from the cassette.

Collimate to the mastoid and petrous parts of the temporal bone under examination.

Note

This projection is now more or less redundant due to the superior diagnostic capabilities of CT.

2.36 ORBITS: OCCIPITO-MENTAL

This is a frequently undertaken projection used to assess injuries to the orbital region (e.g. blow-out fracture of the orbital floor) and to exclude the presence of metallic foreign bodies in the eyes before magnetic resonance imaging (MRI) investigations. The projection is essentially an under-tilted occipito-mental with the orbito-meatal baseline raised 10 degrees less than in the standard occipito-mental projection.

Position of patient and cassette

The projection is best performed with the patient seated facing the skull unit cassette holder or vertical Bucky.

The patient's nose and chin are placed in contact with the midline of the cassette holder. The head is then adjusted to bring the orbito-meatal baseline to a 35-degree angle to the cassette holder.

The horizontal central line of the vertical Bucky or cassette holder should be at the level of the midpoint of the orbits.

Ensure that the median sagittal plane is at right-angles to the Bucky or cassette holder by checking that the outer canthi of the eyes and the external auditory meatuses are equidistant.

Direction and centering of the X-ray beam

The central ray of the skull unit should be perpendicular to the cassette holder and by design will be centered to the middle of the image receptor. If this is the case and the above positioning is performed accurately, then the beam will already be centered.

If using a Bucky, the tube should be centered to the Bucky using a horizontal beam before positioning is undertaken. Again, if the above positioning is performed accurately and the Bucky height is not altered, then the beam will already be centered.

To check that the beam is centered properly, the cross-lines on the Bucky or cassette holder should coincide with the midline at the level of the mid-orbital region.

Essential image characteristics

The orbits should be roughly circular in appearance (they will be more oval in the occipito-mental projection).

The petrous ridges should appear in the lower third of the maxillary sinuses.

There should be no rotation. This can be checked by ensuring that the distance from the lateral orbital wall to the outer skull margins is equidistant on both sides.

Notes

If the examination is purely to exclude foreign bodies in the eye, then tight 'letter-box' collimation to the orbital region should be applied.

A dedicated cassette should be used for foreign bodies This should be cleaned regularly to avoid small artefacts on the screens being confused with foreign bodies.

If a foreign body is suspected, then a second projection may be undertaken, with the eyes in a different position to differentiate this from an image artefact. The initial exposure could be taken with the eyes pointing up and the second with the eyes pointing down.

2.37 NASAL BONES: LATERAL

Position of patient and cassette

The patient sits facing an 18 x 24-cm cassette supported in the cassette stand of a vertical Bucky.

The head is turned so that the median sagittal plane is parallel with the cassette and the inter-pupillary line is perpendicular to the cassette.

The nose should be roughly coincident with the centre of the cassette.

Direction and centering of the X-ray beam

A horizontal central ray is directed through the centre of the nasal bones and collimated to include the nose.

Radiological considerations

Nasal fracture can usually be detected clinically and is rarely treated actively. If a fracture causes nasal deformity or breathing difficulty, then it may be straightened, but lateral projections will not help. Considering the dose of radiation to the eye, this projection should be avoided in most instances.

Notes

A high-resolution cassette may be used if detail is required.

This projection may be useful for foreign bodies in the nose.

In this case, a soft-tissue exposure should be employed.

In the majority of cases, severe nasal injuries will require only an occipito-mental projection to assess the nasal septum and surrounding structures.

The projection can also be undertaken with the patient supine and the cassette supported against the side of the head.

2.38 MANDIBLE

2.38.1 Mandible lateral 30 degrees cephalad

Position of patient and cassette

The patient lies in the supine position. The trunk is rotated slightly and then supported with pads to allow the side of the face being examined to come into contact with the cassette, which will be lying on the tabletop.

The median sagittal plane should be parallel with the cassette and the inter-pupillary line perpendicular.

The neck may be flexed slightly to clear the mandible from the spine.

The cassette and head can now be adjusted and supported so the above position is maintained but is comfortable for the patient.

The long axis of the cassette should be parallel with the long axis of the mandible and the lower border positioned 2 cm below the lower border of the mandible.

The projection may also be performed with a horizontal beam in trauma cases when the patient cannot be moved.

In this case, the patient will be supine with the median sagittal plane at right-angles to the tabletop. The cassette is supported vertically against the side under examination Direction and centering of the X-ray beam

The central ray is angled 30 degrees cranially at an angle of 60 degrees to the cassette and is centered 5 cm inferior to the angle of the mandible remote from the cassette.

Collimate to include the whole of the mandible and temporo-mandibular joint (TMJ) (include the external auditory meatus (EAM) at the edge of the collimation field).

Essential image characteristics

The body and ramus of each side of the mandible should not be superimposed.

The image should include the whole of the mandible, from the TMJ to the symphysis menti.

Radiological considerations

Do not mistake the mandibular canal, which transmits the inferior alveolar nerve, for a fracture.

Common faults and remedies

Superimposition of the mandibular bodies will result if the angle applied to the tube is less than 30 degrees or if the centering point is too high.

If the shoulder is obscuring the region of interest in the horizontal beam projection, then a slight angulation towards the floor may have to be applied, or, if the patient's condition will allow, tilt the head towards the side under examination.

Notes

In cases of injury, both sides should be examined to demonstrate a possible counter- coup fracture.

Tilting the head towards the side being examined may aid positioning if the shoulder is interfering with the primary beam.

2.38.2 Mandible: postero-anterior

Position of patient and cassette

The patient sits facing the vertical Bucky or skull unit cassette holder. Alternatively. in the case of trauma, the projection may be supine on a trolley, giving an antero- posterior projection.

The patient's median sagittal plane should be coincident with the midline of the Bucky or cassette holder. The head is then adjusted to bring the orbito-meatal baseline perpendicular to the Bucky or cassette holder.

The median sagittal plane should be perpendicular to the cassette. Check that the external auditory meatuses are equidistant from the cassette.

The cassette should be positioned such that the middle of an 18 x 24-cm cassette, when placed longitudinally in the Bucky or cassette holder, is centered at the level of the angles of the mandible.

Direction and centering of the X-ray beam

The central ray is directed perpendicular to the cassette and centered in the midline at the levels of the angles of the mandible.

Essential image characteristics

The whole of the mandible from the lower portions of the TMJs to the symphysis menti should be included in the image.

There should be no rotation evident.

Radiological consideration

This projection demonstrates the body and rami of the mandible and may show transverse or oblique fractures not evident on other projections or dental panoramic tomography (OPT) (orthopantomography, OPT).

The region of the symphysis menti is superimposed over the cervical vertebra and will be seen more clearly when using the anterior oblique projection.

Common faults and remedies

Superimposition of the upper parts of the mandible over the temporal bone will result if the orbito-meatal baseline is not perpendicular to the cassette.

Notes

A 10-degree cephalad angulation of the beam may be required to demonstrate the mandibular condyles and temporal mandibular joints.

2.39 TEMPORAL-MANDIBULAR JOINTS

2.39.1 Lateral 25 degrees TM joints caudad

It is usual to examine both temporal-mandibular joints. For each side, a projection is obtained with the mouth open as far as possible and then another projection with the mouth closed. An additional projection may be required with the teeth clenched.

Position of patient and cassette

The patient sits facing the vertical Bucky or skull unit cassette holder or lies prone on the Bucky table. In all cases, the head is rotated to bring the side of the head under examination in contact with the table. The shoulders may also be rotated slightly to help the patient achieve this position.

The head and Bucky or cassette holder level is adjusted so the centre cross-lines are positioned to coincide with a point I cm along the orbito-meatal baseline anterior to the external auditory meatus.

The median sagittal plane is brought parallel to the cassette by ensuring that the inter- pupillary line is at right-angles to the table top and the nasion and external occipital protuberance are equidistant from it.

The cassette is placed longitudinally in the cassette holder, such that two exposures can be made without superimposition of the images.

Direction and centering of the X-ray beam

Using a well-collimated beam or an extension cone, the central ray is angled 25 degrees caudally and will be centered to a point 5 cm superior to the joint remote from the cassette so the central ray passes through the joint nearer the cassette.

Radiological considerations

TMJ images are useful in assessing joint dysfunction by demonstrating erosive and degenerative changes. Open- and closed mouth projections can be very helpful in assessing whether normal anterior gliding movement of the mandibular condyle occurs on jaw opening MRI promises greater accuracy, since it also demonstrates the articular cartilages and fibrocartilage discs and how they behave during joint movement.

Notes

The image should include the correct side-marker and labels to indicate the position of the mouth when the exposure was taken (open, closed, etc.).

2.40 PARANASAL SINUSES - OCCIPITO-MENTAL (Waters view)

This projection is designed to project the petrous part of the temporal bone below the floor of the maxillary sinuses so that fluid levels or pathological changes in the lower part of the sinuses can be visualized clearly.

Position of patient and cassette

The projection is best performed with the patient seated facing the skull unit cassette holder or vertical Bucky.

The patient's nose and chin are placed in contact with the midline of the cassette holder. The head is then adjusted to bring the orbito-meatal baseline to a 45-degree angle to the cassette holder.

The horizontal central line of the Bucky or cassette holder should be at the level of the lower orbital margins.

Ensure that the median sagittal plane is at right-angles to the Bucky or cassette holder by checking that the outer canthi of the eyes and the external auditory meatuses are equidistant.

The patient should open the mouth as wide as possible before exposure. This will allow the posterior part of the sphenoid sinuses to be projected through the mouth.

Direction and centering of the X-ray beam

The central ray of the skull unit should be perpendicular to the cassette holder and by design will be centered to the middle of the image receptor. If this is the case and the above positioning is performed accurately, then the beam will already be centered.

If using a Bucky, the tube should be centered to the Bucky using a horizontal beam before positioning is undertaken. If the above positioning is performed accurately and the Bucky height is not altered, then the beam will already be centered.

To check the beam is centered properly, the cross-lines on the Bucky or cassette holder should coincide with the patient's anterior nasal spine.

Collinate to include all of the sinuses.

Essential image characteristics

The petrous ridges must appear below the floors of the maxillary sinuses.

There should be no rotation. This can be checked by ensuring that the distance from the lateral orbital wall to the outer skull margins is equidistant on both sides.

Common faults and remedies

Petrous ridges appearing over the inferior part of the maxillary sinuses: in this case, several things may have occurred. The orbito-meatal baseline was not positioned at 45 degrees to the film or a five- to ten-degree caudal angulation may be applied to the tube to compensate. As this is an uncomfortable position to maintain, patients often let the angle of the baseline reduce between positioning and exposure. Therefore, always check the baseline angle immediately before exposure.

Note

To distinguish a fluid level from mucosal thickening, an additional projection may be undertaken with the head tilted, such that a transverse plane makes an angle of about 20 degrees to the floor.

2.41 ABDOMEN

2.41.1 Antero-posterior

A 35 x 43cm cassette is used

Position of the patient and the cassette

Patient lies supine in the middle of the table

The anterior superior iliac spines are equally distant from the table top

The cassette is placed longitudinally

The centre of the cassette will be at the level of, 1cm below the line joining iliac crest

Direction and centering of X-ray beam

Vertical central ray is directed to the centre of cassette

Short exposure is made on arrested respiration

Essential image characteristics

Antero-posterior projection for whole abdomen:

Abdomen to include diaphragm, lateral abdominal walls and ischial tuberosities.

Pelvis and spine should be straight, with no rotation.

Reproduction of properitoneal fat lines consistent with age.

Visualization of kidney and psoas outlines consistent with age and bowel content.

Visually sharp reproduction of the bones.

Common faults and remedies

Usually inadequate coning but occasionally too tight coning excludes the diaphragm.

Male gonads not protected.

Careful technique is needed to address these problems.

Radiological considerations

Optimization of abdominal radiographs includes using a lower dose technique, e.g. no grid and a very fast image acquisition system, in the assessment of examinations such as chronic constipation and swallowed foreign body is recommended. Serial images in the latter are not necessary.

All boys should have testicular protection.

Radiographs of the renal tract can be more collimated laterally.

Although it has been demonstrated that a postero-anterior abdominal technique results in a lower dose (Marshall et al. 1994), a supine technique with male gonad protection is preferred in children.

In supine neonates who cannot be moved, a horizontal beam lateral should be taken from the left to reduce the dose to the liver.

Left lateral decubitus images may be required in cases of suspected necrotizing enterocolitis. In this projection, with the patient lying on the left side, free gas will rise, to be located between the lateral margin of the liver and the right abdominal wall.

Abdominal ultrasound has replaced radiography in many conditions.

2.42 PELVIS

2.42.1 Antero-posterior (basic)

Positioning of Patient and Film

The patient lies supine with the median sagittal plane adjusted to coincide with the central longitudinal axis of the couch. The anterior superior iliac spines should be equidistant from the couch top. This distance may be assessed by placing a thumb on each iliac spine and the fingers in contact with the couch. The pelvis is rotated into the correct position and supported as necessary using non-opaque pads. The knees should be flexed over foam pads for comfort. The heels should be separated and the limbs rotated medially so that the long axes of the feet are approximately 5-10 degrees to the vertical. The limbs are maintained in position using sandbags. The film is centred at a level midway between the anterior superior iliac spines and the superior border of the symphysis pubis. The film must be large enough to include the whole pelvis and proximal ends of the femora.

Direction and Centering of the X-ray Beam

Centre in the midline, midway between the level of the anterior superior iliac spines and the superior border of the symphysis pubis with the central ray perpendicular to the film.

Note - If the kVp is too low, the optical density of the superolateral part of the ilia may be too great for adequate visualization, particularly when the patient is thin.

2.42.2 Pelvis/hips - Von Rosen projection

This supplementary projection was sometimes employed to confirm diagnosis of DDH. The disadvantage of the projection is that it produces a number of false positives and negatives, and it has been largely superseded by hip ultrasound.

The ossification centre of the femoral head tends to be a little eccentric and lateral, particularly following treatment for DDH. This may give the false impression of decentering. The degree of dislocation and decentering is best assessed by drawing a line through the mid- sacrum and triradiate cartilage. This line should pass through the medial aspect of the femoral metaphysis. The use of this line in a straight antero-posterior radiograph of the hips is preferred to the Von Rosen projection.

2.42.3 Lateral-both hips (frog projection)

This projection may be employed to supplement the anteroposterior projection in the investigation of irritable hips.

Position of patient and cassette

The child lies supine on the X-ray table, on top of the cassette, with the median sagittal plane of the trunk at right angles to the middle of the cassette.

To maintain this position when examining a baby, a sandbag is placed either side of the baby's trunk, with the arms left unrestrained.

The anterior superior iliac spines should be equidistant from the couch top to ensure that the pelvis is not rotated.

The hips and knees are flexed.

The limbs are then rotated laterally through approximately 60 degrees, with the knees separated and the plantar aspects of the feet placed in contact with each other.

A child may be supported in this position with non-opaque pads.

The cassette is centered at the level of the femoral pulse and must include both hips.

Direction and centering of the X-ray beam

The vertical central ray is directed in the midline at the level of the femoral pulse.

Reference and pictoral guidance:

Merrills's pocket guide to Radiography by Elsevier.

CHAPTER 3

RADIOGRAPHIC CONTRAST PROCEDURES

Fluoroscopic Guided Contrast Procedures are commonly performed in radiology department. It requires a tilting table, dedicated fluoroscopic unit with a spot film device. Contrast procedures require the utilization of either oral or intravascular contrast media which are radiopaque. A high KV technique (90 to 110KV) is employed when barium is used. A very important point while performing fluoroscopic contrast procedures is radiation protection. Fluoroscopy should be performed with full radiation protective measures and for the minimum time which is essentially required. Contrast procedures will be discussed system vise ile gastrointestinal contrast procedures, hepatobiliary procedures, urinary tract procedures etc.

3.1 GIT CONTRAST PROCEDURES

Include the following:

Barium Swallow

Barium Meal

Barium Follow Through

Small Bowel Enema

Barium Enema

- Instant Barium Enema
- Enema Reduction Of Intussusception
- Therapeutic Enema In Meconium Ileus

Loopogram

Sinogram / Fistulogram

GIT ANGIOGRAPHY

• Celiac axis angiography

o Superior-mesenteric angiography

• Inferior-mesenteric angiography

3.2 HEPATOBILIARY SYSTEM CONTRAST PROCEDURES

Include the following:

Oral Cholecystography (Obsolete Now)

Intravenous Cholangiography (Obsolete Now)

Operative Cholangiography

Post Operative (T-Tube) Cholangiography

Endoscopic Retrograde Cholangiopancreatography (ERCP)

Percutaneous Transhepatic Cholangiography (PTC)

Biliary Drainage Procedures:

• Percutaneous transhepatic biliary drainage (PTBD)

• Endoscopic biliary drainage

3.3 URINARY TRACT CONTRAST PROCEDURES

Excretion Urography / Intravenous Urography (IVU)

Antegrade Pyelography

Micturating Cystourethrography

Ascending Urethrography

Retrograde Pyeloureterography

Percutaneous Nephrostomy (PCN)

Arteriography Renal Arteriography

Venography - Including Renal Vein Sampling

3.4 FEMALE GENITAL TRACT CONTRAST PROCEDURE

Hysterosalpingography

3.5 OPTHALMOLOGICAL CONTRAST PROCEDURE

Dacrocystography

3.6 SALIVARY GLAND PROCEDURE

Sialography

3.7 VASCULAR CONTRAST PROCEDURES (DSA)

3.8 COMMON ARTERIOGRAPHIES PERFORMED

Angiocardiography

Carotid angiography

Coronary angiography

Head and neck arteriography

Pulmonary arteriography

Ascending aortography

Translumbar aortography

Cerebral angiography

Renal arteriography

Celiac arteriography

Superior mesenteric arteriography

Inferior mesenteric arteriography

3.9 VENOGRAPHY including

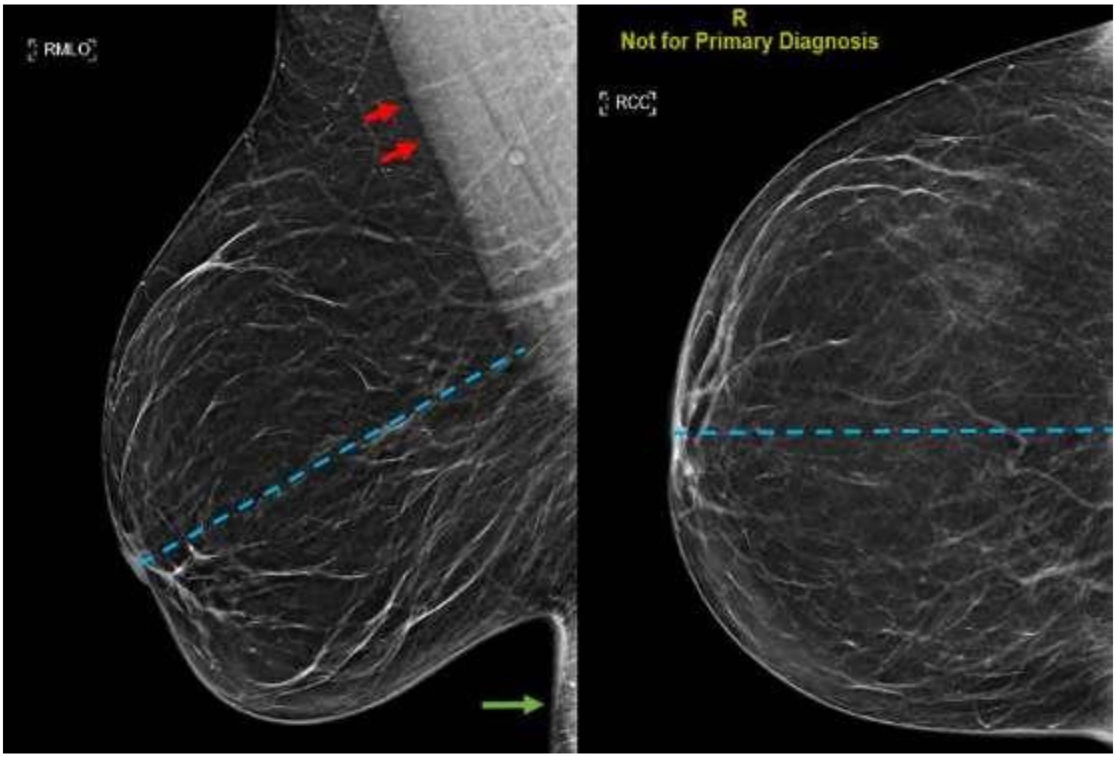
Central venography

Peripheral venography

CHAPTER 4

MAMMOGRAPHY

Mammography is a dedicated radiographic technique for imaging the breast, and the resultant images are known as mammograms.



4.1 Types of mammography

In general terms, there are two types of mammography: screening and diagnostic.

Mammography differs significantly in many respects from the rest of diagnostic imaging.

4.1.1 Screening mammography

In general terms, screening mammography is performed on asymptomatic women to identify malignant breast pathology at an early, potentially curable stage. Regardless of confusing statistics in lay publications, the earlier breast cancer is picked up, all other factors being equal, the better the survival rate. Screening mammography is performed on clients, not patients.

4.1.2 Diagnostic mammography

Imaging performed on symptomatic patients, or to work-up an abnormality found on screening mammography. The objective is to use imaging to typify pathology and arrive at a diagnosis. This is important because different diagnoses have significantly different outcomes and survival rates. For instance, a diagnosis of a simple breast cyst has few implications and does not affect the patient's life expectancy. In contrast, a diagnosis of breast cancer has significant implications for the patient and their life expectancy.

Differences between the screening and diagnostic environments

Screening studies are well performed by trained sympathetic staff in environments that are not necessarily located in hospitals. Screening centers function very well as stand-alone locations without a physician on-site. The studies are usually read by breast radiologists and/or breast physicians in an isolated environment. In contrast to the rest of radiology, these studies are read in batches (boards) and in large volumes, and comparison to prior mammograms is vital. Where screening studies are read in environments where interruptions, phones and distractions are present, the risk of mistakes occurring is higher. In many countries, breast cancer screening programs require screening mammograms to be double-read (i.e. two independent breast imagers read the mammogram) with any discordance being referred to a third independent reader.

The standard screening views performed are the craniocaudal (CC) and mediolateral oblique (MLO) projections of each breast.

Diagnostic studies are performed with a radiologist on-site, involved with every step of the imaging procedure. Standard views are supplemented with additional views (e.g. coned views, cleavage view, compression view, lateral view, mediolateral view) to further assess the screening-detected abnormality.

Criteria for image quality assessment

- all breast glandular tissue imaged
- image annotation
  - date
  - patient ID (name or DOB)
  - side markers
  - radiographer ID
  - cassette ID (ideally)
- correct exposure - can "bright light" skin and nipple
- no movement artifact
- no skin folds
- symmetrical images

4.2 Adequate craniocaudal (CC) views

- all glandular tissue identified
- nipple in profile
- nipple in the midline of image
- length of posterior nipple line (PNL) within 1 cm in size (cf. PNL on MLO)
- images symmetric

4.3 Adequate mediolateral oblique (MLO) views

- pectoral shadow is seen down to the level of the nipple or lower
- inframammary fold is well seen

- nipple in profile
- length of posterior nipple line (PNL) within 1 cm in size (cf. PNL on CC)
- images symmetric

CHAPTER 5

ULTRASOUND

USG is a diagnostic procedure employing high frequency sound waves to form image of body parts or structure. It is helpful in outlining normal anatomy of body parts and also showing the pathology of organs as well. However as sound waves cannot travel well through bone and air therefore no useful information in the form of image can be obtained from lungs or gastrointestinal tract as they contain air. No useful image can be formed from bone. So ultrasound is not useful in imaging lungs, gut or bone.

Important Concepts and Points

Ultrasound is safe with no ionizing effect on body or radiation hazard as seen with X- Rays.

It is a safe and useful investigation in pregnancy.

Ultrasound waves are high frequency sound waves. Their frequency is in mega hertz (MHz). (1 MHz = 1 million cycles/second). Ultrasound frequencies used in medical diagnosis range between 1 - 15 MHz. Routinely 3.5 MHz frequency is used for abdominal examination (Deep examination). But for evaluation of superficial structure like subcutaneous tissues, breast, testis & muscles a very high frequency is used starting from 7.5 MHz to 15 MHz.

Ultrasound waves are material waves that require a medium to pass through & ultrasound waves can not travel through vacuum.

Ultrasound waves travel longitudinally.

5.1 Basic Machinery and Physics of Ultrasound

Ultrasound machine is a machine with four basic parts :-

1. Operating Console

2. Transducer

3. T.V Screen / Monitor

4. Printer

5.1.1. Operating Console

Operating Console has all the basic buttons & switches used by the ultrasonologist.

It has a basic power on & off button to switch on or turn off the machine.

It has switches to select type of transducer, range of frequency of ultrasound waves, intensity or power of ultrasound waves and their focusing depth.

It has a switch to command the printer to print.

It has a switch to freeze or unfreeze the image.

It has measurement buttons on it to measure size, volume, fetal parameters etc.

5.1.2. Ultrasound Transducer

It is of various shapes e.g convex, linear etc. This is the main active part of ultrasound machine which produces ultrasound waves when a voltage is applied across the transducer. The active part of transducer producing sound waves is called piezo electric crystal and is formed from lead zirconate titanate crystals (PZT). When a voltage is applied across the dise formed from PZT, the crystal vibrates and creates a pulse of high frequency sound waves. The frequency of sound waves emitted depends on the thickness of the crystal. The thinner the crystal, the more higher the frequency of sound waves produced.

Sound waves produced from transducer are emitted in pulse and not continuously.

These sound waves are transmitted to human body from transducer through a coupling ultrasound gel which is applied on part of hardy to be examined by ultrasound.

Without gel, sound waves will not pass to human body as air would be between transducer & body and air does not allow sound waves to travel through it.

These sound waves travel through different body tissues & are reflected at tissue interfaces depending on the tissue density and tissue type i.e solid, fluid, blood, air, fat, muscle and bone.

These reflected sound waves are then detected by the same transducer and depending on the tissue characteristics will form an image on screen.

Ultrasound image formed on screen & print is shown in different shades of grey e.g.

a) Clear fluid or urine or simple cyst appears black or echolucent.

b) Infected cyst/Pus may appear black (echo lucent) with floating echoes in it

c) Soft tissue gives different shades of grey e.g

- Muscles-Hypnechoic - grayish black
- Fat-echogenic-light grey

d) Calcification or bone appears white (echogenic) with distal shadowing.

e) Gas gives a bright signal that appears white but with irregular dirty shadowing.

5.1.3. T.V Screen / Monitor

It is the small screen on top of the operating console which displays the image formed by ultrasound waves reflected from different tissues in the body part examined. It is shown in a gray scale form that is in different shades of grey ranging from black (clear water / fluid) to white (bone, calcification / gas). The screen shows the image dynamically i.e moving in real time and we can assess movement of organs as well as heart beat, peristalsis of gut, fetal parts movement etc. However the image can be made static by switching on the freeze button.

5.1.4. Printer

Every modern ultrasound machine has a printer in it which copies the static image on the ultrasound screen / monitor. This print can be handed over to patient for record. Image can be stored in CDs, magnetic disks etc.

5.2 BASIC ROUTES / FORMS OF ULTRASOUND

5.2.1. Transcutaneous / percutaneous ultrasound.

This form of ultrasound is performed by a percutaneous approach and ultrasound transducer is placed on patient's skin. This route is commonly and routinely used to perform abdominal ultrasound, pelvic ultrasound, musculoskeletal ultrasound, vascular ultrasound and ultrasound brain in infants.

5.2.2. Endocavitary / endoluminal / endoscopic ultrasound

This type of ultrasound is performed by placing ultrasound probe within lumen of gut or organs. Its sub types are

a) Endovaginal ultrasound / transvaginal ultrasound **(TVS)**

It is performed in females to assess pelvic organs and pelvic pathology by placing ultrasound probe in vagina. This route assesses anatomy and pathology much better than transcutaneous route.

b) Endorectal/transrectal ultrasound **(TRUS)**

It is performed in males by placing ultrasound probe in rectum to assess rectal pathology, pathology of prostate or other pelvic organ pathology. This route assesses pelvic organ anatomy and pathology much better than transcutaneous route.

c) Endoscopic ultrasound

It is performed by introducing ultrasound probe per orally or per rectally into the upper gastrointestinal tract or lower gastrointestinal tract respectively. It is used to evaluate abnormality of gut wall and local lymph nodal anatomy in case of esophagus, stomach, upper small intestine or large intestine. It can even show all the different bowel wall layers separately like mucosa, submucosa, muscularis propria and serosa.

5.2.3. Endovascular ultrasound

It is performed by a very small ultrasound probe which is introduced within the lumen of a blood vessel to assess abnormality of vessel wall like plaques, atheroma etc. This technique assesses intravascular pathologies much better than transcutaneous route. All the above routes of ultrasound are utilized not only to perform diagnostic ultrasound but also for ultrasound guided intervention like ultrasound guided biopsies and abscess drainage etc.

5.3 DOPPLER ULTRASONOGRAPHY

This a special type of ultrasound which is a flow sensitive ultrasound. It shows blood vessels in an organ or mass. It is helpful in evaluation of blood flow in arteries and veins of different organs or tissues. It forms a colored ultrasound image shown in red, blue & yellow colors. The basic principle in Doppler ultrasound is that when ultrasound waves of a certain frequency strike moving red blood cells in an artery or vein the frequency of the ultrasound wave reflected from blood cells and sent to transducer will be different depending on the velocity of blood. If the blood is flowing towards the transducer the reflected sound waves frequency will be higher than incident ultrasound wave frequency. If blood is flowing away from transducer the reflected frequency will be lower than incident ultrasound wave frequency. Blood flowing towards transducer will reflect higher frequency ultrasound wave and is shown in red color. While blood flowing away from the transducer will reflect a lower frequency ultrasound wave and is shown in blue color. Conventionally speaking, all arteries are shown in red & veins are shown in blue color.

5.3.1 Clinical uses of Doppler Ultrasound:

- It can show and confirm that a hypoechoic lesion seen on simple ultrasound (Grey Scale Dynamic Ultrasound) is a blood vessel. This confirmation is not possible by simple gray scale ultrasound.
- It can give us information regarding the normal vascular pattern and vascular anatomy of organs of the body.
- It can give us information about the vascularity of a mass lesion.
- It can differentiate between artery or vein on basis of waveform if we switch on "Spectral wave form" mode of Doppler.
- It can tell us the exact velocity of blood flow in a vessel.

- It can tell us definitely if there is thrombosis of veins (DVT).
- "Spectral wave form mode" can show us if any artery or vein has an abnormal waveform.
- We can calculate various vascular parameters by means of Doppler ultrasound including peak systolic velocity, end diastolic velocity and acceleration time etc.

5.4 ECHOCARDIOGRAPHY

Echocardiography means ultrasound of the heart & main vessels around it. It is a coupled ultrasound technique which utilizes both simple grey scale dynamic ultrasound & Doppler ultrasound. It :-

a) Can measure cardiac chamber size & volume.

b) Can calculate velocity of arteries & show their waveform.

c) Can calculate stroke volume and cardiac output.

d) Can show & confirm various congenital and acquired cardiac abnormalities etc. like ASD, VSD, valvular heart diseases.

e) Can detect and confirm pericardial disease like pericardial effusion & pericardial 2 thickening, calcification & constrictive pericarditis.....

5.5 CARE OF ULTRASOUND MACHINE

1. All parts of ultrasound equipment should be kept clean on daily basis.
2. Ultrasound machine should not be placed near any major electric appliance as it may interfere with ultrasound waves produced by machine and create noise.
3. A stable electrical supply to machine with stabilizer and UPS (uninterrupted power supply) is mandatory.
4. Machine to be switched off daily after use and switched on about 10 minutes prior to start of work.

5. **Transducer** is the most sensitive part of the machine and it should be handled with utmost care. The following points should be observed in transducer care :-
    a. Transducers should always be placed in their respective holder after use.
    b. Transducer should be placed in holder with its sensitive functioning crystal surface upwards.
    c. All tangles and knots in cable of transducer should be removed before placing and setting the transducer in its holder daily after work.
    d. Transducer should be gently wiped with a soft cotton cloth after use.
    e. Handling of transducer while cleaning and placing should be very gentle so as to avoid damage to sensitive crystal surface to prevent abrasion.
    f. No strong chemicals or detergents should be used to clean transducer surface.

5.6 PATIENT PREPARATION FOR ULTRASOUND

1. At least 06 hours of fasting is required for gallbladder ultrasound examination.
2. Plenty of oral fluid intake is advised and patient is asked to hold urine for a full urinary bladder ultrasound scan. A full urinary bladder scan is required for following ultrasound examinations :-
    a. Ultrasound of urinary bladder.
    b. Ultrasound of uterus and ovaries in female.
    c. Ultrasound of prostate in males.
    d. Ultrasound in early pregnancy
    e. Ultrasound for placental localization and placental pathology.

f. Ultrasound of any pelvic mass or pelvic pathology.

3. An empty urinary bladder is required for both transvaginal and transrectal ultrasound.
4. Wearing of a gown by patient for ultrasound breast.
5. Proper exposure of the part of body to be examined by ultrasound.
6. Covering the rest of body by a clean sheet to make patient comfortable.
7. Handling of female patients only by nurse or female hospital employees.

5.7 PATIENT POSITIONING FOR ULTRASOUND

Nearly all abdominal ultrasound require a supine position of the patient on ultrasound couch with hands on pillow.

5.8 SPECIAL POSITIONS FOR ULTRASOUND

For thyroid ultrasound or carotid vessel Doppler study, a pillow should be placed under patient's upper back and shoulder to place neck in an extended position for examination.

Doppler ultrasound of legs may be done in prone position.

Venous Doppler study of legs may be done with patient sitting on ultrasound couch & legs hanging towards floor.

Varicocele examination may be done with patient standing erect.

Ultrasound of shoulder is done with patient sitting on a stool

Transvaginal and transrectal ultrasound is done in lithotomy position.

5.9 ULTRASOUND GUIDED INTERVENTIONAL PROCEDURES

Many interventional procedures are being performed under dynamic ultrasound guidance. Nowadays some of these are :-

a. Ultrasound guided fine needle aspiration cytology (FNAC) of masses / organs.
b. Ultrasound guided tissue core biopsy of masses / organs.
c. Ultrasound guided abscess drainage.
d. Ultrasound guided injection of steroids / anti inflammatory / anaesthetic agents in painful inflammatory conditions like Morton's neuroma, arthritis etc.
e. Ultrasound guided per cutaneous nephrostomy.

5.10 Role of Radiographer in Ultrasound Guided Intervention

Get a written informed consent signed by patient or attendant prior to procedure.

Check and show the results of relevant pre-procedural investigations of patient to Radiologist.

- These investigations are atleast:-

a. Blood Hb%

b. Platelet Count

c. PT, APTT, INR

I.V line of patient should established and secured prior to all major interventional procedures.

Should keep the biopsy tray or aspiration tray well maintained with provision of:-

a. LP needles different gauge (14G-24G)
b. Surgical Syringes with needles of different capacity e.g 2ml, 3ml, 5ml, 10ml and 20ml etc.
c. Pyodine solution.
d. Spirit swabs.

e. Local anaesthetic agents like Lignocaine.
f. Surgical blades.
g. Cutting needles & thread (silk 2.0).
h. Tincture benzoin Co for sealing.
i. Cotton swabs.
j. Gauze pieces.
k. Glass slides with slide holder for FNAC sample.
l. Alcohol solution in slide holder bottle for slide fixing.
m. Formalin in bottle for tissue core biopsy specimen placement.

Should label the slides or biopsy specimen carefully.

Should get duly signed forms by the Radiologist and hand it over to patient or attendant for histopathology examination/cytology.

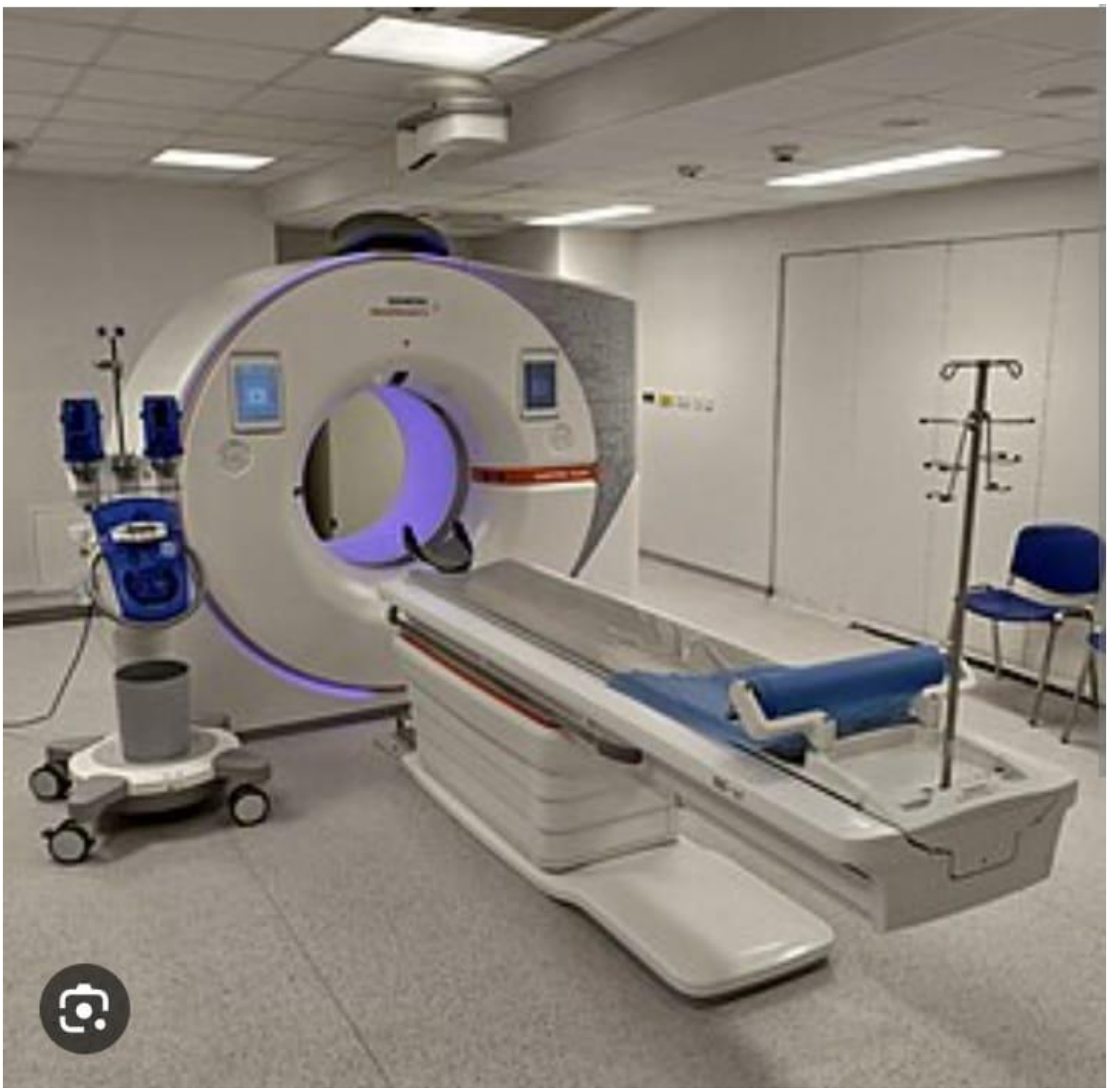
Emergency tray drugs & equipment of the department should be well maintained by the Radiographer and ready at hand in case of emergency.

Post procedural Vital signs recording to be done in required cases.

Close watch on patient in department for about 30 minutes post procedure and in case of any vital sign abnormality or complication immediate consultation with Radiologist.

CHAPTER 6

CT SCAN (Computed Tomography)



The CT scanner is typically a large, machine with a short tunnel, in the center. The examination table slides into tunnel.

Rotating x-ray tube and electronic x-ray detectors are located opposite each other in a ring, called a gantry. The detectors measure the amount of radiation being absorbed throughout the body. At the same time, the examination table is moving through the tunnel, so that the x-ray beam follows a spiral path.

A special computer program processes this large volume of data to create two-dimensional cross-sectional images, which are then displayed on a monitor. This technique is called helical or spiral CT.

The computer workstation that processes the imaging information is located in a separate room, where the technologist operates the scanner and monitors examination.

New technology has brought new CT scanners to obtain multiple slices in a single rotation. These scanners, called "multislice CT", allow thinner slices to be obtained in a shorter period of time, resulting in fast speed, which is beneficial for all patients but especially children, the elderly and critically ill.

For children, the CT scanner technique will be adjusted to reduce the radiation dose.

For some CT exams, a contrast material is used to enhance visibility in the area of the body being studied.

Benefits

CT scans of internal organs, bones, soft tissue and blood vessels provide greater clarity and reveal more details than regular x-ray exams.

CT scanning is painless, noninvasive and accurate.

A major advantage of CT is its ability to image bone, soft tissue and blood vessels all at the same time.

CT examinations are fast and simple; in emergency cases, they can reveal intermal injuries and bleeding, quickly.

CT is cost-effective, and less sensitive to patient movement than MRI, it is a good tool for minimally invasive procedures such as needle biopsies and needle aspirations of many areas of the body.

Diagnosis and treatment of spinal, and other skeletal problems and injuries to skeletal structures

The preferred method for diagnosing many different cancers, including lung, liver and pancreatic cancer,

Monitor response to chemotherapy.

Measure bone mineral density for the detection of osteoporosis

No radiation remains in a patient's body after a CT examination.

For children, CT imaging is more often used to evaluate:

Lymphoma

Neuroblastoma

Congenital malformations of blood vessels

The kidneys

6.1 PREPARATION

Patient should wear comfortable, loose-fitting clothing, or may be given a gown to wear during the procedure.

Metal objects including jewellery, eyeglasses, dentures and hairpins may affect the CT images and should be removed prior to your exam. May also be asked to remove hearing aids and removable dental work.

Patient is asked not to eat or drink anything for several hours beforehand, especially if a contrast material is to be used in CT exam. You should ask the patient if he is taking any medicines or has any allergies. If patient has a known allergy to contrast material, the doctor may prescribe medications to reduce the risk of an allergic reaction.

Also seek information, regarding any recent illnesses or other diseases, like a history of heart disease, asthma, diabetes, kidney disease or thyroid problems, which may increase the risk of an unusual adverse effect.

Women should always be asked by the CT technologist if there is any possibility of pregnancy.

6.2 PROCEDURE OF CT SCAN

The technologist begins by positioning, the patient on the CT examination table, usually lying supine or prone or on his side.

Straps and pillows may be used to help maintain the correct position and to hold still during the exam. Patient is asked to hold breath during the scanning. Any motion, whether breathing or body movements, can lead to artifacts on the images.

The technologist, under the direction of a physician, may offer a mild sedative to help patient, tolerate the procedure, specially for the children who cannot hold still for the examination

With pediatric patients, a parent may be allowed in the room but will be required to wear a lead apron to minimize radiation exposure.

If contrast material is used, it will be swallowed, injected through an intravenous line (IV) or administered by enema, depending on the type of examination.

CT scanning of the body is usually completed within 30 minutes.

Risks

There is always a slight chance of cancer from excessive exposure to radiation

The effective radiation dose from this procedure ranges from approximately 2mSv, to 10 mSv

Women should always be asked about pregnancy. CT scanning is, not recommended for pregnant women.

Nursing mothers should resume breast-feeding after 24 hours, after contrast material injection.

The risk of serious allergic reaction to contrast materials is extremely rare, and radiology departments should be well-equipped to deal with them.

Children are more sensitive to radiation, they should have a CT study /repeat CT studies only if absolutely necessary.

6.3 THE CT GUIDED INTERVENTIONAL PROCEDURES

Imaging-guided, minimally invasive procedures such as needle biopsy are most often performed by a specially trained interventional radiologist.

A technologist will maintain an intravenous (IV) line into arm so that sedation or relaxation medication may be given intravenously during the procedure or a mild sedative may be given prior to the biopsy.

A CT scan is first performed, to locate the best site for needle insertion and the safest approach. Once the location of the nodule is confirmed, the entry site is marked on the skin.

The skin is then disinfected and anesthetized with its underlying tissue. The needle is inserted through the skin into the body.

Another CT scan is performed to confirm that the tip of the needle lies at the desired location. When the tip of the needle is seen to be in the proper position, the biopsy specimen is withdrawn through the needle.

Once the biopsy is complete, pressure will be applied to stop any bleeding and the opening in the skin is covered with a dressing. No sutures are needed.

CT-guided biopsies require patients to be able to hold still on the CT table for up to 30 minutes.

Aftercare

Patient may be taken to an observation area for few hours. X-ray(s) or other imaging tests may be performed to monitor for complications.

Contraindications:

The procedure is not indicated for the spleen because there is a high risk of severe post-biopsy hemorrhage.

CT-guided biopsy is not indicated for patients with bleeding disorders such as hemophilia, thrombocytopenia etc.

Preparation

The technique will vary depending on the site of specimen collection and the patient's general condition. In most procedures, the patient lies on the CT table on his back, or on either side, depending on where the needle is to be inserted. Some patients may require intravenous injection of pain killers

Risks

The risks associated with CT-guided biopsy depend on the site where the biopsy specimen is collected. They include:

Bleeding.

Infection.

Pneumothorax.

CHAPTER 7

MAGNETIC RESONANCE IMAGING (MRI)

In this technology patient is placed in a strong magnetic field. The hydrogen atoms in the patient align with the magnetic field. These hydrogen atoms are used to form the image. Various sequences as TIW, T2W, Fat suppressed sequences are then taken. These images utilize the properties of hydrogen atoms in different tissues. Different tissues and abnormalities are recognized by the image formed on different sequences.

Advantages of MRI over other diagnostic imaging modalities:

MRI has best contrast resolution so is useful for imaging of soft tissues.

MRI does not use ionizing radiation

It has direct multiplanar capability with ability to image in sagittal, axial and coronal planes.

Bone or air artifacts are not a problem as with CT Scan

It is totally non invasive

Limitations:

For imaging of bone trauma, CT is superior

Patients having certain metals incorporated in them as pacemakers, metallic clips, cannot be imaged with MRI if the metal is paramagnetic.

Patients may experience claustrophobia during an MRI scan

The loud noise produced during an MRI examination may be distressing for the patient.

Accidental quenching with release of helium and nitrogen cooling gases into the room can affect the patient and might cause suffocation or produce frostbite.

MRI is not a cost effective technique.

It is not widely available.

It requires a long time for data acquisition.

CHAPTER 8

RADIONUCLIDE IMAGING

8.1 Gamma Imaging

In this use is made of radio active isotopes to form image. The isotopes of an element are nuclides which have the same number of protons but different number of neutrons. These isotopes are unstable and transform spontaneously until they become stable nuclei, with emission of alpha, beta and gamma rays.

Alpha and beta rays are charged particles and are of not much use in diagnostic radiology.

8.1.1 Gamma rays:

They have the same properties as X Rays except that their source of production is different i-e they are produced by radioactive decay.

A radioisotope is given by intravenous injection or orally. The isotope concentrates at the region of interest and an image is formed which is captured by gamma camera and displayed on the monitor. This image is interpreted by the specialist in nuclear medicine.

8.2 Spectrum of radio nuclide imaging:

Radionuclide scans are commonly used for imaging:

1. Bones
2. Thyroid gland
3. Kidneys
4. Lungs
5. Heart

8.2.1 Imaging of bones:

Radiopharmaceutical used:

Tc 99m labelled MDP (methylene diphosphonate)

Indications:

Staging of cancer and response to therapy.

Assessment of primary bone tumors

Bone infections

Metabolic bone disease

Avascular necrosis and bone infarctions

Arthritis

Trauma

8.2.2 Imaging of thyroid gland

Radiopharmaceutical used:

1. Tc 99m pertechnetate

2. Iodine 123, 131, or 125 labelled with sodium iodide

Indications:

Investigation of thyroid nodules

Diagnosis and post intervention assessment of thyroid cancer

Suspected ectopic thyroid

Assessment of goitre

Investigation of the origin of thyrotoxicosis

8.2.3 Imaging of lung

Radiopharmaceutical used:

Ventilation scanning:

1. Tc 99m DTPA aerosols (Diethylene Triamine Penta acetic acid)

2. Xenon 133 gas

3. Krypton 81m gas

Perfusion scanning:

1. Tc 99m macroaggregated albumin

Indications:

Suspected pulmonary embolism

Assessment of ventilation and perfusion abnormalities

Differentiation of primary and secondary pulmonary hypertension

8.2.4 Imaging of kidneys

Radiopharmaceutical used:

Static renal scintigraphy:

Tc 99m labeled DMSA (Dimercaptosuccinic acid)

Dynamic renal scintigraphy:

1. Tc 99m MAG 3 (mercaptoacetylglycine)

2. Tc 99m DTPA

3. 1 123 Hippuran

Indications:

Static renal scintigraphy:

Demonstration of ectopic renal tissue

Renal tumor

Demonstration of congenital abnormalities and mass lesions

Dynamic renal scintigraphy:

Diagnosis of obstructive vs non obstructive dilatation

Assessment of renal function

Assessment of bladder function

Assessment of vesico ureteric reflux

8.3 Imaging of tumors

Radiopharmaceutical:

Gallium 67

Indications:

Staging of lymphomas

Assessment and prediction of their response to therapy

Detection of early relapse

Other tumors as hepatomas, bronchial carcinomas, multiple myeloma, and sarcomas may be imaged with it.

8.4 Cardiac scanning:

Radiopharmaceutical:

Thallium 201

Indications:

To assess myocardial perfusion post myocardial infarction

Diagnosis and assessment of the extent of coronary artery disease

Evaluation of the effects of angioplasty and bypass surgery on myocardial perfusion with pre and post intervention imaging.

8.5 Limitations of radionuclide scanning:

Radionuclide scanning is a highly sensitive but a non specific technique meaning thereby that it picks up the lesion with no clue to diagnosis.

It gives radiation to the whole body after injection so should be used sparingly.

CHAPTER 9

RADIATION THERAPY / RADIOTHERAPY / RADIATION ONCOLOGY

Radiotherapy or radiation oncology is defined as the medical use of high dose ionizing radiation as part of cancer treatment to kill cancer cells. Radiation therapy works by damaging the DNA of cells.

9.1 Types of Radiotherapy

It is of two main types:

1) External beam radiotherapy.
2) Internal radiotherapy.

9.1.1 EXTERNAL BEAM RADIOTHERAPY (EBRT)

It is a type of therapy in which radiation is given to patient from outside.

It is of following sub types:

a) Conventional external beam radiotherapy EBRT (photon therapy):

Single 2D X-Ray beam external radiation is given to patient is given via linear accelerator machine (Actual treatment machine). The treatment is planned on a specially calibrated Fluoroscopy X-Ray machine called Treatment simulator machine.

b) 3 Dimensional conformal radiotherapy:

Specialized 3D CT scanners or MRI scanners are used to outline the exact soft tissue extent of tumors for marking the radiation field. Radiation field is therefore smaller and more precise compared to conventional external beam radiation therapy and hence this method has less radiation side effects compared to EBRT.

<u>c) Particle therapy:</u>

Energetic ionizing particles like electrons instead of X-Ray photons are directed at target tumor by linear accelerator machine.

9.1.2 INTERNAL RADIOTHERAPY

Internal radiotherapy is delivered by placing radiation source inside or next to the area or organ requiring radiation therapy. It is used to treat cervical cancer, carcinoma prostate, breast cancer etc. The advantage of internal radiotherapy as opposed to ERBT is more effective treatment and less radiation side effects.

9.2 RADIATION DOSE & FRACTIONATION

The amount of radiation given to patient during radiotherapy is measured in Gray (Gy). This total dose is not given at one time but is divided in small doses and spread out over a specified period of time. This helps to reduce side effects of radiation and makes radiotherapy more effective for treatment. This division of total dose is called Dose Fractionation. A typical fractionation of dose in adults is 1.8 to 2 Gy/day, five days a week. However it varies on histological type of tumor, site of tumor, stage of tumor & patient's age & health status.

9.3 RADIATION SIDE EFFECTS

In radiation therapy, high intensity ionizing radiation (MV / megavolts / 10° V) is used as opposed to low intensity ionizing radiation (KV / kilovolts / 103 V) used in Diagnostic Radiology. Radiation side effects are therefore commonly seen in high dose radiotherapy. Side effects can be divided into two types:

1) Acute side effects

2) Late side effects

9.3.1 Acute side effects include

a. Local skin pain, redness, swelling & even ulceration in severe cases.

b. Temporary soreness & ulceration of mouth & throat.

c. Nausea, vomiting and diarrhea.

d. Cerebral edema (in case of cranial radiation).

e. Infertility (if gonads are irradiated).

9.3.2 Late side effects include

a. Fibrosis.

b. Hair loss.

c. Dryness of skin, mouth & eyes (due to damage to sweat glands, salivary glands and lacrimal gland).

d. Lymphedema.

e. Secondary cancer development.

f. Heart disease (in case of radiation for breast cancer).

g. Decline in cognitive function like loss of memory, thinking process disturbance etc (in case of head radiation therapy).

CHAPTER 10

RADIATION PROTECTION

10.1 Protection of staff

The three rules to protect staff from radiation are:

1. Time
2. Distance
3. Protective barriers

10.1.1 Time:

The exposure time should be kept as less as possible. This would decrease the radiation dose to the patient as well as the staff.

10.1.2 Distance:

Increasing distance from the source of radiation decreases the exposure to the staff.

10.1.3 Protective barriers:

Protective clothing with lead aprons with lead equivalent of at least 0.35-0.5mm.

- Thyroid shield with lead equivalent of at least 0.25mm lead.
- Lead Gloves, if required of at least 0.25 mm lead.
- Lead spectacles should be worn for eye protection.
- The staff should never stand in path of primary beam.

10.2 Personal Dosimetry Systems

1. Film badge
2. Them Thermoluminescent dosimeters
3. Electronic dosimeter

10.2.1 Film badge

It is most common form of personal dosimeter in our set up. In this a film usually the size of dental film is used. The film is used without screens. This film is carried in a plastic cassette or badge. This badge carries the identification of the wearer and has plastic and metal filters in it to differentiate between the different types of radiation.

3 types of filters are usually incorporated in to the film badge.

1. Thick plastic filter

2. Aluminium filter

3. Tin lead filter

The image formed on the film after passing through these filters differentiates between the different types of radiation that a person has been exposed to.

10.2.2 Thermoluminescent dosimeters

In these a small chip of lithium flouride is used. This chip after single use can be reused. This dosimeter measures the total dose received but does not differentiate between the various kinds of radiations received.

10.3 Protection of general public:

Shielding of X-Ray rooms with lead equivalent of 2.5mm lead in doors, windows and walls. 120mm concrete or 12mm barium plaster is equal to Imm lead.

10.3.1 Warming lights and signs:

They should be displayed outside the X-Ray rooms to alert the general public whenever on exposure is having made.

Allow only the person to be radio graphed in the room.

10.3.2 Protection of patient:

Correct positioning, kilovoltage, exposure and film-screen combination must be used to prevent need for repeat films.

The primary beam must be accurately limited with cones, apertures or light beam diaphragms.

Gonadal shield should be used for children to prevent unnecessary exposure to gonads.

Fast film screen combination should be used.

Notices should be displayed in waiting rooms and changing cubicles instructing patients to inform the radiographer before they are radio graphed, if they are, or think they may be pregnant.

Unless absolutely essential, a pregnant patient should never be radio graphed. Under unavoidable circumstances, radiation of the fetus should be avoided by protective covering of patient and appropriate coning of beam.

10.4 Radiation units:

Roentgen: It is the unit of radiation exposure.

Rad: It is the unit of absorbed dose.

Gray: It is the SI unit of absorbed dose. 1 Gray= 100 Rads

Sievert: Unit of absorbed dose equivalent.

Radiation dose to staff is measured in milli sievert (mSv) According to UK regulations 1999, the dose limits are:

10.5 Dose limits in milli sievert (mSv)

Whole body:

For Staff - 20 mSV

Trainees aged 16 to 18 years – 6 mSV

Public visitors – 1 mSV

Eyes:

150 mSV

50 mSV

and 15 mSV respectively

Extremities and other organs:

500 mSV

150 mSV

50 mSV respectively.

10.6 Radiation hazards:

The hazards of radiation are divided into:

a. Stochastic effects

b. Non stochastic effects.

10.6.1 Non stochastic effects:

These are also known as deterministic effects. They are dose dependent. These effects increase with increase in radiation dose eg cataracts, skin damage, bone marrow cell loss, sterility. These effects may be encountered with doses in radiation therapy and inadvertent exposure to large doses of radiation. These effects can be divided into:

a) Prodromal syndrome:

It occurs with radiation dose in excess of 100 rad delivered to total body. Nausea, vomiting, diarrhea, leucopenia are the features of this syndrome.

b) Hematologic syndrome:

It occurs with radiation exposure to 200-1000 rads of radiation. The main features of this syndrome are: nausea, vomiting, diarrhea, anemia, leucopenia, hemorrhage, fever, infection are the features of this syndrome.

c) Gastrointestinal syndrome:

Exposure to 1000-5000 rads of radiation causes this syndrome. nausea, vomiting, diarrhea, anemia, leucopenia, hemorrhage, fever, infection, electrolyte imbalance, lethargy, fatigue, shock are the features of this syndrome.

d) CNS syndrome:

Exposure to >5000 rads of radiation leads to this syndrome, nausea, vomiting, diarrhea, anemia, leucopenia, hemorrhage, fever, infection, ataxia, edema, vasculitis, meningitis are the features of this syndrome.

LD 50/30: It is the dose of radiation to the whole body that will result in death within 30 days to 50% of the subjects irradiated.

10.6.2 Stochastic effects:

They are all or none effects. The probability of an effect occurring increases with dose ie either the disease will develop or the disease will not develop e.g. development of leukemias and certain cancers etc.

CHAPTER 11

X-RAY EQUIPMENT

X-Rray Machine

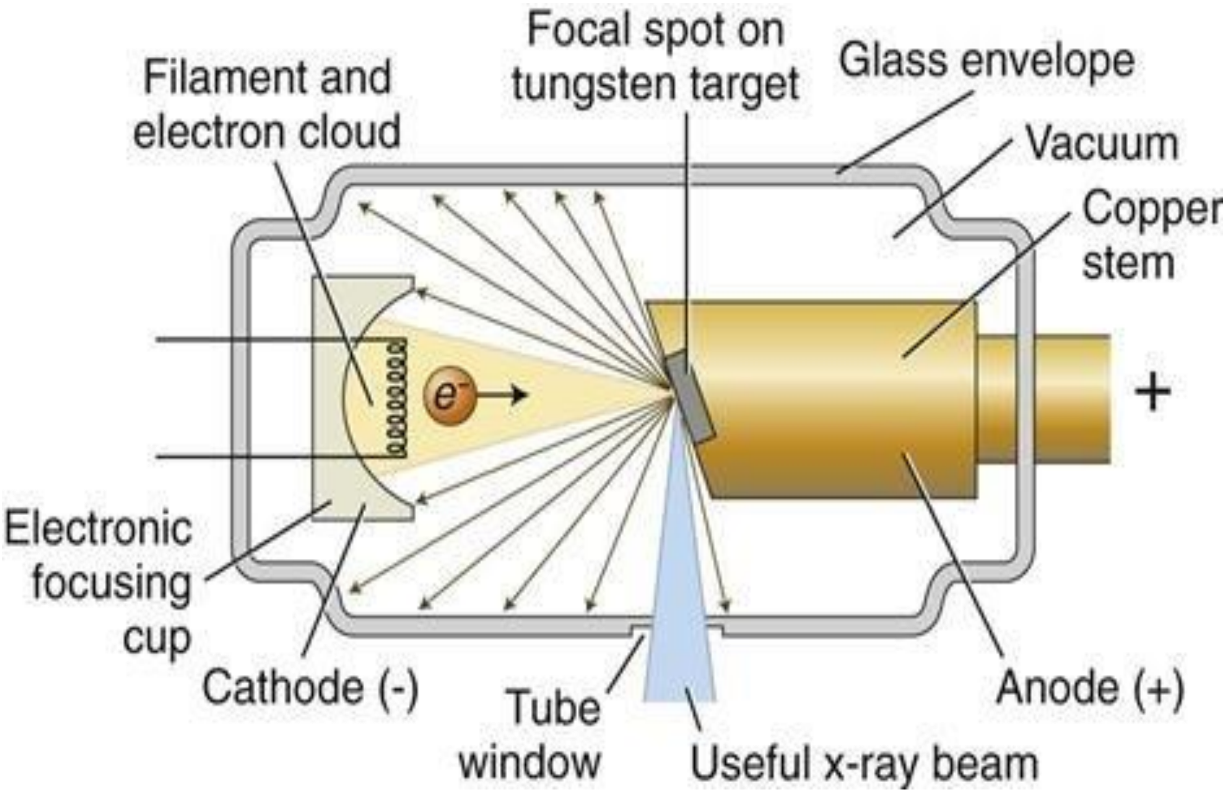
11.1 X-Ray Tube

It is contained in protective housing lined with lead.

The protective housing contains oil that serves as an electrical insulator and a thermal cushion.

It contains an:

Anode and a cathode enveloped in glass tube with vacuum in it.



11.1.1 Cathode:

It is the negative end of the tube. It has two parts:

a. Filament

b. Focusing cup.

The filament is made of Tungsten. Tungsten is used because of its ability to with stand very high temperatures. It has a melting point of 3370°C.

The focusing cup focuses the electrons produced from the cathode towards the anode.

11.1.2 Anode:

It is the tube target.

It is the positive side of the X-Ray tube. Two type of anodes are in use

a. Stationary

b. Rotating

Stationary Anodes:

These do not move when bombarded by electrons from the cathode. Consequently they are liable to heat up:

They are used in:

a. Dental X-Ray machines

b. Portable machines

c. Special purpose units in which high tube currents and power are not required.

Rotating Anode:

As the name indicates, the anode rotates during X-Ray production. Consequently, new surface is exposed to X-Rays with each rotation and the anode does not heat up easily. They are in use with high tube currents as with static X-Ray machines, fluoroscopy, and interventional radiological procedures.

The rotating anode is driven by an electromagnetic induction motor.

The whole assembly is contained in an evacuated glass envelope.

11.2 Control Console:

This apparatus allows the technician to control the X-Ray tube current (mA) and the kilovoltage (KV).

Kilovoltage:

It determines the energy of the X-Ray photons.

Milliamperage:

It is the tube current i.e. the number of electrons flowing from the cathode to the anode. This in turn depends on:

Temperature of the filament:

The higher the temperature the greater would be the number of electrons emitted.

Filament current:

As the filament current increases, the filament becomes hotter with release of more electrons.

11.3. X-Ray Generator

X-Ray generator is a device that supplies electric power to the X-Ray tube.

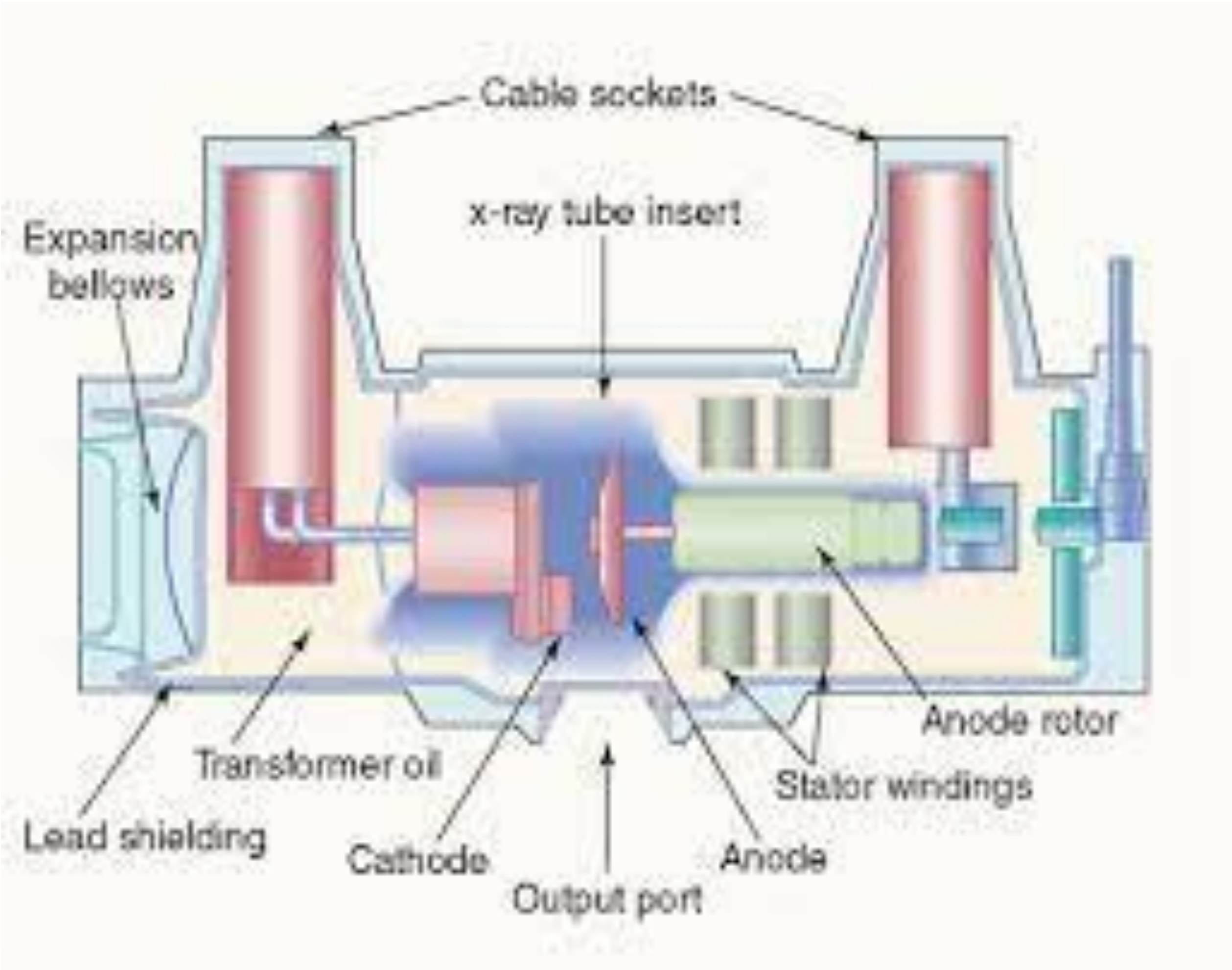
X-Ray generator may be of 3 types.

a. Single phase X-Ray Generator

b. Dual phase X-Ray Generator

c. Triple phase X-Ray Generator

Nowadays all X-Ray generators are usually triple phase X-Ray generators because the electricity supply to these generators is in three phases which is almost a continuous current.



Parts of X-Ray Generators:

There are 2 main parts of X-Ray generator

a. Operating panel / operating console

b. Transformer assembly

Operating Console / Operating Panel:

It has all main controls & switches on it e.g

a. On/off switch - to switch on X-Ray machine

b. mA selector switch / button

c. KVP selector/control

d. Timer selection/mAs selector

e. Exposure button

f. Auto transformer is within control panel..

11.4 Transformer Assembly (X-Ray Generator Assembly):

Transformer assembly is composed of

a. Transformers

b. Rectifiers

c. Meters

Transformers:

Transformers change the voltage. These are of 2 types

a. Step up transformer/high voltage transformer:

- It increases the voltage 500-1000 times
- It supplies current and voltage to the main X-Ray tube for production of X-Rays

b. Step down transformer/low voltage transformer:-

- It decreases the voltage 5-10 times
- It supplies current to heat the filament / cathode so that after heating the filament can emit electrons.

11.5 Rectifier:

The function of rectifiers is to convert alternating current supplied to it into direct current. X- Rays are only produced during positive phase of voltage of alternating current. Negative phase of voltage of alternating current is useless. So rectifiers change negative phase of voltage into positive phase thus utilizing all phases of current to produce X-Rays.

A INPUT WAVE FORM

B HALF-WAVE RECTIFICATION

C FULL-WAVE RECTIFICATION

11.6 Meters:

There are 2 types of meters in transformer assembly. These meters are

a. "Pre reading" KVp meter

b. "mA meter"

11.7 KVp meter:

It measures voltage difference across X-Ray tube i.e. potential difference between anode and cathode of X-Ray tube.

mA meter:

It measures X-Ray tube current flowing across X-Ray tube due to flow of electrons.

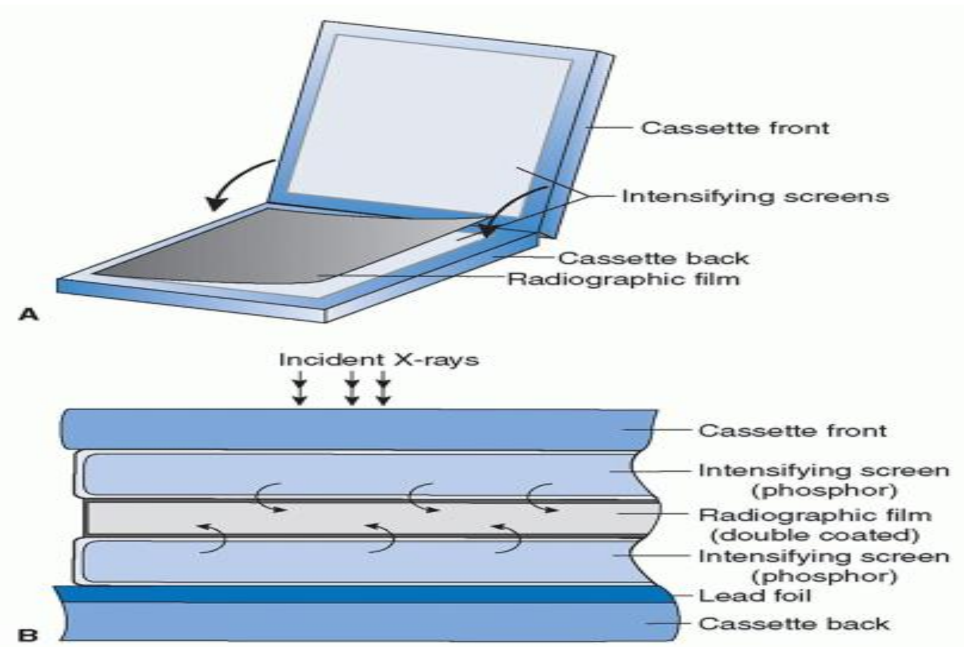
11.8 FILM CASSETTE

Film cassette is a rigid holder that contains screens and film. The front of the screen is made of low atomic number material such as plastic or cardboard so that X-Ray beam is not attenuated. Attached to the inside of the front cover of the cassette is the front screen.

The back surface of the cassette cover is thicker than the front screen. The back screen is attached to the back cover.

The radiographic film is loaded between these two screens.

Between each screen and cassette cover is a compression device such as felt or rubber that maintains close film screen contact when the cassette is closed.



Construction of film cassette

11.9 FLUOROSCOPY

In fluoroscopy, visible image is produced by a phosphor screen which converts the pattern of X-Rays leaving the patient into visible image. A phosphor screen converts the X-Rays into light.

Steps of image production by a fluoroscope:

1. The X Rays pass through the patient and fall on the input screen. The input screen phosphor is made of cesium iodide.

2. The phosphor screen converts the x rays into light.

3. The light falls on the photocathode. The photocathode converts light into electrons.

4. The electrons are accelerated by 25-35 KV between the negative input and the positive output screen.

5. The accelerated electrons fall on the smaller output screen. This screen is made of zinc cadmium sulphide activated with silver.

6. The electrons are converted back to light by the output screen.

7. Final image produced is visible on the TV monitor.