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The skull and facial bones. |
| 2    | **The nasal cavity and paranasal sinuses.** |
| 3    | **The mandible and teeth**  
The oral cavity and salivary glands. |
| 4    | **The orbit and the orbital contents.** |
| 5    | **The ear.** |
| 6    | **The pharynx and related spaces**  
The nasopharynx and related spaces. |
| 7    | **The larynx.**  
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| 8    | **The neck vessels** |
| 9    | **The central nervous system:**  
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| 12   | **Brainstem.**  
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Introduction

- In the past skull radiographs were considered an essential step in the investigative protocol of a patient suspected to have neurological disease.
- Now, with the availability of CT and MRI there has been a dramatic decline in the use of plain films and the indications for skull radiographs have been redefined.
- The major indication for skull radiographs is in the evaluation of skeletal dysplasias, diagnostic survey in abuse, abnormal head shapes, infections and tumors affecting the skull bones, metabolic bone disease, leukemias and multiple myeloma.
- Abnormalities in skull radiographs may be seen in the form of change in the density, size and shape of the skull, as well as skull defects.
In this tutorial we will study ...

- Skull x-ray
  - AP view
  - Lateral view
  - Open mouth (odontoid) view
- Neck x-ray (lateral view)
- Paranasal sinuses x-ray (both AP and lateral view) and CT.
- Neck sections (MRI)
  - Axial sections: through each vertebra to demonstrate the neck viscera...
  - Sagittal sections
- Sialography (the radiographic examination of the salivary glands, mainly x-ray)
- Angiogram (to demonstrate the anatomy of the main blood vessels in the base of skull and neck region)
- Some clinical correlate related to the above subjects

- BRAIN ANATOMY IS NOT INVOLVED!!
- A SEPARATE TUTORIAL WAS MADE TO DEMONSTRATE THE ANATOMY OF BRAIN
Skull anatomy

- The skull rests on the superior aspect of the vertebral column.
- It is made up of 22 separate bones divided into two distinct groups
  1. Cranial bones (8)
  2. Facial bones (14)
1. Cranial bones

- The cranial bones are further divided into the **calvaria** and the **floor**.
- The cranial bones form a protective housing for the brain.

Namely: -

a) Frontal  
b) Occipital  
c) Parietal (2)  
d) Ethmoid  
e) Sphenoid  
f) Temporal (2)
CRANIAL BONES (8)
The eight bones of the cranium are divided into the calvaria (skullcap) and the floor. Each of these two areas primarily consists of four bones:

Calvaria (Skullcap)

1. Frontal
2. Right parietal
3. Left parietal
4. Occipital

Floor

5. Right temporal
6. Left temporal
7. Sphenoid (sfe'-noid)
8. Ethmoid (eth'-moid)
Top of skull = skull cap
= Calvarium

- It is made up of 4 bones
- Frontal
- L & R Parietal
- Occipital
The Floor of the Cranium is made of 4 bones

(The four on the floor!)

- The Ethmoid
- The Sphenoid
- Left & Right Temporal bones
2. Facial bones

- The facial bones provide structure, shape and support for the face.
- They also form a protective housing for the upper ends of the respiratory and digestive tracts and with several of the cranial bones form the **orbital sockets** for protection of the organs of sight.

**Namely:**

- a) Nasal (2)
- b) Lacrimal (2)
- c) Maxillary (2)
- d) Zygomatic (2)
- e) Palatine (2)
- f) Inferior nasal conchae (2)
- g) Vomer (1)
- h) Mandible (1)
There are 14 Facial Bones

- 2 maxillary bones
- 2 nasal
- 2 lacrimal
- 2 Zygoma (malar)
- 2 palatine
- 2 inferior nasal conchae
- 1 vomer
- 1 mandible
2 Maxillary bones

Right maxilla

Left maxilla

Largest IMMOVABLE bones of face
2 nasal bones

2 lacrimal bones
2 Zygomas
2 Palatine bones
2 inferior nasal conchae
1 Vomer
1 Mandible

- Ramus
- Angle (gonion)
- Mental protuberance
- Body
What are fontanels & sutures?

Six areas of incomplete ossification in a newborn.
Cranial sutures

- Except for the mandibles, the bones of the cranium and face are joined by fibrous joints called **sutures**.
- The sutures are named:
  1. **Coronal sutures** :- found between frontal and parietal bones.
  2. **Sagittal sutures** :- located on the top of the head between the two parietal bones and just behind the coronal suture line.
  3. **Squamosal suture** :- between temporal and parietal bones.
  4. **Lamboidal sutures** :- between occipital and parietal bones.
Cranial sutures
On the lateral aspect of the skull, the junction of the parietal bone, squamosal suture and greater wing of the sphenoid is the **pterion**, which over lies the middle meningeal artery.

At the junction of the occipital bone, parietal bone and mastoid bone portion of the temporal bone is the **asterion**.
Fontanel

- In the newborn infant, the bones of the cranium are thin and not fully developed.
- They contain a small amount of calcium, are distinctly marked and present six areas of incomplete ossification called fontanels.
At what age do the fontanels close?

- Posterior and sphenoidal fontanels close during first 1-3 months after birth.
- Anterior and mastoid fontanels close during 2nd year of life.
Major Landmarks used for skull radiography:

1. Vertex
2. External Occipital Protuberance (E.O.P.)
3. External Auditory Meatus
5. Infra-orbital point
6. Nasion
7. Glabella
Landmarks

- **Outer canthus of eye**: the point where the upper and lower eyelids meet laterally.

- **Infra-orbital margin / point**: the inferior rim of the orbit, with the point being located at its lowest point.

- **Nasion**: the articulation between the nasal and frontal bone.

- **Glabella**: a bony prominence found on the frontal bone immediately superior to the Nasion.

- **Vertex**: the highest point of the skull in the median sagittal plane.

- **External occipital protuberance (inion)**: a bony prominence found on the occipital bone, usually coincident with the sagittal plane.

- **External auditory meatus (EAM)**: the opening within the ear that leads into the external auditory canal.
- Acanthomeatal line (AML)
- Lips-meatal line (LML)
- Mentomeatal line (MML)
- Glabellomeatal line (GML)
- Orbitomeatal line (OML)
- Infracorbitomeatal line (IOML) (Reid's base line)

- Glabellaloalveolar (GAL)
- External acoustic meatus (EAM) or Auricular point
- Inion
Skull X-ray Views

A. Basic
1. AP (Fronto-occipital) (Towne view)
2. PA (Occipito-Frontal) 0 angle
3. PA with angles:
   a. PA 15-23 angle (Caldwell method)
   b. PA 37-45 angle (Waters view) (Occipito-mental)
4. Lateral view (Schullers view)

B. Special
Fronto-occipital projections

- Central ray is parallel to the sagittal plane, except that the central ray now enters the skull through the frontal bone and exits through the occipital bone.
- Used for immobile patients, same anatomy demonstrated as OF projections...but orbits & frontal bones are magnified.
- Centring is done at external occipital protuberance.
- Part of a routine skull series.
- The tube is angled to throw the anterior part of the skull away from the occipital region of the skull.
SKULL
Townes view
1. Parietal bone
2. Lambdoid suture
3. Foramen magnum
4. Petrous temporal bone
5. Mandible
6. Mastoid air cells
7. Transverse sinus
8. Sphenoid sinus
9. Greater wing of sphenoid
10. Superior sagittal sinus
Occipito-frontal projections

- Central ray is parallel to the sagittal plane and named according to the direction of the central ray.
- Central ray enters the skull through occipital bone and exits through the frontal bone... Therefore called occipito-frontal (OF) projection.
- Centering at nasion.
OF / PA VIEW
1. Nasal Septum
2. Frontal Sinus
3. Maxillary Sinus
4. Ethmoid Sinus
5. Inferior Turbinate
6. Superior orbital fissure
7. Sagittal suture
8. Coronal suture
9. Sphenoid ridge
10. Mastoid process
11. Hard palate
12. Innominateline
13. Petrous ridge
3.a.PA 15-23 angle (Caldwell method)

**Caldwell’s View:** The patient is positioned with both the nose and forehead against the x-ray cassette while the x-ray beam is directed downward 15 degrees to 23 degrees to the canthomeatal line.
Caldwell Sinus Projection Film

This view will provide a clear view of the frontal and ethmoidal sinuses.

The superior orbital rims can be evaluated.

To project the petrous ridges farther down, increase angle to 25 degrees.
b. PA 37-45 angle (Waters view) (occipito-mental)

**WATERS VIEW:** Waters projection is created by placing the chin of the patient on the x-ray cassette with the canthomeatal line (the line that connects the lateral canthus and the external auditory meatus) at 37 degrees to 45 degrees.
PNS WATERS VIEW FOR ALL FACIAL BONES

- Frontal Sinus
- Bony Nasal Septum
- Anterior Nasal Spine
- Maxillary Sinus
- Coronoid Process
- Maxilla
- Condyle
- Mastoid
- Mandibular Angle
- Inferior Orbital Rim
- Zygomatic Bone
- Zygomatic Arch
- Petrous Ridge
- Mandible
- Odontoid Process
Occipito Mental OM (Waters)
Waters Projection Sinus

- The most important view for **sinus** problems or **injury** involving the maxilla or orbits.

- By taking the view erect, fluid levels within the maxillary sinuses can be seen.
SINUSES
1. Frontal sinus
2. Ethmoid Sinus
3. Nasal Septum (bony)
4. Zygomatic-Frontal Suture
5. Maxillary Sinus
6. Zygoma
7. Zygomatic Arch
8. Mandible
9. Inferior orbital margin
10. Left orbit
Lateral projection

- Central ray passes along a coronal plane at right-angles to the median sagittal plane.
- Named according to the side of the head nearer to the image receptor.
- In example, the beam enters the head on the left side, passes along a coronal plane, and exits the head on the right side, where the image receptor is located. Therefore, a right lateral projection.
Skull – lateral view

- What you should carefully observe in this view is:
  - the sinuses
  - Sella turica
  - Bony feature of the mandible, orbit, nose and oral cavity
  - Some about cervical vertebrae
Lateral view of skull

1. Ramus of mandible
2. Styloid process of temporal bone
1. External auditory meatus
2. Mastoid air cells
3. Auricle
4. Calcified pineal body
5. Sella turcica
6. Inner table of skull bone
7. Outer table of skull bone
8. Internal occipital protuberance
9. Sphenoid air sinus
Schullers Projection

- To evaluate the temporomandibular joints and mastoid air cells and inner ear.
Schullers Projection
Oblique projections

- Oblique projection is obtained when the central ray is at some angle to the median sagittal plane and the coronal plane.
Erect

- 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.
Base Posterior Skull

- Routine skull view that can be used to evaluate the upper cervical spine.
- Provides an axial view of C-1 and C-2 as well as the foramen magnum.
Common Positioning Errors

Rotation and tilt are two of the most common positioning errors.

A. Rotation occurs when the median Sagittal plane is not parallel to the film.

B. Tilt occurs when the interpupillary line is not at 90° to the film.
Radiological Approach For Skull X-rays

- Abnormalities that can be detected on the plain skull X-rays can be categorized in the following groups:
  1. Abnormal density (increased or decreased)
  2. Abnormal contour of the skull
  3. Abnormal intracranial volume
  4. Increased thickness of the skull
  5. Single lucent defect / Multiple lucent defects
  6. Sclerotic areas
  7. Intracranial calcification
The mandible
The mandible, located inferiorly in the facial skeleton, is the largest and strongest bone of the face.

It forms the lower jaw and acts as a receptacle for the lower teeth. It also articulates on either side with the temporal bone, forming the temporomandibular joint.
Anatomical Structure
The mandible consists of a horizontal body (anteriorly) and two vertical rami (posteriorly). The body and the rami meet on each side at the angle of the mandible.

Body
The body of the mandible is curved, and shaped much like a horseshoe. It has two borders:

Alveolar border (superior) – contains 16 sockets to hold the lower teeth.
Base (inferior) – site of attachment for the digastric muscle medially
The body is marked in the midline by the mandibular symphysis. This is a small ridge of bone that represents the fusion of the two halves during development. The symphysis encloses a triangular eminence – the mental protuberance, which forms the shape of the chin.

Lateral to the mental protuberance is the mental foramen (below the second premolar tooth on either side). It acts as a passageway for neurovascular structures.
Rami
There are two mandibular rami, which project perpendicularly upwards from the angle of the mandible. Each ramus contains the following bony landmarks:

Head – situated posteriorly, and articulates with the temporal bone to form the temporomandibular joint.
Neck – supports the head of the ramus, and site of attachment of the lateral pterygoid muscle.
Coronoid process – site of attachment of the temporalis muscle
The internal surface of the ramus is also marked by the mandibular foramen, which acts as a passageway for neurovascular structures.
Foramina
A foramen refers to any opening through which neurovascular structures can travel. The mandible is marked by two foramina.

The mandibular foramen is located on the internal surface of the ramus of the mandible. It serves as a conduit for the inferior alveolar nerve and inferior alveolar artery. They travel through the mandibular foramen, into the mandibular canal, and exit at the mental foramen.
The mental foramen is positioned on the external surface of the mandibular body, below the second premolar tooth. It allows the inferior alveolar nerve and artery to exit the mandibular canal. When the inferior alveolar nerve passes through the mental foramen, it becomes the mental nerve (innervates the skin of the lower lip and the front of the chin).
Radiological imaging of temporo-mandibular joint and mandible.

Plain radiography.
Ultrasound.
Computed tomography (CT).
Magnetic resonance imaging (MRI).
Arthrography.
The temporomandibular joint is the joint of the jaw and is frequently referred to as TMJ. The TMJ is a bilateral synovial articulation between the mandible and temporal bone. The name of the joint is derived from the two bones which form the joint: the upper temporal bone which is part of the cranium (skull), and the lower jawbone or mandible.

There are six main components of the TMJ.
Mandibular condyles
Articular surface of the temporal bone
Capsule
Articular disc
Ligaments
Lateral pterygoid
The Temporomandibular Joint

- Superior head of Lateral Pterygoid
- Inferior head of Lateral Pterygoid
- Mandibular Fossa
- Superior Synovial Cavity
- Articular Disc
- Inferior Synovial Cavity
- Retrodiscal Tissue
- Condyle
Schullers Projection
Lateral view of skull

1. Ramus of mandible
2. Styloid process of temporal bone
Schullers Projection

- To evaluate the temporomandibular joints and mastoid air cells and inner ear.
DPG - Normal temporomandibular joint

Hover over image to show findings.

Temporal bone

TMJ

Mandible
Normal mandible - Orthopantomogram (OPG)

Hover over image to show findings

- Condyle
- Coronoid process
- Ramus
- Teeth
- Body
- Symphysis
- Angle

Activate Web Browser
Go to Setting
Basic Anatomy of the Mandible

- Coronoid
- Mandibular Foramen
- Alveolar Ridge
- Condyle
- Ramus
- Angle
- Symphysis
- Body
- Mental Foramen
MRI and autopsy sections: upper row oblique sagittal MRI, asymptomatic volunteer: left lateral, middle medial, right opened mouth
INRODUCTION

- The radiographic recognition of disease requires knowledge of radiographic appearance of normal anatomical structures.
- The radiographic appearance of various structures which can be visualized on intra oral periapical radiographs can be classified under:
  - Teeth
  - Supporting structures
  - Maxilla
  - Mandible
  - Restorative materials
TEETH

Teeth are composed primarily of dentin, with an enamel cap over the coronal portion and a thin layer of cementum over the root surface. The enamel cap characteristically appears more radiopaque than the other tissues because it is the most dense, naturally occurring substance in the body. Because it is 90% mineral, it causes the greatest attenuation of x-ray photons. Its radiographic appearance is uniformly opaque and without evidence of the fine structure.
Teeth

- Pulp
- Enamel
- Dentin
SUPPORTING STRUCTURES

- Lamina dura
- Alveolar crest
- Periodontal ligament space
- Cancellous bone
LAMINA DURA

This is a wall of tooth socket that surrounds the tooth.

It is made of dense cortical bone.

It appears as thin radiopaque line that surrounds root of the tooth.

It is continuous with shadow of cortical bone at alveolar crest.

Double lamina dura appears if mesial or distal surfaces of root present two elevations in path of x-ray beam.
PERIODONTAL LIGAMENT SPACE

Because the periodontal ligament (PDL) is composed primarily of collagen, it appears as a radiolucent space between the tooth root and the lamina dura.

This space begins at the alveolar crest, extends around the portions of the tooth roots within the alveolus, and returns to the alveolar crest on the opposite side of the tooth.

The PDL varies in width from patient to patient, from tooth to tooth in the individual, and even from location to location around one tooth.

Usually it is thinner in the middle of the root and slightly wider near the alveolar crest and root apex, suggesting that the fulcrum of physiologic movement is in the region where the PDL is thinnest.

The thickness of the ligament relates to the degree of function because the PDL is thinnest around the roots of embedded teeth and those that have lost their antagonists.

The reverse is not necessarily true, however, because an appreciably wider space is not regularly observed in persons with especially heavy occlusion or bruxism.
There are two types of bone – cortical and cancellous bone.

CORTICAL BONE
Cortical bone means outer layer of bone. It resists passage of x-ray beam and appears radiopaque on periapical radiograph. Inferior border of mandible is composed of cortical bone.
CANCELLOUS BONE

It is spongy soft bone located between two layers of dense cortical bone.

Cancellous bone is composed of numerous bony trabeculae that form lattice network of intercommunicating spaces filled with bone marrow.

The trabecular actual pieces of bone resist passage of x ray beam and appear radiopaque, in contrast, marrow spaces permit passage of x ray beam and appear radiolucent.
ALVEOLAR CREST

Radiopaque line between teeth, gingival margin of the alveolar process, cortical border of the alveolar bone.
A point of bone in ant. teeth; flat in posterior teeth
CEJ to alveolar crest is less than 1.5mm
Recede apically with age
Markable resorption with periodontal disease
Continuing with lamina dura and forms a sharp angle → Rounding angle indicative periodontal disease
ANATOMIC LANDMARKS OF MAXILLA
ANTERIOR NASAL SPINE

Seen in maxillary central incisors in periapical radiograph. It is located in midline approx. 1.5-2 cm above alveolar crest, usually at or just below junction of inferior end of nasal septum and inferior outline of nasal aperture. It is bony in composition so appears radiopaque.
INTERMAXILLARY SUTURE

Also called as median suture.
Appears as radiolucent line in midline between two portions of maxilla.
Extends from alveolar crest between central incisors through anterior nasal spine and continues posteriorly between maxillary palatine processes to posterior aspect of hard palate.
May terminate at alveolar crest in a small rounded or v shaped enlargement.
Appears radiolucent on radiograph.
FLOOR OF NASAL APERTURE

Air filled nasal cavity and nasal cavity lies above oral cavity. Seen on central incisor projections. Appears as (inferior border of fossa aperture) a radiopaque line extending bilaterally away from base of anterior nasal spine. Above the line, is radiolucent space of inferior portion of cavity.
INCISIVE FORAMEN

Also called as anterior palatine foramen.

Radiographic image is projected between roots and in region of midline and apical thirds of maxillary central incisors.

Transmits nasopalatine nerves and vessels.
NASAL SEPTUM

Appears radiopaque on radiograph.
Composed of bone.
Seen in midline of central incisors.
MAXILLARY SINUS

- It is air containing cavity lined with mucous membrane.
- Also called antrum of highmore.
- Anteriorly, each sinus is restricted by canine fossa.
- Appears as three sided pyramid.
- On periapical radiographs, floor of maxillary sinus and nasal cavity are superimposed, cross each other and form a inverted Y shape in the area.
- Roots of maxillary molars lie close to maxillary sinus.
- Floor of sinus – radiopaque
- Maxillary sinus - radiolucent
The nasal and maxillary bones form the nasolacrimal canal. It runs from the medial aspect of the anteroinferior border of the orbit inferiorly to drain under the inferior concha into the nasal cavity. Occasionally, it can be visualized on periapical radiographs in the region above the apex of the canine, especially when steep vertical angulation is used. The nasolacrimal canals are routinely seen on maxillary occlusal projection in the region of the molars. Appear as ovoid radiolucency on radiograph.
ZYGOMA

- Zygoma or cheek bone articulates with zygomatic process of maxilla.
- Composed of dense cortical bone.
- Appears as radiopaque band extending posterior from zygomatic process of maxilla.
- Appears superior to maxillary molars.
AMATOMIC LANDMARKS OF MANDIBLE
MENTAL FORAMEN

It is a hole or opening in bone in mandibular premolar region. Appears as ovoid radiolucency in apical portion of mandibular premolars. Can be misdiagnosed as cyst or abscess.
It is tube like passageway through bone that travels length of mandible.
Extends from mandibular foramen to mental foramen.
It in houses inferior alveolar nerves and vessels.
It is outlined by two radiopaque lines that represent cortical walls of canal.
Appears below or superimposed over apices of maxillary teeth.
RESTORATIVE MATERIALS

APPEAR RADIOPAQUE ON PERIAPICAL RADIOGRAPHS
Radiological imaging of salivary gland diseases.
Anatomy: Parotid Gland

- Nearly 80% of the parotid gland (PG) is found below the level of the external auditory canal, between the mandible and the SCM.
- Superficial to the posterior aspect of the masseter.
Anatomy: Submandibular gland

- Located in the submandibular triangle of the neck, inferior & lateral to mylohyoid muscle.
- The posterior-superior portion of the gland curves up around the posterior border of the mylohyoid and gives rise to Wharton’s duct.
Anatomy: Sublingual glands

Lie on the superior surface of the mylohyoid muscle and are separated from the oral cavity by a thin layer of mucosa.
Imaging modalities available to assess salivary glands include:

Plain film radiography.
Sialography.
CT scan.
MRI.
Diagnostic ultrasound.
Nuclear scintigraphy.

These imaging modalities play an important role in evaluating a patient with pain, swelling, or other symptoms related to possible salivary gland disorders. Imaging helps in differentiating lesions of salivary glands from those of parapharyngeal space, masticator space, and mandible, submandibular and submental spaces. In addition to localizing the lesion, it also aids in determining the extent of disease, involvement of skull base, mandible, and neural spread in case of malignant lesions.
The arrow is on (parotid duct).

In this view, we can detect inflammation to parotid gland and any obstruction if it occurs...
Sialography – Submandibular gland

Submandibular gland ...
Lateral view
In this view we can detects inflammation to parotid gland and any obstruction if it occurs ...
Submandibular gland...
Superior-inferior view
In this view we can detect inflammation in the parotid gland and any obstruction if it occurs...
Benign Lymphoepithelial Lesions
Submandibular Gland/Space Abscess
Stone in Wharton's Duct

Submandibular gland stone.
Left sublingual space extending to the submandibular space consistent with a plunging ranula (arrow).
Extends from the lips to the oropharyngeal isthmus

- The oropharyngeal isthmus:
  - Is the junction of mouth and pharynx.
  - Is bounded:
    - Above by the soft palate and the palatoglossal folds
    - Below by the dorsum of the tongue

Subdivided into Vestibule & Oral cavity proper
A. Vestibule

- Slitlike space between the cheeks and the gums
- Communicates with the exterior through the oral fissure
- When the jaws are closed, communicates with the oral cavity proper behind the 3rd molar tooth on each side
- Superiorly and inferiorly limited by the reflection of mucous membrane from lips and cheek onto the gums
The lateral wall of the vestibule is formed by the cheek
- The cheek is composed of Buccinator muscle, covered laterally by the skin & medially by the mucous membrane
- A small papilla on the mucosa opposite the upper 2\textsuperscript{nd} molar tooth marks the opening of the duct of the parotid gland
B. Oral Cavity Proper

- It is the cavity within the alveolar margins of the maxillae and the mandible
  - Its **Roof** is formed by the hard palate anteriorly and the soft palate posteriorly
  - Its **Floor** is formed by the mylohyoid muscle. The anterior 2/3\(^{rd}\) of the tongue lies on the floor.
Floor of the Mouth

- Covered with mucous membrane
- In the midline, a mucosal fold, the frenulum, connects the tongue to the floor of the mouth
- On each side of frenulum a small papilla has the opening of the duct of the submandibular gland
- A rounded ridge extending backward & laterally from the papilla is produced by the sublingual gland
Nerve Supply

A. Sensory
  - Roof: by greater palatine and nasopalatine nerves (branches of maxillary nerve)
  - Floor: by lingual nerve (branch of mandibular nerve)
  - Cheek: by buccal nerve (branch of mandibular nerve)

B. Motor
  - Muscle in the cheek (buccinator) and the lip (orbicularis oris) are supplied by the branches of the facial nerve
Mass of striated muscles covered with the mucous membrane
Divided into right and left halves by a median septum
Three parts:
1. Oral (anterior ⅔)
2. Pharyngeal (posterior ⅓)
3. Root (base)
Two surfaces:
A. Dorsal
B. Ventral
A. Dorsal Surface

- Divided into **anterior two third** and **posterior one third** by a V-shaped **sulcus terminalis**.
- The apex of the sulcus faces backward and is marked by a pit called the **foramen cecum**.
- Foramen cecum, an embryological remnant, marks the site of the upper end of the thyroglossal duct.
Dorsal Surface cont’d

- **Anterior two third:** mucosa is rough, shows three types of papillae:
  - Filliform
  - Fungiform
  - Vallate

- **Posterior one third:** No papillae but shows nodular surface because of underlying lymphatic nodules, the lingual tonsils.
B. Ventral Surface

- Smooth (no papillae)
- In the midline anteriorly, a mucosal fold, frenulum connects the tongue with the floor of the mouth
- Lateral to frenulum, deep lingual vein can be seen through the mucosa
- Lateral to lingual vein, a fold of mucosa forms the plica fimbriata
The tongue is composed of two types of muscles:

- A. Intrinsic
- B. Extrinsic
A. Intrinsic Muscles

- Confined to tongue
- No bony attachment
- Consist of:
  1. Longitudinal fibers
  2. Transverse fibers
  3. Vertical fibers
- Function: Alter the shape of the tongue
B. Extrinsic Muscles

- Connect the tongue to the surrounding structures: the soft palate and the bones (mandible, hyoid bone, styloid process)

- Include:
  1. Palatoglossus
  2. Genioglossus
  3. Hyoglossus
  4. Styloglossus

- Function: Help in movements of the tongue
Movement

1. **Protrusion**: Genioglossus on both sides acting together
2. **Retraction**: Styloglossus and hyoglossus on both sides acting together
3. **Depression**: Hyoglossus and genioglossus on both sides acting together
4. **Elevation**: Styloglossus and palatoglossus on both sides acting together
Nerve Supply
A. Sensory Nerve Supply

1. Anterior ⅔:
   • General sensations: Lingual nerve
   • Special sensations: chorda tympani

2. Posterior ⅓:
   • General & special sensations: glossopharyngeal nerve

3. Base:
   • General & special sensations: internal laryngeal nerve
B. Motor Nerve Supply

1. Intrinsic muscles:
   - Hypoglossal nerve

2. Extrinsic muscles:
   - All supplied by the hypoglossal nerve, except the palatoglossus

- The palatoglossus supplied by the pharyngeal plexus
Blood Supply

A. Arteries:
- 1. Lingual artery
- 2. Tonsillar branch of facial artery
- 3. Ascending pharyngeal artery

B. Veins:
- Lingual vein, ultimately drains into the internal jugular vein
Lymphatic Drainage

1. Tip:
   - Submental nodes bilaterally & then deep cervical nodes

2. Anterior two third:
   - Submandibular unilaterally & then deep cervical nodes

3. Posterior third:
   - Deep cervical nodes (jugulodigastric mainly)
The tongue is the most important articulator for speech production. During speech, the tongue can make amazing range of movements.

The primary function of the tongue is to provide a mechanism for taste. Taste buds are located on different areas of the tongue, but are generally found around the edges. They are sensitive to four main tastes: Bitter, Sour, Salty & Sweet.
The tongue is needed for sucking, chewing, swallowing, eating, drinking, kissing, sweeping the mouth for food debris and other particles and for making funny faces (poking the tongue out, waggling it)

Trumpeters and horn & flute players have very well developed tongue muscles, and are able to perform rapid, controlled movements or articulations
Clinical Notes

- Lacerations of the tongue
- Tongue-Tie (ankyloglossia) (due to large frenulum)
- Lesion of the hypoglossal nerve
  - The protruded tongue deviates toward the side of the lesion
  - Tongue is atrophied & wrinkled
‘If there is goodness in your heart, it will come to your tongue’.
The tongue is a fleshy, movable, muscular organ, attached in most vertebrates to the floor of the mouth, that is the principal organ of taste, an aid in chewing and swallowing, and, in humans, an important organ of speech.
Taste Buds

- Circumvallate Papilla
- Filiform papilla
- Fungiform papilla
- Mucus-secreting gland
- Taste bud
- Connective tissue
- Tongue epithelium
**Five Basic Tastes**

Why are they important?

- **Umami** - savory/meaty
- **Bitter** - alkaloid
- **Sour** - $\text{H}^+$
- **Salty** - metallic ions
- **Sweet** - sugar
Gustatory Papillae

- **Fungiform papillae:** Are less common than the filiforms.
- **Vallate (or circumvallate):** The largest and most prominent,
- **Foliate papillae:** which are most easily seen in the Order Lagomorpha (rabbits, hares, and conies).
Facial nerve → (afferent) 2/3 anterior portion of tongue
Glossopharyngeal posterior 1/3 of tongue
Vagus nerve - few taste buds on epiglottis and pharynx
These afferent fibers synapse in medulla → thalamus → gustatory cortex in parietal lobes and fibers to hypothalamus in limbic system
Dry tongue with a paper towel and place a little sugar on surface. What do you taste?
Taste Aversion

• The taste projections to the hypothalamus and limbic system account for the strong association between taste and emotions.

• Sweet foods evoke reactions of pleasure, while bitter foods can evoke reactions of disgust.
Do you know?

Why do the elders like to take in food with strong flavour?

It’s too salty!
Because ....

• When you were a baby, you had taste buds, not only on your tongue, but on the sides and roof of your mouth. This means you were very sensitive to different foods.

• As you grew, the taste buds began to disappear from the sides and roof of your mouth, leaving taste buds mostly on your tongue.

• As you get older, your taste buds will become even less sensitive, so you will be more likely to eat foods that you thought were too strong as a child.
Remember

- Spicy’ is not a taste. It is the sensation of pain in the tongue resulting from the destruction of taste buds by the ‘hot’ food like chilly.

It is spicy!
Also Note

- Taste is influenced by olfactory sensation and nasal congestion affecting your taste.
- Tongue can detect other stimuli rather than taste like temperature and texture.
- In general, girls have more taste buds than boys.
- Flavor is a complex mixture of sensory input composed of taste (Gustation), smell (olfaction) and the tactile sensation of food as it is being munched.
- The receptors for alkaloids evolved to be the most sensitive in order to allow humans to detect plant poisons before they are eaten.
Palate
Palate

- Lies in the **roof** of the oral cavity
- Has two parts:
  - A. Hard (**bony**) palate anteriorly
  - B. Soft (**muscular**) palate posteriorly
A. Hard Palate

- Lies in the roof of the oral cavity
- Forms the floor of the nasal cavity
- Formed by:
  - a. Palatine processes of maxillae in front
  - b. Horizontal plates of palatine bones behind
- Bounded by alveolar arches
Posteriorly, continuous with soft palate
Its undersurface covered by mucoperiosteum
Shows transverse ridges in the anterior parts
Attached to the posterior border of the hard palate
Covered on its upper and lower surfaces by mucous membrane
Composed of:
• 1. Muscle fibers
• 2. An aponeurosis
• 3. Lymphoid tissue
• 4. Glands
• 5. Blood vessels
• 6. Nerves
Palatine Aponeurosis

- Fibrous sheath
- Attached to posterior border of hard palate
- Is expanded tendon of tensor velli palatini
- Splits to enclose musculus uvulae
- Gives origin & insertion to palatine muscles
1. **Tensor veli palatini**
   - **Origin:** spine of sphenoid; auditory tube
   - **Insertion:** forms palatine aponeurosis
   - **Action:** Tenses soft palate

2. **Levator veli palatini**
   - **Origin:** petrous temporal bone, auditory tube, palatine aponeurosis
   - **Insertion:** palatine aponeurosis
   - **Action:** Raises soft palate

3. **Musculus uvulae**
   - **Origin:** posterior border of hard palate
   - **Insertion:** mucosa of uvula
   - **Action:** Elevates uvula
4. Palatoglossus
- **Origin:** palatine aponeurosis
- **Insertion:** side of tongue
- **Action:** pulls root of tongue upward, narrowing oropharyngeal isthmus

5. Palatopharyngeus
- **Origin:** palatine aponeurosis
- **Insertion:** posterior border of thyroid cartilage
- **Action:** Elevates wall of the pharynx
A. Sensory Nerve Supply

1. Mostly by the maxillary nerve through its branches:
   - Greater palatine nerve
   - Lesser palatine nerve
   - Nasopalatine nerve

2. Glossopharyngeal nerve supplies the region of the soft palate
1. All the muscles, except tensor veli palatini, are supplied by the:
   - Pharyngeal plexus

2. Tensor veli palatini supplied by the:
   - Nerve to medial pterygoid, a branch of the mandibular division of the trigeminal nerve
Blood Supply

1. Branches of the maxillary artery
   • Greater palatine
   • Lesser palatine
   • Sphenopalatine

2. Ascending palatine, branch of the facial artery

3. Ascending pharyngeal, branch of the external carotid artery
Cleft palate:
- Unilateral
- Bilateral
- Median

Paralysis of the soft palate:
- The pharyngeal isthmus cannot be closed during swallowing and speech.
IMAGING IN ORBIT
IMAGING TECHNIQUES

• X-RAY
• ULTRASONOGRAPHY
• CT SCAN
• MRI
X-RAY

- WATERS VIEW
- CALDWELL’S VIEW
- LATERAL VIEW
- SUBMENTOVERTEX VIEW
- RHESE VIEW
WATERS VIEW: Waters projection is created by placing the chin of the patient on the x-ray cassette with the canthomeatal line (the line that connects the lateral canthus and the external auditory meatus) at 37 degrees to 45 degrees.
Caldwell’s View: The patient is positioned with both the nose and forehead against the x-ray cassette while the x-ray beam is directed downward 15 degrees to 23 degrees to the canthomeatal line.
(a, frontal sinus; b, innominate line; c, inferior orbital rim; d, posterior orbital floor; e, superior orbital fissure; f, greater wing of sphenoid; g, ethmoid sinus; h, medial orbital wall; i, petrous ridge; j, zygomatic-frontal suture; k, foramen rotundum)
LATERAL VIEW: lateral projection (Fig. 4) is created by placing the patient's head against the x-ray cassette and centering the cassette on the lateral canthus. The x-ray beam is directed perpendicularly to the midpoint of the cassette and enters the patient's head at the lateral canthus remote from the cassette.
Radiograph of a lateral projection. (a, orbital roof; b, frontal sinus; c, ethmoid sinus; d, anterior clinoid process; e, sella turcica; f, planum sphenoidale)
SUBMENTOVERTEX VIEW: this projection is obtained with the patient's neck extended either in the supine or upright position. The top of the head is placed so that the infraorbitomeatal line is parallel with the x-ray cassette. The x-ray beam is directed at right angles to the infraorbitomeatal line.
(a, zygomatic arch; b, orbit; c, lateral orbital wall; d, posterior wall of maxillary sinus; e, pterygoid plate; f, sphenoid sinus)
RHESE VIEW: The zygoma, nose, and chin should touch the cassette. The x-ray beam is directed posterior-anteriorly at 40 degrees to the midsagittal plane.
Radiograph of an oblique apical projection. (a, right optic canal; b, optic strut; c, superior orbital fissure; d, ethmoid sinus; e, planum sphenoidale; f, greater wing of sphenoid)
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X-RAY SIGNS OF ORBITAL DISEASES

- SIZE OF ORBIT
- CHANGE IN BONE DENSITY
- CHANGE IN ORBITAL SHAPE
- DEHISCENCE OF ORBITAL BONES
- INTRAORBITAL CALCIFICATION
- ENLARGEMENT OF SUP. ORBITAL FISSURE
- CHANGE IN OPTIC CANAL
Orbital Dermoid
Figure 8a. Coronal CT scan showing left cavernous haemangioma. Note that the mass is intraconal, well defined, homogeneous, with smooth margins; b. A case of orbital lymphangioma. Note the irregular margin, heterogenous consistency, and the presence of phleboliths; c. A case of right lacrimal gland tumour. Anterior coronal scan shows homogeneous irregular soft tissue mass occupying the entire superolateral orbit. The tumour has crossed the vertical midline of the right orbit.
Optic nerve meningioma
Anatomy of the Ear

Three Main Sections

**Inner Ear**
- Oval Window
- Round Window
- Cochlea
- Semicircular Canals

**Outer Ear**
- Pinna
- External Auditory Canal

**Middle Ear**
- Tympanic Membrane (Ear Drum)
- Auditory Ossicles (malleus, incus, stapes)
- Middle Ear Cavity
- Eustachian Tube
The External Ear

- **Consists of:**
  - **Auricle (pinna)**
    - Made of elastic cartilage
    - Helix (rim)
    - Lobule (ear lobe)
  - **External auditory canal**
    - Lies within temporal bone & connects to ear drum (tympanic memb)
    - Contains ceruminous glands which secrete ear wax
  - **Tympanic membrane**
    - Epithelial & simple cuboidal
    - Changes acoustic energy into mechanical energy
    - Perforated eardrum = tear
The Middle Ear
Auditory Ossicles
(smallest bones in body)
- Malleus
  - Attaches to ear drum
  - Articulates with incus
- Incus
  - Articulates with stapes
- Stapes (stirrup)
  - Footplate of stapes fits into oval window

Opening to **Eustachian tube**
Protection by Two Tiny Muscles

**Tensor Tympani**
- Attaches to Malleus to increase tension on ear drum & prevent damage to inner ear.

**Stapedius**
- Smallest skeletal muscle
- Dampens large vibrations of stapes to protect oval window.
Auditory Tube
(Eustachian tube)

- Is a route for pathogens to travel from nose and throat to ear causing **Otitis Media**
- During swallowing and yawning it opens to equal pressure in middle ear.
The Inner Ear (Labyrinth)

- Bony labyrinth
  - Contains perilymph
  - Semicircular canals
    - Anterior, posterior, and lateral
    - Lie right angles to each other
  - Vestibule
    - Oval portion
  - Cochlea
    - Looks like a snail
    - Converts mechanical energy into electrical energy

Membranous labyrinth

- Contains endolymph
The Cochlea
Divided into 3 channels

- **Cochlear duct** (scala media)
  - Contains the **Organ of Corti**

- **Scala vestibuli**
  - Ends at the **oval window**

- **Scala tympani**
Organ of Corti

The end organ of hearing

- Contains stereocilia & receptor hair cells
- Tectorial and Basilar Membranes
- Cochlear fluids
- Fluid movement causes deflection of nerve endings
- Nerve impulses (electrical energy) are generated and sent to the brain
Summary of How We Hear

Acoustic energy, in the form of sound waves, is channeled into the ear canal by the pinna. Sound waves hit the tympanic membrane and cause it to vibrate, like a drum, changing it into mechanical energy. The malleus, which is attached to the tympanic membrane, starts the ossicles into motion. The stapes moves in and out of the oval window of the cochlea creating a fluid motion, or hydraulic energy. The fluid movement causes membranes in the Organ of Corti to shear against the hair cells. This creates an electrical signal which is sent up the Auditory Nerve (cochlear nerve) to the brain. The brain interprets it as sound!
Cross CT sectional anatomy of the inner ear.

Fig. 1.------Axial HRCT of Inner Ear

White arrowhead: Modiolus with cochlea
White arrow: IAC
Black arrowhead: Vestibule
Black arrow: Posterior semicircular canal
Axial CT image shows: 1, mastoid air cells; 2, incus (short process); 3, incudomalleal joint; 4, malleus (head); 5, epitympanum (anterior epitympanic recess); 6, basal turn of the cochlea; 7, middle turn of the cochlea; 8, otic capsule; 9, IAC; 10, modiolus; 11, vestibule
Coronal CT image shows: 1, mastoid air cells; 2, tegmen mastoideum; 3, tegmen tympani; 4, IAC; 5, vestibule; 6, hypotympanum; 7, mesotympanum; 8, epitympanum; 9, cochlear promontory; 10, tympanic membrane; 11, scutum; 12, Prussak space; 13, malleus (head); 14, stapes (crus); 15, superior semicircular canal; 16, tympanic segment of the facial nerve; 17, oval window; 18, crista falciformis; 19, EAC
The pharynx is situated behind the nasal cavities, the mouth, and the larynx.

It may be divided into nasal, oral, and laryngeal parts.

Its upper, wider end lying under the skull.

Its lower, narrow end becoming continuous with the esophagus opposite the sixth cervical vertebra.
Radiological anatomy of the naso, oro and hypopharynx.
The pharynx has a musculomembranous wall, which is deficient anteriorly.

Here, it is replaced by the posterior openings into the nose (choanae), the opening into the mouth, and the inlet of the larynx.

By means of the auditory tube, the mucous membrane is also continuous with that of the tympanic cavity.
1. Nasal Pharynx

- This lies above the soft palate and behind the nasal cavities.

- In the submucosa of the roof is a collection of lymphoid tissue called the pharyngeal tonsil.

- The pharyngeal isthmus is the opening in the floor between the soft palate and the posterior pharyngeal wall.

- On the lateral wall is the opening of the auditory tube, the elevated ridge of which is called the tubal elevation.
2. Oral Pharynx

- This lies behind the oral cavity
- The floor is formed by the posterior one third of the tongue and the interval between the tongue and epiglottis
- In the midline is the median glossoepiglottic fold
- On each side the lateral glossoepiglottic fold
- The depression on each side of the median glossoepiglottic fold is called the vallecula
On the lateral wall on each side are the palatoglossal and the palatopharyngeal arches or folds and the palatine tonsils between them.

The palatoglossal arch is a fold of mucous membrane covering the palatoglossus muscle.

The interval between the two palatoglossal arches is called the oropharyngeal isthmus.

It marks the boundary between the mouth and pharynx.
At the junction of the mouth with the oral part of the pharynx, and the nose with the nasal part of the pharynx, are collections of lymphoid tissue.

They are of considerable clinical importance.

The palatine tonsils and the nasopharyngeal tonsils are the most important.
3. Laryngeal Pharynx

- This lies behind the opening into the larynx
- The lateral wall is formed by the thyroid cartilage and the thyrohyoid membrane
- The piriform fossa is a depression in the mucous membrane on each side of the laryngeal inlet
Waldeyer's Ring of Lymphoid Tissue

- The lymphoid tissue that surrounds the opening into the respiratory and digestive systems forms a ring.

- The lateral part of the ring is formed by the palatine tonsils and tubal tonsils.

- The pharyngeal tonsil in the roof of the nasopharynx forms the upper part, and the lingual tonsil on the posterior third of the tongue forms the lower part.
Lateral radiograph of the neck: soft-tissue view showing pharynx and larynx
The Anatomy of the Nasopharynx

- Occupies the superior and posterior aspect of the aerodigestive tract
The Anatomy of the Nasopharynx

- Opens anteriorly to the nasal cavity
Eustachian Tube
The Anatomy of the Oropharynx

- Nasal Cavity
- Oral Cavity
- Larynx
- Nasopharynx
- Hypopharynx
Neck anatomy.

Superficial neck structures.
- nasopharynx
- oropharynx
- oral cavity

Deep neck structures.
The deep anatomy is separated by fascial planes into seven deep compartments of the head and neck:
- pharyngeal (superficial) mucosal space
- parapharyngeal space
- parotid space
- carotid space
- masticator space
- retropharyngeal space
- perivertebral space
LATERAL NECK

1. Hard palate
2. Soft palate
3. Nasopharynx
4. Oropharynx
Airway x-ray AP view—showing normal anatomy. Notice the wafer-thin epiglottis.
AIRWAY
1. Calcified tracheal cartilage rings
2. Hyoid bone
3. Epiglottis
4. Thyroid cartilage
5. Cricoid cartilage
Cross sectional imaging

• Computed tomography:
  + Fast, widely available
  + Multidetector technology: faster acquisition, reconstruction in coronal and sagittal planes
  - Iodinated contrast
  - Radiation exposure

• Magnetic resonance imaging:
  + Excellent soft tissue differentiation
  + No radiation exposure
  - Longer exam, more prone to motion and breathing artifacts
  - More expensive
Anatomic Localization.

- Pharyngeal mucosal space:
  - Nasopharynx
  - Oropharynx
  - Hypopharynx
Torus Tubarius

Lateral pharyngeal recess
Neck Spaces

- Infrahvroid neck spaces:
  - Visceral space
  - Posterior cervical space
  - Anterior cervical space
  - Retropharyngeal space
  - Prevertebral space
  - Carotid space
Larynx

- Larynx:
  - Glottis
  - Subglottis
  - Supraglottis
Neck MR Imaging Anatomy.

- Better soft tissue differentiation

- Lymph nodes can be better seen than on CT.
Suprahyoid neck anatomy:
ARTERIOGRAM

1. Internal Carotid Artery
2. Intracranial Carotid
3. Maxillary Artery
4. Occipital Artery
5. External Carotid Artery
6. Common Carotid Artery
7. Facial Artery
The Larynx

- The larynx is the portion of the respiratory tract containing the vocal cords.
- A 2-inch-long, tube-shaped organ, opens into the laryngopharynx above and is continuous with the trachea below.
FUNCTIONS OF LARYNX

- The larynx assist in:
  - Deglutition (swallowing)
  - Respiration (breathing)

Main function of larynx is;
- Phonation (voice production)
Structure

- The larynx consists of four basic components:
  - A cartilaginous skeleton
  - Membranes and ligaments
  - Muscles
The Cartilages

- THE CARTILAGENOUS PART comprised of:
  - Single Cartilages:
    - Thyroid
    - Cricoid
    - Epiglottis
  - Paired Cartilages:
    - Arytenoid
    - Corniculate
    - Cuneiform
Thyroid Cartilage

- Thyroid cartilage is the largest cartilage of the larynx.
- It has two parts that are joined together in the center.
- Central prominence is called ADAM’S APPLE.
Cricoid Cartilage

- Lies below the thyroid cartilage
- Forms a complete ring
- Has a narrow anterior arch & a broad posterior lamina
Epiglottis

- Leaf shaped, situated behind the root of the tongue

- **Connected:**
  - In front to the body of hyoid bone
  - By its stalk to the back of thyroid cartilage.

- Upper edge is free.
FRONT AND LATERAL VIEW OF EPIGLOTTIS

- Anterior surface of epiglottis
- Posterior surface of epiglottis
- Right thyroid lamina
- Thyro-epiglottic ligament
- Cricoid
- Epiglottic tubercle
- Trachea

- Epiglottis
- Lateral glossoepiglottic folds
- Vallecula
- Median glossoepiglottic fold
Arytenoid Cartilages

- Small, pyramidal in shape
- Situated at the back of the larynx.
Corniculate & Cuneiform Cartilages

Corniculate Cartilages
- Small nodules
- Join with arytenoid cartilages

Cuneiform Cartilages
- Small rod shaped.
- Do not join with any other cartilage.
5) **ARYTENOID**
(Transverse and oblique arytenoid) - Adduct vocal folds

4) **LATERAL CRICOARYTENOID** - Adduct vocal folds

3) **POSTERIOR CRICOARYTENOID** - Abducts vocal fold

Arytenoids Can rotate/slide

Adduct closes rima glottidis
Abduct opens rima glottidis
TERMS ASSOCIATED WITH LARYNX

**VESTIBULE** - inlet above false vocal folds

**VESTIBULAR (FALSE VOCAL) FOLDS** - overlie vestibular ligaments

**VENTRICLE** - area between true and false vocal folds; lateral extension is Laryngeal Sinus

**VOCAL (TRUE VOCAL) FOLDS** - overlie vocal ligaments
VIII. OBSTRUCTION OF LARYNX: TRACHEOTOMY

open airway to lungs below obstructed larynx

Tracheotomy - cut between 1st & 2nd or 2nd - 3rd Tracheal cartilages
Larynx

- Larynx:
  - Glottis
  - Subglottis
  - Supraglottis
Upper larynx show superior aspect of the epiglottis (arrow).
**Figure 3A:** Sagittal CT image through the larynx. Sagittal CT reformation shows the epiglottis (thin arrow) and the preepiglottic fat space (thick arrow). Note the close relationship of the base of tongue (elbow arrow) with the epiglottis.

**Figure 3B:** Sagittal T1W MR image through the larynx. Sagittal T1W MRI shows the epiglottis (thin arrow) and the preepiglottic fat space (thick arrow). Note the close relationship of the base of tongue (elbow arrow) with the epiglottis.
1- Nasal cavity.
2- Nasopharynx.
3- Pharynx.
4- Larynx.
5- Tongue.
6- Spinal column.
7- Spinal cord.
8- Epiglottis.
9- Cricoid cartilage.
10- Cricotracheal membrane.
11- Trachea.
Thyroid Gland

- Found at the base of the throat
- Consists of two lobes and a connecting isthmus
- Produces two hormones
  - Thyroid hormone
  - Calcitonin
Roles and Functions of the Thyroid & Parathyroid

- **Thyroids:**
  - Controls the rate at which the body produces energy from nutrients
  - Regulates metabolism
  - Produces:
    - Triiodothyronine (T3)
    - Thyroxine (T4)
    - Calcitonin

- **Parathyroids:**
  - Control the calcium in our bodies
Anatomy and Physiology: Endocrine System

Thyroid Gland
- Two lobes in the anterior neck on either side of the trachea inferior to the thyroid cartilage
- Joined by the isthmus
- May have a pyramidal lobe (often absent or very small)

Parathyroid
- 4 glands
- Located behind the upper and lower poles of the thyroid
- Releases PTH to regulate serum calcium
Thyroid Gland

- Thyroid hormone disorders
  - Cretinism
    - Caused by hyposcretion of thyroxine
    - Results in dwarfism during childhood

CRETINISM

- Condition of severely stunted physical and mental growth.

SYMPTOMS

- Patient is dwarf with severe mental defect.
- Coarse dry skin
- Deficient hair & teeth.
- Retarded skeletal growth.
- Reduced BMR
Thyroid Gland

- Thyroid hormone disorders (continued)
  - Myxedema
    - Caused by hypothyroidism in adults
    - Results in physical and mental sluggishness
Imaging modalities:

Plain X-Ray.
Thyroid US.
Thyroid isotope uptake Scan.
CT scan.
MRI study.
Normal thyroid gland

Strap muscles

Carotid artery

Thyroid gland weighs 20 g.

Right/left lobes:
1.5 cm x 1.5 cm x 4 cm.

Isthmus: less than 0.4 cm
Homogenous in echotexture.
Thyroid Scan (nuclear medicine): Expressed as a PICTURE

- Primary use is to determine whether palpated nodules are functional or non-functional.
  - "Hot" nodules concentrate the radionuclide and are essentially always benign.
  - "Cold" nodules are usually benign but are sometimes malignant.
  - The majority, perhaps 90%, of palpable nodules are cold.
Advantages of thyroid US

- Painless, quick, no contrast material, no radiation
- Can be used in pregnancy, while on L-thyroxine therapy, after exogenous iodine exposure
- Can detect thyroid nodules as small as 2-3 mm and provide guidance for FNA biopsy
2 cases with acute suppurative thyroiditis. Contrast-enhanced CT shows a fluid collection (arrows) with internal gas (arrowhead) involving lobes of thyroid gland (open arrows) and adjacent soft tissue.
Comparison between scans from the normal patient and a patient with Grave's disease. Note the overall increased uptake throughout the enlarged thyroid gland in the Grave's patient.
Endemic goiter—iodine deficiency disorders.

Retrosternal (Substernal) endemic diffuse Goiter.
Multinodular goitre. A. Transverse dual ultrasound image shows enlargement of thyroid lobes and isthmus and multiple hyperechoic solid nodules with uniform thin halo (arrows). Mixed solid and cystic thyroid nodule in the left lobe. Tr: tracheal gas shadow.

B. Transverse sonogram and color-doppler mode scan show a well-defined isoechoic thyroid nodule with thin complete hypoechoic halo, intranodular cystic/colloid space and peripheral vascularity, findings indicative of a hyperplastic nodule.
Thyroid Isotope scan

Cold nodule
Radioactive nuclear medicine study showing a 'hot' thyroid nodule in a patient with hyperthyroidism.
Blood supply - Arteries

- The arterial supply of the head and neck is derived from the common carotid, vertebral and subclavian arteries.
- The right common carotid arises from the brachiocephalic trunk.
- The left common carotid arises from the aortic arch directly.
Blood supply - Arteries

- The common carotid runs upwards in the neck to the upper border of the thyroid cartilage.
- Then it divides into external and internal carotid arteries.
• Circulation of blood to head and neck, (Arterial supply)

• The paired arteries supplying head and neck are **common carotid arteries** and **vertebral arteries**.

• Right common carotid artery and left common carotid artery pass upwards on either side of the neck and have the same distribution on each side.
Circulation of blood to head and neck, (Arterial supply) cont.

At the level of thyroid cartilage each divide into internal carotid artery and external carotid artery. The external carotid artery supply the superficial tissue of head and neck, via a number of branches.
Circulation of blood to head and neck, (Arterial supply) cont.

The internal carotid artery is a major contributor to the circle of Willis, which supply the greater part of the brain. It also has branches that supply the forehead, eyes and nose.
Blood supply - Arteries

1. The *external carotid artery* provides the major blood supply for the face and mouth.

- The two major terminal branches of the *external carotid artery* are the *maxillary* and the *facial* arteries.
As the artery travels upwards, it supplies:

- In the carotid triangle:
  - Superior thyroid artery, arising from its anterior aspect
  - Ascending pharyngeal artery - arising from medial, or deep, aspect
  - Lingual artery - arising from its anterior aspect
  - Facial artery - arise from its anterior aspect
  - Occipital artery - arising from its posterior aspect
  - Posterior auricular artery - arising from posterior aspect

The external carotid artery terminates as two branches:

- Maxillary artery
- Superficial temporal artery
Blood supply - Arteries

II The internal carotid artery has a dilation at its root, the carotid sinus.

- The internal carotid artery has no branches outside the skull and enters the skull through the carotid canal.
- Inside the skull the internal carotid artery gives off which supplies the optic nerve, eye, orbit and scalp.
Arterial Supply to the Brain

There are two paired arteries which are responsible for the blood supply to the brain: the vertebral arteries, and the internal carotid arteries. These arteries arise in the neck, and ascend to the oranium.

Within the cranial vault, the terminal branches of these arteries form an anastomotic circle, called the Circle of Willis. From this circle, branches arise which supply the majority of the cerebrum.

Other parts of the CNS, such as the pons and spinal cord, are supplied by smaller branches from the vertebral arteries.

We shall now look at these individual components.

Internal Carotid Arteries

Fig 1.0 – Arteriogram of the arterial supply to the CNS.
Vascular Anatomy.

MR-angiography of the aortic arch and head & neck arterial vessels overview.
Arch of Aorta
Common Carotid Artery
Brachiocephalic Trunk
Vertebral Artery
Common Carotid Artery
Vertebral Artery
Common Carotid Artery
Brachiocephalic Trunk
Arch of Aorta

MRA - Magnetic Resonance Angiography
Blood Supply to Head
Patient lie down in supine or semisupine position
Head hyperextended & rotated 45° away from side being examined
Higher-frequency linear transducers (≥ 7.5 MHz)
Normal carotid bifurcation

Black & white US

ICA Larger & lateral
ECA Smaller & internal

Color Doppler ultrasound

Normal flow separation
Carotid bifurcation

Longitudinal B-mode image of carotid bifurcation
ICA & ECA seen in same plane
Internal & external carotid artery

Power Doppler US

2 small branches originating from ECA
EXTERNAL CAROTID ARTERY

COURSE AND DISTRIBUTION: The external carotid artery, arises opposite the upper border of the thyroid cartilage, and taking a slightly curved course, ascends upwards and forwards, and then inclines backwards, to the space b/w the neck of the condyle of the lower jaw, and the external meatus, where it divides into the temporal $\&$ internal maxillary arteries.

ANTERIOR
Superior thyroid
Linguial
facial

ASCENDING
Ascending
pharyngeal

POSTERIOR
Occipital
Posterior
auricular

TERMINAL
Temporal
Internal maxillary
EXTERNAL CAROTID ARTERY

It arises from the common carotid artery when it bifurcates into the external and internal carotid artery.

**Course:**

- It begins at the level of the upper border of thyroid cartilage.
- It passes upward and forward, and then inclines backward to the space behind the neck of the mandible, where it divides into the superficial temporal and maxillary artery within the parotid gland.
Branches of External Carotid Artery:

Anterior: * Superior thyroid  
           * Lingual  
           * Facial

Posterior: * Occipital  
            * Posterior auricular

Medial: * Ascending pharyngeal

Terminal: * Maxillary  
           * Superficial temporal
CAROTID ANGIOGRAM

1- Common Carotid Artery
2- Superior Thyroid Artery
3- Lingual Artery
4- Facial Artery
5- Occipital Artery
6- Maxillary Artery
7- Superficial Temporal Artery
8- Carotid Siphon
INTERNAL CAROTID ARTERY

Internal carotid arteries are major arteries of the head and neck that supply blood to the brain.

Course:
It arises around the level of the third cervical vertebra when the common carotid bifurcates into this artery and its more superficial counterpart, the external carotid artery.
Circle of Willis
(also called Willis’ Circle, cerebral arterial circle, arterial Circle of Willis, and Willis Polygon)

- It is a circle of arteries that supply blood to the brain. It is named after Thomas Willis (1621-1675), an English physician.

Comprises the following arteries:
- Anterior cerebral artery (left and right)
- Anterior communicating artery
- Internal carotid artery (left and right)
- Posterior cerebral artery (left and right)
- Posterior communicating artery (left and right)
- The basilar artery and middle cerebral arteries, though they supply the brain, are not considered part of the circle.
Circle of Willis

:Position*

At the base of the brain
Circle of Willis

*Description*

1) RT & LT ant. Cerebral arteries (Carotid system)
2) RT & LT post. Cerebral arteries (Basilar system)
2 post. Communicating arteries connecting the ICA with PCA
1 ant. Communicating artery connecting the 2 ACA
Regional Blood Supply to the Cerebrum

There are three cerebral arteries; anterior, middle and posterior. They each supply a different portion of the cerebrum.

The anterior cerebral arteries supply the anteromedial portion of the cerebrum. The middle cerebral arteries are situated laterally, supplying the majority of the lateral part of the brain. The posterior cerebral arteries supply both the medial and lateral parts of the posterior cerebrum.

Fig 1.4 – Overview of the blood supply to the cerebrum
Figure 17.4 The arteries on the base of the brain. The anterior part of the right temporal lobe has been removed to display the initial course of the middle cerebral artery within the
The lateral surface of the left cerebral hemisphere, showing the areas supplied by the cerebral arteries. In these figures the area supplied by the anterior cerebral artery is coloured blue, that by the middle cerebral artery pink and that by the posterior cerebral artery is yellow.
Posterior Cerebral Artery: Course

Major arteries of the brain. A, medial aspect
Spinal Cord
OBJECTIVES

• describe the external structure of the spinal cord,
• draw and describe the internal structure of the spinal cord,
• draw and describe the ascending and descending tracts within the spinal cord,
• describe the meninges surrounding the spinal cord,
• describe the blood supply of the spinal cord,
• explain the clinical correlations of & applications related to the spinal cord.
Organization of Nervous System

- Central Nervous System (CNS) = brain and spinal cord
- Peripheral Nervous System (PNS) = nerves
Spinal Nerves (31 pairs)

- Each pair of nerves located in particular segment (cervical, thoracic, lumbar, etc.)
- Each nerve pair is numbered for the vertebra sitting above it (i.e. nerves exit below vertebrae)
  - 8 pairs of cervical spinal nerves; *C₁-C₈
  - 12 pairs of thoracic spinal nerves; T₁-T₁₂
  - 5 pairs of lumbar spinal nerves; L₁-L₅
  - 5 pairs of sacral spinal nerves; S₁-S₅
  - 1 pair of coccygeal spinal nerves; C₀
Spinal Cord

- Continuous with medulla oblongata
- Extends to approximately L2
- 31 pairs spinal nerves
The spinal cord is the 2\textsuperscript{nd} part of the central nervous system extend from the medulla oblongata at the foramen magnum above in side The vertebral canal of the vertebral column below
Gross Appearance

- Cylindrical in shape
- Foramen magnum → L1/L2 (adult)
- L3 (newborn)
- Occupies upper $\frac{2}{3}$ of vertebral canal
- Surrounded by 3 layers of meninges:
  - dura mater
  - arachnoid mater
  - pia mater
- CSF in subarachnoid space
Spinal Cord Growth

- Runs from Medulla Oblongata to level of L1 (adults)
- Runs to level of L3-4 (infants)
Regions of Spinal Cord

- Cervical
- Thoracic
- Lumbar
- Sacral
- Coccygeal
- Cervical + Lumbar enlargements
- Cauda equina
- Conus medullaris
- Filum terminale
- Enlargements: cervical & lumbar
- Conus medullaris
- Filum terminale
- Anterior median fissure
- Posterior median sulcus
- 31 pairs of spinal nerves attached to it by the anterior roots & posterior roots
Spinal Cord in Situ

Enlargement of Cauda Equina
Spinal Cord (sp cd)

• Passes inferiorly through foramen magnum into vertebral canal

• 31 pairs of spinal nerves branch off spinal cord through intervertebral foramen

• Spinal cord made of a core of gray matter surrounded by white matter
4 Kinds of Nerve Fibers

- **Somatic Sensory** — “body senses”
  - touch, pressure, temperature, vibration of body, muscles stretching, balance
- **Visceral Sensory** — “organ senses”
  - Stretch, pain, temperature in organs
  - (eg) nausea, hunger, cramps
- **Somatic Motor** — “body movement”
  - Voluntary contraction of skeletal muscles
- **Visceral Motor** — “organ movement”
  - Contraction of smooth muscle, glands
  - = Autonomic Nervous System
Cross Section of Spinal Cord

- **Gray Matter**
  - “H” shaped Inner core
  - **Gray Commissure** = crossbar of “H”
- **Central Canal** = in gray commissure
  - Posterior/Dorsal horns
  - Anterior/Ventral horns
- **Composed of**
  - Cell bodies
  - Unmyelinated axons
  - Dendrites
  - Neuroglia

Pg 394
Gray Matter

- **Posterior Horns** = made of interneurons transmit info from cell bodies outside of sp cd **INTO** the sp cd
  - Dorsal Root contains Sensory Fibers
    - Somatic Sensory (SS)
    - Visceral Sensory (VS)
  - Dorsal Root Ganglia - swelling in dorsal root that these interneurons pass through

- **Anterior Horns** = made of cell bodies of motor neurons that send axons **OUT** of sp cd to muscles and glands
  - Ventral Root contains Motor Fibers
    - Visceral Motor
    - Somatic Motor
Gray Matter

- H-shaped pillar with anterior & posterior gray horns
- United by gray commissure containing the central canal
- Lateral gray column (horn) present in thoracic & upper lumbar segments
- Amount of gray matter related to the amount of muscle innervated
- Consists of nerve cells, neuroglia, blood vessels
Structure Of The Spinal Cord

- Sensory (Afferent) In
- DORSAL
- White matter
- Central canal
- Association or interneurons
- Grey matter
- Grey commissure
- Motor (Efferent) Out
White Matter

• Divided into
  – anterior white column
  – lateral white column
  – posterior white column
• Consists of nerve fibres, neuroglia, blood vessels
• White due to myelinated fibres
Tracts

• Ascending
• Descending
• Intersegmental
White Matter

• Fxn: Allows communication between parts of spinal cord, and between brain + spinal cord

• Two main types of nerve fibers
  • **Ascending:** carry SENSORY info from body to brain
    • (eg) touch, pressure, pain, temperature,
  • **Descending:** carry MOTOR info from brain to sp cd
    • (eg) control precise, skilled movement = writing, maintain balance, create movement
The Big Picture

- Just lateral to intervertebral foramen, each spinal nerve then splits in 2
  - Dorsal Rami
  - Ventral Rami
- Contain BOTH Sensory and Motor fibers!!
Meninges

- Dura mater
- Arachnoid mater
- Pia mater
Meningeal Spaces

- *dura mater* and *periosteum* of *epidural space*

- *dura mater* and *arachnoid-*
  - *subdural space* - no CSF

- *arachnoid* and *pia mater-*
  - *subarchnoid space* - CSF
Spinal Meninges

Three membranes surround all of CNS

1) Dura mater

2) Arachnoid

3) Pia mater

(c) Posterior view
Meninges of Brain and Spinal Cord

- **Pia mater** (deep)
  - delicate
  - highly vascular
  - adheres to brain/spinal cord tissue

- **Arachnoid mater** (middle)
  - impermeable layer = barrier
  - raised off pia mater by rootlets

- **Spinal Dura Mater** (most superficial)
  - single dural sheath

- **Subarachnoid Space**
  - between arachnoid and pia mater
  - contains CSF

- **Epidural Space**
  - Between dura mater and vertebra
  - Contains fat and veins
Dura mater

- Dense, strong fibrous membrane
- Encloses the spinal cord & cauda equina
- Continuous above with meningeal layer of dura covering the brain
- Ends at the level of S2
- Separated from wall of vertebral canal by the **extradural space**
- Contains loose areolar tissue & **internal vertebral venous space**
Arachnoid mater

- Delicate impermeable membrane
- Lies between pia and dura mater
- Separated from pia mater by subarachnoid space
- Continuous above with arachnoid mater covering the brain
- Ends on filum terminale at level of S2
Pia mater

- Vascular membrane
- Closely covers spinal cord
- Thickened on either side between nerve roots to form the ligamentum denticulatum
Blood supply

Arteries of the spinal cord

- Anterior spinal artery
- Posterior spinal artery
- Segmental spinal arteries
Anterior spinal artery

- Formed by the union of 2 arteries
- From vertebral artery
- Supply anterior $\frac{2}{3}$ of spinal cord

Posterior spinal arteries

- Arise from vertebral artery or posterior inferior cerebellar arteries (PICA)
- Descend close to the posterior roots
- Supply posterior $\frac{1}{3}$ of spinal cord
Segmental spinal arteries

• Branches of arteries outside the vertebral column
• Gives off the anterior & posterior radicular arteries
Blood Supply to Spinal Cord

• The spinal cord is supplied with blood by three arteries that run along its length starting in the brain, and many arteries that approach it through the sides of the spinal column.

• The three longitudinal arteries are called the anterior spinal artery, and the right and left posterior spinal arteries.

• These travel in the subarachnoid space and send branches into the spinal cord.

• They form anastamoses via the anterior and posterior segmental medullary arteries, which enter the spinal cord at various points along its length.

• Supply blood upto cervical segments.
Blood supply to the spinal cord: horizontal distribution

The central area supplied only by the anterior spinal artery is predominantly a motor area.
RADIOLOGY OF SPINAL CORD
Radiology Of Spinal Cord

- Welcome to the **Radiology Of Spinal Cord (Imaging module)**.
- After completing this module you should be able to:
  - identify, and distinguish between, common types of Radiographic Images
  - including **Plain X-rays**, **X-Ray Myelograms**, **CT**, **CT Myelograms**, and **MRI**.
  - You should also be able to recognize some **RADIOLOGICAL** presentation of spinal cord diseases.
Radiology Of Spinal Cord

- **Outline of presentation:**
  - Anatomy of spinal cord.
  - Anatomy of vertebral column.
  - Radiological Investigations.
    - Plain X-rays,
    - X-Ray Myelograms,
    - CT,
    - CT Myelograms, and
    - MRI.
  - some RADIOLOGICAL presentation of spinal cord diseases.
Radiological Methods Of Investigations

- Plain X-rays,
- X-Ray Myelograms,
- CT,
- CT Myelograms, and
- MRI.
Plain X-rays
Plain X-rays
Myelogram

- A Myelogram
- (also known as myelography)
- is a diagnostic tool that uses radiographic contrast media (dye) that is injected into the spinal canal’s fluid (cerebrospinal fluid, CSF). After the dye is injected, the contrast dye serves to **illuminate** the spinal canal, cord, and nerve roots during imaging.
radiographic contrast media

(NO DYE)

AN

(dye)
Lumbar myelogram (AP, Lateral & both oblique views)

1 = conus medullaris  
2 = Cauda equina  
3 = Left S₁ nerve root  
4 = Osteophyte  
5 = epidural compression due to herniated L₄-₅ disk  
7 = Root sleeve
Computerized Tomographic Imaging

CT
CT Myelograms
CT myelogram side view
Colored area defines dye in CSF
Magnetic resonance imaging

MRI

(study of choice)
Magnetic Resonance Imaging

Plain X-rays, CT
Imaging Decisions

Plain Radiographs (*x-rays*) are usually the first series of images to be ordered by the physician.

If fractures, or other bony defects, are suspected, CT images can provide very detailed information.

When soft tissue injury is suspected, MRI is usually the imaging technology of choice.
It is often necessary to utilize multiple imaging modalities. X-ray, CT and MRI to get all the information required for treatment.
Nasal Cavity and Paranasal Sinuses
Introduction

- Nasal cavity is a passage from the external nose anteriorly to the nasopharynx posteriorly.
- The frontal, ethmoid, sphenoid and maxillary sinuses form the paired paranasal sinuses.
- They are situated around and drain into the nasal cavity.
- The entire complex is lined by mucus secreting epithelium.
The nose consists of the a. **external nose** and the b. **nasal cavity**.

Both are divided by a septum into right and left halves.
The external nose has two elliptical orifices called the **naris (nostrils)**, which are separated from each other by the **nasal septum**. The lateral margin, the **ala nasi**, is rounded and mobile.
b. Nasal Cavity

The nasal cavity has:

1. floor,
2. roof,
3. lateral wall,
4. medial or septal wall.
4. The Lateral Walls of Nasal Cavity

Marked by 3 projections:
A. Superior concha
B. Middle concha
C. Inferior concha

The space below each concha is called a meatus.
The Lateral Walls of Nasal Cavity

**Inferior meatus:** nasolacrimal duct.  

**Middle meatus:**  
- Maxillary sinus  
- Frontal sinus  
- Anterior ethmoid sinuses

**Superior meatus:** posterior ethmoid sinuses.  

**Sphenoethmoidal recess:** sphenoid sinus.  

![Diagram of nasal cavities](image-url)
Nasal Cavity

- Nasal Septum
- Floor of the nasal cavity
- Lateral wall of the cavity
Paranasal Sinuses

- Frontal
- Ethmoid
- Sphenoid
- Maxillary
The Paranasal Sinuses
The paranasal sinuses are cavities found in the interior of the maxilla, frontal, sphenoid, and ethmoid bones. They are lined with mucoperiosteum and filled with air. They communicate with the nasal cavity through relatively small apertures.
Occipito Mental OM (Waters)
Lateral View

Position

Image

Frontal Sinuses
Ethmoid Sinuses
Maxillary Sinuses
Sphenoid Sinuses
Nasal Bones
Nasal Bones & Septum
Paranasal sinuses

PA 15 Caldwell

- Frontal sinus
- Ethmoid
- Mastoid
- Maxillary
Paranasal sinuses x-ray

- Frontal sinuses
- Ethmoidal sinuses
- Maxillary sinuses
Paranasal sinus – x-ray

1. Frontal sinuses
2. Ethmoidal sinuses
3. Maxillary sinuses
4. Sphenoidal sinuses
Paranasal sinuses – CT

Frontal sinuses
Ethmoidal sinuses

? = temporal air spaces !!
- Ethmoidal air cells
- Maxillary antrum
Paranasal sinuses
Paranasal sinuses
Lateral View
Thorax

- Region of the body between the neck and abdomen
- Flattened in front and behind, but rounded on the sides
- The bony framework of the walls is called the **thoracic cage**, which is formed of:
  - Vertebral column posteriorly
  - Ribs & intercostal spaces on the sides
  - Sternum and costal cartilages anteriorly
• **Superiorly:** It communicates with the neck through an opening on either sides, it is closed by a dense suprapleural membrane.
Bony Thorax

- Sternum
- 12 Ribs
- 12 Thoracic Vertebrae

Function
- Supports walls of pleural cavity & diaphragm
- Volume of cavity able to change during respiration
- Protects heart and lungs
12 Rib Pairs

- **True Ribs**
  - 1-7
  - Attached to the Sternum

- **False Ribs**
  - 8-12
  - Do not attach directly to the sternum; attach to costal cartilage of 7th rib

- **Floating Ribs**
  - 11 and 12
  - Attached only to the vertebrae

**Number Variation**
- **Cervical Ribs**
  - Articulate with C7 but rarely attach to sternum
- **Lumbar Ribs**
  - Less Common
• The thoracic cage:
  ▪ Protects the lungs, heart and large vessels
  ▪ Provides attachment to the muscles of thorax, upper limb, abdomen & back

• The cavity of thorax is divided into:
  • A median partition, the mediastinum
  • Laterally placed pleurae & lungs
Cutaneous Nerves

• **Anterior wall:**
  - Above the level of sternal angle: **Supraclavicular nerves**
  - Below the level of sternal angle: Segmental innervation by anterior and lateral cutaneous branches of the intercostal nerves

• **Posterior wall:**
  - Segmental innervation by posterior rami of the thoracic spinal nerves nerves
Thoracic Dermatomes
The Intercostal Space
Intercostal Space

• It is the space between two ribs
• Since there are 12 ribs on each side, there are 11 intercostal spaces.
• Each space contains:
  ▪ Intercostal muscles
  ▪ Intercostal neurovascular bundle
  ▪ Lymphatics
Intercostal muscles

• Each intercostal space has **three** muscles:
  • **External Intercostal**
  • **Internal Intercostal**
  • **Innermost Intercostal**

• Supplied by corresponding **intercostal nerves**

• Action:
  • Tend to pull the ribs nearer to each other
    ▪ **Strengthen the tissue of the space**
Muscles of the respiration

1. **Diaphragm muscle:**
is a thin skeletal muscle that sits at the base of the chest and separates the abdomen from the chest.

2. **External intercostal muscles**
   Action: Elevate ribs

3. **Internal intercostal muscles**
   Action: Depress ribs
Intercostal Neurovascular Bundle

- Lies between the **innermost** and the **internal intercostal** muscles
- Runs high in the intercostal space, related to subcostal groove of the rib above
- Has a strict order in arrangement: Vein-Artery-Nerve (VAN), from top to bottom
Intercostal Nerves

- **Twelve** pairs
- Are the **anterior primary rami** of the **thoracic spinal nerves**.
- **1-6** distributed in the intercostal spaces, **7-11th** supply the anterior abdominal wall
- Anterior ramus of **12th** nerve runs forward in the abdomen as the **subcostal nerve**
IMAGING MODALITIES OF THORAXIC WALL
SOFT TISSUE

- Normal fat planes are clearly defined in the soft tissues.
- They appear as smooth layers of low density (black), between layers of relatively dense (whiter) muscles.
- Irregular low density within soft tissues may be as a result of tracking air as a result of injury to the airways or pleura.
- This is known as surgical emphysema and produces the distinctive clinical sign of palpable subcutaneous ‘bubble wrap’.
Soft tissue fat

This close-up demonstrates a normal fat plane between layers of muscle. Fat is less dense than muscle and so appears blacker.

Note that the edge of fat is smooth. Irregular areas of black within the soft tissues may represent air tracking in the subcutaneous layers. This is known as surgical emphysema.
BONES
- The most dense tissue visible on CXR.
- Look for fractures, dislocation, subluxation, osteoblastic or osteolytic lesions etc.

Clavicle, scapula, and humerus

The clavicle, scapula and humerus are often clearly seen on a chest x-ray. Occasionally you will see evidence of important disease such as metastases in these bones.

Key
- 1 - Clavicle
- 2 - Acromioclavicular joint
- 3 - Acromion process of scapula
- 4 - Body of scapula
- 5 - Glenoid fossa of scapula
- 6 - Head of left humerus
- 7 - Glenohumeral joint
- 8 - Coracoid process of scapula
**BONES:**

- Bones on chest x-ray involved are:
  - Clavicle
  - Ribs
  - Spinous process
  - Scapula
  - Little part of humerus

**IMP POINT:**

- Check for any fracture any lesion or any abnormality
LEFT 4TH RIB

POSTERIOR AND ANTERIOR PORTIONS
The Osseous Components of the Thorax. Check the spine, ribs, clavicles, scapulae, and proximal humeri if visible. The Soft Tissues of the Chest Wall. Check for the presence of both breast shadows in females. In cases of radical mastectomy, the muscle planes will be altered.
INCLUSION:

- Chest x-ray should include entire thoracic cage.
- First rib
- Clavicle
- Lateral edges of ribs
- Costophrenic angles
Bony Fragments
- Ribs
- Sternum
- Spine
- Shoulder girdle
- Clavicles
Systematic Approach

- Name/marker/rotation/penetration

- Clavicles equidistant from spinous processes of thoracic spine

- Can just see lower thoracic spine
Systematic Approach

- Lines/metal work

Look for:
- Sternal wires (implies previous thoracic surgery)
- Tip of endotracheal tube (2cm above carina)
Systematic Approach

- Bones
  - Look at each rib in turn
  - Clavicles
  - Scapulae and humeri if visible
  - Lower cervical and thoracic spine
Rotation

Identify the medial ends of the clavicles and select one of the thoracic vertebra spinous processes that falls between them.

The medial ends of the clavicles should be equidistant from the spinous process, if that’s not the case then the X-Ray is rotated.
Well centred PA chest X-ray

- Find the medial ends of the clavicles
- Find the vertebral spinous processes
- The spinous processes should lie half way between the medial ends of the clavicles
IMAGING MODALITIES OF DIAPHRAGM
* Diaphragm : Seperation
* Thoracic Diaphragm
* Pelvic Diaphragm
* Urogenital Diaphragm
THORACIC DIAPHRAGM (ANATOMY)

- Dome shaped
- Muscular fibres: origin
  - Sternal - below XIPHOID process,
  - Costal - Inner surface of costal cartilages of 6th ribs,
  - Lumbar - Aponurotic arches of lumbar vertebrae
• lumbocostal arches: 2 pairs

Medial lumbocostal arches: tendinous arch covering psoas major; continuous medially with left crura; attached to L2 vertebral body and in the front of the transverse process of L1 and L2

Lateral lumbocostal arches: covers quadratus lumborum; attached medially to the L1 transverse process and attached laterally to the tip of the 12th rib

• Crurae: Right and Left; Blends to the Anterior longitudinal ligament of vertebrae

• CENTRAL TENDON: Strong aponeurosis below pericardium
Aortic Hiatus (T₁₂)

Oesophageal Hiatus (T₁₀)

Vena caval foramen (Ts)

Lesser apertures BLOOD SUPPLY At

1. Costal margins - lower 5 intercostal A.

2. Abdominal surface - Rt & Lt Inf.Phrenic A.

3. Superior phrenic A. And Musculophrenic A NERVE SUPPLY

Rt and Left phrenic N. & inter-costal N.
Xiphoid process

Opening for Lesser Splanchnic Nerve
NORMAL CHEST X-RAY
Systematic Approach

- Diaphragm

- Both diaphragms should form a sharp margin with the lateral chest wall
- Both diaphragm contours should be clearly visible medially to the spine

Position of stomach gas bubble (not present on this CXR)
The Subdiaphragmatic Area. Check for the normal arrangement of the abdominal visceral shadows, including the stomach bubble, liver and spleen. Check for calcifications, organomegaly, abnormal collections of air, etc.

The Osseous Components of the Thorax. Check the spine, ribs, clavicles, scapulae, and proximal humeri if visible. The Soft Tissues of the Chest Wall. Check for the presence of both breast shadows in females. In cases of radical mastectomy, the muscle planes will be altered.
COSTOPHRENIC ANGLE AND RECESS

• The costophrenic recesses are formed by hemidiaphragms and chest wall.
• They contain the rim of the lung bases which lie over the dome of each hemidiaphragm.
• These angles are known as the costophrenic angles.
• Costophrenic angles should form acute angles that are sharp to the point.
Costophrenic angles

On a PA view, the costophrenic recesses are seen on each side as the costophrenic angles. The costophrenic angles consist of the lateral chest wall and the dome of each hemidiaphragm.
HEMIDIAPHRAGM

Hemidiaphragms
Here you can see the right hemidiaphragm lying slightly higher than the left. The liver is located immediately inferior to the diaphragm on the right.

The stomach bubble can be seen below the left hemidiaphragm, and through this, normal lung is seen. If you look closely you can see lung markings below the diaphragm on both sides.

Medially the hemidiaphragms form an angle with the heart. These are called the cardiophrenic angles (asterisks), which are often smooth rather than sharp.

On both sides the contour of the hemidiaphragm should be seen passing medially as far as the spine.
Hemidiaphragms
The left and right hemidiaphragms are almost superimposed on a lateral view. Anteriorly the left hemidiaphragm blends with the heart and becomes indistinct.
HEMIDIAPHRAGM:

Cardiophrenic angles

Hemidiaphragms

Stomach

Right hemidiaphragm

Left hemidiaphragm
• Normal Diaphragm is 2-3 mm thick
• Which is normally not measurable in right side unless there is free peritoneal gas or bowel loop separating the liver from diaphragm.
• In the left side the combined stomach wall and diaphragm form linear density of 5-8 mm thick.
• Thickening in most cases are normal.
• Pathological thickening is seen in
  1. Tumors of diaphragm; stomach & pleura
  2. Subpulmonary fluid
  3. Diaphragmatic humps
  4. Abdominal lesions: splenomegaly, hepatomegaly
DIAPHRAGMATIC PARALYSIS

- Due to injury to Phrenic nerve.
- Unilateral or Bilateral
  
  Increase load can cause respiratory failure
  - Associated with conditions like: Spinal cord transection, Multiple sclerosis, Amyotrophic lateral Sclerosis, Cervical spondylosis GBS,
  - Isolated Phrenic Nerve dysfunction: Compression by tumor, Cardiac surgery cold injury, blunt trauma, etc.
Chest radiograph show elevated hemidiaphragm and Atelectasis of lung
Flouroscopy aids in clear visualization of the movement of the diaphragm
Sniff Test: Paradoxical Elevation of diaphragm in inspiration
Other tests: PFT, EMG and phrenic nerve stimulation
RUPTURE OF DIAPHRAGM

Traumatic diaphragmatic injuries occur in 0.8%-8% of patients who sustain blunt trauma. Up to 90% of diaphragmatic ruptures from blunt trauma occur in young men after motor vehicle accidents.
ASSOCIATED INJURIES

- Common: pelvic fractures (40%-55%), splenic injuries (60%), and renal injuries
- High frequency of liver injuries, which are more frequently associated with right than with left diaphragmatic tears
- Thoracic injuries: pneumohemothoraces and rib fractures are seen in 90% of patients. Aortic thoracic injuries are reported in 5% of patients
DIAPHRAGM INJURY

Chest X-ray:

\( (a) \) intrathoracic herniation of a hollow viscus (stomach, colon, small bowel) with or without focal constriction of the viscus at the site of the tear (collar sign)

\( (b) \) visualization of a nasogastric tube above the hemidiaphragm on the left side

• Findings suggestive of hemidiaphragmatic rupture include elevation of the hemidiaphragm, distortion or obliteration of the outline of the hemidiaphragm, and contralateral shift of the mediastinum
• CT CHEST:
• Helical CT has proved to be more valuable in the detection of diaphragmatic injuries with a sensitivity of 71%
CONGENITAL DIAPHRAGMATIC HERNIA

- Diaphragmatic hernias include Bochdalek (posterolateral), Morgagni (retrosternal), and hiatal hernias.

- **Antenatal USG** scan can diagnose all types earlier.

- USG can aid in determining the survivability of the foetus.

- **Congenital diaphragmatic hernia (CDH)** is a major surgical emergency in newborns. The key to survival lies in prompt diagnosis and treatment.

- Pulmonary hypertension and Pulmonary hypoplasia are complications.

**Morgagni Hernia:**
Morgagni foramen is an opening caused by failure of fusion between septum transversum and lateral body wall where internal mammary artery crosses diaphragm.

**Hiatal Hernia:**
Delay in the descent of the stomach keeping the hiatus relatively larger is thought to be the cause.

**Bochdalek Hernia:**
This posterolateral defect is thought to arise from malformation of pleuroperitoneal fold or its failure to fuse with intercostal muscles.
MORGAGNI’S HERNIA

Anterior defect of the diaphragm
MORGAGNI HERNIA
HIATUS HERNIA

- A.K.a. oesophageal hiatal hernia
- Herniation of stomach through the oesophageal hiatus of the diaphragm

Content: always Stomach; rarely with bowel loops (if the defect is large enough)
- Focal eventration (arrow) at the anteromedial aspect of the right hemidiaphragm.
- The eventration contains part of the liver.
Diaphragmatic tumors may be divided:

1. primary benign neoplasms;
2. primary malignant neoplasms;
3. secondary malignant neoplasms;
4. cysts;
5. inflammatory lesions;
6. endometriosis.
Figure 2 - Magnetic resonance showing a mass in right hemithorax.
Mediastinum

- Mediastinum = space between lungs.
- Superior mediastinum:
  Separated from inferior by horizontal plane between sternal angle and IV disc T4-T5.
8. THE MEDIASTINUM

• The mediastinum contains the heart and great vessels (Middle mediastinum) and potential spaces in front of the heart (anterior mediastinum), behind the heart (Posterior mediastinum) and above the heart (superior mediastinum).

• These potential spaces are not defined on a normal CXR, but their awareness can help in describing location of disease processes.

• There are several structures in the superior mediastinum that should always be checked. These include aortic knuckle, aorto–pulmonary window and the right para–tracheal stripe.
Mediastinum
- It is the partition between the two pleural cavities and lungs. It includes a large number of structures.
- It is subdivided into:
  a. Superior mediastinum
  b. Inferior mediastinum: anterior, middle and posterior

a. Superior mediastinum:
- thymus
- Esophagus
- Trachea
- Arch of Aorta
- Big branches of Aortic arch
- Brachiocephalic (innominate) veins
- Upper half of superior vena cava
- Phrenic nerves
- Vagi nerves

b. Inferior mediastinum
1. Anterior mediastinum
   - Thymus
   - Lymphatics & fat

2. Middle mediastinum:
   - Pericardium
   - Heart
   - Pulmonary trunk
   - Ascending Aorta
   - Lower half of SVC
   - Upper part of IVC
   - Bifurcation of trachea

3. Posterior mediastinum:
   - Esophagus
   - Descending thoracic Aorta
   - Azygos and hemiazygos veins
   - Vagi
a. Superior Mediastinum

- **Retrosternal:**
  - Great vessels and branches.
  - Thymus.

- **Prevertebral:**
  - Trachea
  - Esophagus
  - Thoracic duct
  - Sympathetic trunks
  - Vagus nerves
Mediastinum

- B.Inferior:
  1. Anterior:
  2. Middle:
  3. Posterior:
b. Inferior Mediastinum

1. Anterior:
   - Thymus, fat, lymph nodes

2. Middle:
   - Pericardium
   - Phrenic nerves
   - Pericardiacophrenic artery
   - Heart and great vessels
Inferior Mediastinum

3. Posterior:

- Esophagus
- Thoracic duct
- Aorta and branches
- Vagus nerves
- Sympathetic trunks
- Azygos system of veins
a. SUPERIOR MEDIASTINUM
Thymus

- Occupies superior mediastinum on either side of the midline.
- Behind manubrium.
- Covered by converging pleura of the lungs.
- Involutes with fat after puberty.
b. Inferior Mediastinum

1. Anterior: Thymus, fat, lymph nodes
2. Middle Mediastinum (inferior)

- **Pericardium:**

  Encloses heart.
Middle Mediastinum (inferior)

- **Pericardium:**
  - Pericardial cavity.
  - Parietal (serous):
    - Fused to fibrous pericardium.
  - Fibrous:
3. POSTERIOR MEDIASTINUM
Esophagus

- From base of neck to:
  - Left of midline to:
  - Midline to:
  - Left of midline.

- Passes through diaphragm at level of T10.

- Lies:
  - Behind trachea.
  - In front of vertebral column.
Left Thoracic duct

- Receives lymph from left internal jugular lymph trunk.
- Receives lymph from left subclavian lymph trunk.
- Empties into venous system at junction of:
  - Left internal jugular vein.
  - Left subclavian vein.
Right Thoracic duct

- Drains upper right thoracic cavity, right upper extremity, and right side of head and neck.
- Empties into venous system at junction of:
  - Right internal jugular vein.
  - Right subclavian vein.
Thoracic Sympathetic Chain

- Lies against neck of ribs and costovertebral junctions.
- 12 thoracic ganglia pairs:
  - First one often fused with inferior cervical ganglion:
    - Referred to as stellate ganglion collectively.
Vagus Nerve

- Cranial nerve X
- Major parasympathetic supply to thoracic and abdominal visceral
Course of Vagus Nerve

- Parallel to esophagus: Innervates esophagus
- Passes posterior to root of lung on each side.
- Pierces diaphragm with esophagus.
- Becomes gastric nerve.
- Supplies viscera in thoracic cavity.
Vagus Nerve Branches

- Cardiac branches to cardiac plexus.
- Pulmonary branches to pulmonary plexus.
- Esophageal branches to esophageal plexus.
Phrenic Nerve

- Arises in neck from: Ventral rami of C3-5 (C4 = major contribution)
- Passes anterior to pulmonary root on each side (only nerve to do so).
- Sole motor innervation to diaphragm.
- Sensory fibers to pericardium, mediastinal pleura, and pleural and peritoneal coverings of diaphragm.
Lymphatic Drainage of Thorax

- **Thoracic Duct**
  
  Begins in abdomen on right side of midline.
  Receives most of lymph from body below diaphragm.
  Drains left side of thoracic cavity and part of right.
  Receives lymph from left internal jugular lymph trunk.
Clinical correlations

- Deflection of Mediastinum

✓ If air enters the pleural cavity (a condition called pneumothorax), the lung on that side immediately collapses and the mediastinum is displaced to the opposite side.

✓ Patient’s being breathless and in a state of shock; on examination, the trachea and the heart are found to be displaced to the opposite side.
Systematic Approach

• Mediastinum
  • Hilar vascular structures should be crisply defined
  • No widening of mediastinum
  • Trachea should be central
Mediastinum

- Anterior mediastinum
  - thymus, fat, lymphatics
- Posterior mediastinum
  - descending aorta, esophagus, azygos veins, autonamics, thoracic duct
- Middle mediastinum
  - heart, pericardium, aorta, trachea, main bronchi, lymph nodes

Mediastinal lesions and their distribution in 102 patients
The esophagus lies posterior to the trachea but can be displaced to the left (more common) or right. It is often collapsed and appears as a flattened structure of soft-tissue attenuation. Small amounts of air or fluid may be seen in its lumen.

The brachiocephalic veins are the most anterior and lateral vessels visible, lying immediately behind the clavicular heads. Although they vary in size, their positions are relatively constant. The right brachiocephalic vein has a nearly vertical course throughout its length. The left brachiocephalic vein is longer and courses horizontally as it crosses the mediastinum. The innominate (brachiocephalic) artery is located in close proximity to the anterior tracheal wall, near its midline or slightly to the right of midline in most normals; it is the most variable of all the great arteries.
Radiological Anatomy of the Upper Gastrointestinal Tract
Esophageal Anatomy

- Fibromuscular tube about 10” (25 cm) long: C6–T10
- Variation in length according to age. (Pedia:C5-T9)
- Flat in upper 2/3 & rounded in lower 1/3
- Esophageal plexus (vagus + sympathetics)
- Vagal trunks (anterior & posterior)
- Esophageal hiatus in diaphragm
- Right crus of diaphragm forms a sphincter-like sling
Esophageal Anatomy

Esophageal Constrictions

- Superiorly: level of cricoid cartilage, juncture with pharynx
- Middle: crossed by aorta and left main bronchus
- Inferiorly: diaphragmatic sphincter
Radiology of Esophageal Anatomy

Imaging Modalities

✓ Fluoroscopy (Barium Swallow, Upper GI)
✓ CT
Radiology of Esophageal Anatomy

Imaging Modalities

✓ Fluoroscopy (Barium Swallow, Upper GI)

• This is dynamic study which allow visualization of outline and movement (peristalsis)
• Examination may be performed using single-contrast or double-contrast.
• Patients are asked to be NPO 8 hours prior to examination.
Radiology of Esophageal Anatomy

Imaging Modalities

✓ Fluoroscopy (Barium Swallow, Upper GI)

Barium Swallow Indications:

- Dysphagia
- Pain
- Tracheo-esophageal Fistula
- Esophageal perforation
- Pre-operative assessment of bronchial Ca
Esophageal Anatomy

Esophageal Constrictions

This oblique view of a normal barium swallow shows the normal impressions made by

(A) aortic arch.
(B) left mainstem bronchus.
(LA) left atrium on the esophagus
Esophageal Anatomy

Esophageal Peristalsis
Abnormal:
Tertiary contractions (A)
presbyesophagus: Nonpropulsive contractions
Diffuse esophageal spasm**
Nutcracker esophagus
Decreased peristalsis resulting from achalasia, scleroderma, dermatomyositis, polymyositis, esophagitis, .......
Stomach Anatomy

✓ Regions of stomach:
  • Cardiac
  • Fundus
  • Corpus
  • Pyloric: antrum, canal, sphincter
✓ Lesser & greater omental
✓ Winslow’s foramen: communication of lesser & greater sacs

Rugae are mucosal folds seen in the nondistended stomach. The areae gastricae represent the normal reticular mucosal pattern of the stomach, most prominent in the body and antrum. The lesser curvature forms the right gastric border and extends from the cardia to the pylorus.
Radiology Stomach Anatomy

Imaging Modalities

✓ Fluoroscopy (Barium Swallow, Upper GI)
✓ CT

Exam may be performed
Single-contrast
Double-contrast
**Radiology Stomach Anatomy**

- esophagus
- Lower esophageal sphincter
- fundus
- cardia
- lesser curvature
- pylorus
- greater curvature
- duodenum
- stomach rugae
- antrum
- body
- rugae
- Rugal Folds
- Fundus
- Douodenal Bulb
- Antrum
- Body
- 'C' Loop Douodenum
Radiology Stomach Anatomy

Imaging Modalities

✓ COMPUTED TOMOGRAPHY
LYMPHATIC SYSTEM
What is lymph?

Tissue fluid (interstitial fluid) that enters the lymphatic vessels
Essentially a drainage system accessory to venous system

Larger particles that escape into tissue fluid can only be removed via lymphatic system.
Functions of the Lymphatic System

- **Reabsorbs excess interstitial fluid:**
  - returns it to the venous circulation
  - maintain blood volume levels
  - prevent interstitial fluid levels from rising out of control.

- **Transport dietary lipids:**
  - transported through lacteals
  - drain into larger lymphatic vessels
  - eventually into the bloodstream.

- **Lymphocyte development, and the immune response.**
Components of the Lymphatic System

- Lymph
- Lymphatic Vessels
  - Lymphatic Capillaries
  - Lymphatic Vessels
  - Lymphatic Trunks
  - Lymphatic Ducts
- Lymphatic Organs
  - Thymus
  - Lymph Nodes
  - Spleen
  - Tonsils
- Lymphatic cells
Lymph Vessels

- Lymphatic capillaries
- Lymphatic collecting vessels
- Lymphatic trunks
- Lymphatic ducts
Lymphatic Vessels

Features of structure

- Three layered wall but thinner than vein,
- More numerous valves than in vein
- Interposed by lymph nodes at intervals
- Arranged in superficial and deep sets
Right lymphatic duct

- Formed by union of right jugular, subclavian, and bronchomediastinal trunks
- Ends by entering the right venous angle
LYMPHATIC DUCTS

- **Thoracic duct**
  - Begins in front of L1 as a dilated sac, the cisterna chyli
  - formed by left and right lumbar trunks and intestinal trunk
  - Enter thoracic cavity & ascends
  - Travels upward, veering to the left at the level of T5
At the root of the neck, it turns laterally
arches forwards and descends to enter the left venous angle
before termination, it receives the left jugular, Subclavian and broncho-mediastinal trunk
RIGHT LYMPHATIC DUCT - Receives lymph from right half of head, neck, thorax and right upper limb, right lung, right side of heart, right surface of liver

THORACIC DUCT - Drains lymph from lower limbs, pelvic cavity, abdominal cavity, left side of thorax, and left side of the head, neck and left upper limb
Lymphatic Cells

- Also called lymphoid cells.
- Located in both the lymphatic system and the cardiovascular system.
- Work together to elicit an immune response.
- Types of lymphatic cells are:
  - macrophages
  - epithelial cells
  - dendritic cells
  - lymphocytes
LYMPHATIC ORGANS

Primary organs
- Red bone marrow
- Thymus gland

Secondary organs
- Lymph nodes
- Lymph nodules
- Spleen
Lymph Nodes

- Small, round or oval
- Located along the pathways of lymph vessels.
- Length from 1 - 25 millimeters
- Typically found in clusters
- Receive lymph from many body regions.
- Lymph nodes are also found individually
Lymph node

Features

- Bean-shaped bodies
- With *afferent vessels* (entering at the periphery) and *efferent lymph vessels* (emerging at the hilus)
- Arranged in groups, along the blood vessels or the flexural side of the joint
- Divided into *superficial and deep* groups
Regional Lymph Node is the lymph node where the lymph of the organ or part of the body drains to firstly

Sentinel Lymph Node (in clinic)
Spleen

- **Location**
  - Left epigastric region
  - between 9\textsuperscript{th}-11\textsuperscript{th} rib
  - in line of 10\textsuperscript{th} rib

- **Largest** lymphatic organ in the body.

- Can vary considerably in size and weight

- **Function**
**THYMUS**

**Features**

- Consists of two elongated lobes
- Is a large organ in the fetus
- Occupies the thoracic cavity behind the sternum
- Secrete lymphopoietin
Tonsils

- Clusters of lymphatic cells and extracellular matrix not completely surrounded by a connective tissue capsule.
- Consist of multiple germinal centers and crypts

- Several groups of tonsils form a protective ring around the pharynx.
  - Pharyngeal tonsils (or adenoids) in nasopharynx
  - Palatine tonsils in oral cavity
  - Lingual tonsils along posterior one-third of the tongue
LYMPHANGITIS

Inflammation of the lymph vessels

Commonest cause bacteria called streptococcus pyogenes (most common).

- Lymph vessels appear as red streaks through the skin
FILARIASIS

(b) Microfilaria develop into infective larvae in the mosquito and are injected into a new host.

(c) Larvae mature into adult worms and spread through the lymphatic vessels, where they mate and lay eggs.
LYMPHEDEMA

- Occurs due to accumulation of lymphatic fluid in the interstitial tissue.
- Sometimes can be appreciated after wearing tight clothing or jewellery on affected limb.
LYMPHADENOPATHY

- Means a **disease of the lymph nodes**

- Lymph nodes become **swollen/enlarged** and may be painful to touch
LYMPHOMAS

- Cancers originating either from the lymphocytes in the lymph nodes or the lymphatic tissue in organs

- Risk factors -- HIV, HEPATITIS, EBV infections
TONSILLITIS

- Infection of the pharyngeal tonsils
- Tonsils are swollen,
- Fever and pain during swallowing usually present
- Treatment – surgical removal of tonsils (TONSILLECTOMY)
SPLENOMEGALY

- Enlarged Spleen
- Various causes
Pericardium:
1- It is a fibroserous sac which surrounds the heart and adjacent parts of the big vessels originating from or ending into the heart.

2- It is formed of
outer fibrous sheath----fibrous pericardium
inner serous sac--------serous pericardium

Fibrous pericardium:
- Shape: conical
- Apex, base
- Relations: ant, post, on each side

Serous pericardium:
- It is closed serous sac covered by fibrous pericardium and it is invaginated by the heart from behind and above
- Layers

Arterial supply and Venous drainage:
Fibrous and parietal layer of serous
- internal thoracic and descending Aorta
Visceral layer of serous----coronary arteries and drained into coronary sinus

Nerve supply:
Fibrous and parietal layer of serous----phrenic
Visceral layer of serous----autonomic

Applied Anatomy:
pericardial puncture
Heart:
- It is a pyramidal, hollow, four-chambered, muscular organ (forming the major part of middle mediastinum).
- It is formed of 4 chambers
- Atrioventricular groove (coronary sulcus)
- Anterior and inferior interventricular grooves
- Interatrial and interventricular septums
- Being pyramidal it has:
  - 1. apex:
  - 2. base:
  - 3.4 surfaces: sternocostal, diaphragmatic, right and left surfaces
Right Atrium:

-Site

- Receives venous blood from whole body
  SVC---upper post.
  IVC---lower post

- Right auricle

Interatrial septum shows----fossa ovalis

Opening in RT:
SVC, IVC, coronary sinus, tricuspid opening
Right Ventricle:

Interventricular septum

Opening in RV:
Tricuspid opening and valve

Pulmonary opening and valve
**Left Atrium:**
- Receives 4 pulmonary veins
- Left auricle

**Opening in IT:**
4 pulmonary veins
Mitral opening
**Left Ventricle:**

**Opening in LV:**
- Mitral opening and valve
- Aortic opening and valve

- Pulmonary valve
- Aortic valve
- Tricuspid valve
- Mitral valve
- Papillary muscle
Conducting system of the heart:
Formed of modified myocardial fibers called (Purkinje fibers) which are specialized for initiation, conduction and maintenance of the cardiac rhythm.
1- Sinoatrial (SA) node-----site, function
2- Atrioventricular (AV) node-----site
3- Atrioventricular (AV) bundle-----right , left branches
Arterial supply of the heart:
1- right coronary artery:
2- Left coronary artery:

Venous drainage of the heart:
1- Coronary sinus: Length, site, receives all venous drainage of the heart as: great, middle and small cardiac veins

Nerve supply of the heart:
1- Sympathetic innervation:
Stimulates heart rate (tachycardia) coronary vasodilatation

2- Parasympathetic innervation:
Slows heart rate (bradycardia) coronary vasoconstriction

3- Pain fibers: upper thoracic segments of the spinal cord
HEART SIZE:

- Cardiac size is assessed as cardiothoracic ratio (CTR)

- CTR is the transverse cardiac diameter divided by the transverse chest diameter

NORMAL CTR:

- IN ADULTS:
  - Approximately 50%

- IN NEONATES:
  - Approximately 65%

Cardio = 15.2
Thoracic = 32.8
Normal heart size

Cardiothoracic ratio (CTR)

Cardiac size is measured by dropping parallel lines down both sides of the heart, at the most lateral points on each side, and measuring between them. Thoracic width is measured by dropping parallel lines down the inner aspect of the widest points of the rib cage, and measuring between these. The cardio-thoracic ratio can then be stated.

Here the CTR is approximately 15 : 33 (arbitrary units) and is therefore within the normal limit (expressed as a percentage) of 50%.
HEART CONTOUR:

- Formed by borders of heart

**BORDERS:**

- **RIGHT BORDER:** Formed by right atrium
- **LEFT BORDER:** Formed by left ventricle
- **ANTERIOR BORDER:** Formed by right ventricle
- **POSTERIOR BORDER:** Formed by left atrium
CORONAL SLICES.

RT. VENTRICLE

PULMONARY OUTFLOW

LT. VENTRICLE

LIVER
Normal MRI Chest

Magnetic Resonance Imaging (MRI) utilizes changing magnetic and electrical fields to obtain images of a patient. Factors can be altered to enhance resolution of different structures thus blood for example can look bright white or dark black.

Among the advantages of MRI are:

1. X-rays and the attendant hazards of ionizing radiation are not present.
2. Scans in multiple different projections e.g. oblique, sagittal, coronal, axial can be obtained with ease.
Normal Sagittal MRI Chest

Key:
1A  Ascending aorta
1B  Aortic arch
1C  Descending aorta
2   (R) brachiocephalic artery
3   (L) carotid artery
4   (L) Subclavian artery
5   Right ventricular outflow tract
6   Right ventricle
7   Left ventricle
8   Right atrium
9   Left atrium
10  Pulmonary artery
11  Right main coronary artery
12  Left main coronary artery
13  Left anterior descending coronary artery
14  Sternum
15  Right innominate vein
16  Left innominate vein
17  Trachea
Normal Parasagittal MRI Chest

MRI 4

Key:
1A  Ascending aorta
1B  Aortic arch
1C  Descending aorta
2   (R) brachiocephalic artery
3   (L) carotid artery
4   (L) Subclavian artery
5   Right ventricular outflow tract
6   Right ventricle
7   Left ventricle
10  Pulmonary artery
11  Right main coronary artery
12  Left main coronary artery
13  Left anterior descending coronary artery
14  Sternum
15  Right innominate vein
16  Left innominate vein
17  Trachea
Intravenous contrast has been injected from a catheter placed from a Lt. subclavian site with the tip of the catheter in the main pulmonary artery. Rapid imaging while
Coronary arteries

- left coronary artery
- circumflex branch
- right coronary artery
- anterior interventricular branch = LAD
- marginal branch
- posterior interventricular branch
Coronary Angiograms

LT Coronary Art LAO

- Sinus Node Artery
- Left main coronary artery
- AV Groove
- LAD
- Diagonal artery
- Left circumflex artery
- Obtuse marginal artery
- IV Groove
- Septal perforator
Azygos = unpaired/ single:
- Straight, para-vertebral, present only on rt side, have valves
- Drain blood from post abd wall & post mediastinum

Forms an important collateral channel connecting SVC & IVC
Hemiazygos vein

• Also k/a inferior hemiazygous vein Mirror image of lower part of azygos v
The most important nerves of the mediastinum are the **phrenic** and **vagus nerves**, the thoracic spinal nerves, the sympathetic trunks and ganglia, and the autonomic plexuses.
Abnormal right paratracheal stripe

Widening of right paratracheal stripe caused by a large ectopic parathyroid adenoma. Note diffuse osteopenia from hyperparathyroidism.
Abnormal aortic-pulmonary stripe

Abnormal contour of the aortic-pulmonary stripe due to lymphoma with anterior mediastinal lymphadenopathy within the prevascular space.
Learning Objectives

By the end of this Lecture the student will be able to:

- List and identify the major anatomy of the spine
- List the common indications for the vertebral column
- Identify the common technical factors for the vertebral column radiography
- List the basic and Optional projections for spine radiography
- Discuss the correct body position, part position, central ray, and center point for specific positions for each projection.
- Critique and evaluate spine radiographs based on position, collimation and central ray, exposure, and structure best shown.
Vertebral Column – Anatomy Review

Vertebral column (26)
- Cervical 7
- Thoracic 12
- Lumbar 5
- Sacrum 1 (5 fused)
- Coccyx 1 (3-5 fused)

Function
- Provides support for head, neck and trunk
- Transfers weight to Appendicular skeleton
- Protects spinal cord

Diagram showing vertebrae labeled:
- Cervical
- Thoracic
- Lumbar
- Sacrum
- Coccyx

Atlas (C1)
Axis (C2)
C7
T1
T12
L1
L5
(S1-5)
Coccyx
<table>
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<tr>
<th>Term</th>
<th># of Vertebrae</th>
<th>Body Area</th>
<th>Abbreviation</th>
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<td>Cervical</td>
<td>7</td>
<td>Neck</td>
<td>C1 – C7</td>
</tr>
<tr>
<td>Thoracic</td>
<td>12</td>
<td>Chest</td>
<td>T1 – T12</td>
</tr>
<tr>
<td>Lumbar</td>
<td>5 (or 6)</td>
<td>Low Back</td>
<td>L1 – L5</td>
</tr>
<tr>
<td>Sacrum</td>
<td>5 (fused)</td>
<td>Pelvis</td>
<td>S1 – S5</td>
</tr>
<tr>
<td>Coccyx</td>
<td>3-4 (1)</td>
<td>Tailbone</td>
<td>None</td>
</tr>
</tbody>
</table>
Structure of a Typical Vertebrae

- Posterior
- Spinous process
- Vertebral arch
- Lamina
- Transverse process
- Superior articular process
- Pedicle
- Vertebral foramen
- Body

Anterior
VERTEBRAL ANATOMY

COMMON FEATURES SHARED BY MOST VERTEBRAE ARE-

1. VERTEBRAL BODY
2. POSTERIOR ARCH
   - PEDICLE
   - LAMINA
   - SPINOUS PROCESS
   - TRANSVERSE PROCESS
   - ARTICULAR PROCESS
POSTERIOR ARCH

- 2 STOUT PILLARS BRIDGING VERTEBRAL BODY AND POSTERIOR ARCH CALLED **PEDICLE**

- PEDICLE GOES DORSALLY FUSING WITH PAIR OF ARCHED FLAT **LAMINA**.

- LAMINA DORSALLY FUSE IN MIDLINE TO FORM **SPINOUS PROCESS**.

- PEDICLE, LAMINA WITH SPINOUS PROCESS FORM **VERTEBRAL FORAMEN**, COMPLETE OSSEOUS RING THAT ENCLOSE SPINAL CORD.

- **TRANSVERSE PROCESS** IS A STRUCTURE EXTENDING FROM JUNCTION OF LAMINA AND PEDICLE.

- TRANSVERSE PROCESS ALLOW MOVEMENT OF SPINE AND
CERVICAL VERTEBRAE

- Dens of axis
- Transverse ligament of atlas - holds dens in place
- C1 (atlas)
- C2 (axis)
- C3
- Inferior articular process
- Bifid spinous process
- Transverse processes
- C7 (vertebra prominens)

- 7 VERTEBRAE
- **DIFFERENTIATING FEATURE IS PRESENCE OF TRANSVERSE FORAMEN.**
- LORDOTIC CURVE
- PROVIDES MOBILITY AND STABILITY TO HEAD.
C1 (ATLAS)

- No body, no spinous process
- Develop as a ring of bone with anterior and posterior arches that connect 2 lateral masses.
C2 (Axis)

- During the development of atlas, what should be the body naturally fuse to axis forming **dens or odontoid peg** and presented as body of axis.

- Posteriorly groove in the neck of odontoid represents position of strong **transverse atlantal ligament**.

- At the tip of odontoid peg there is attachment of **apical ligament**. It connects odontoid to base of skull at basion, anterior part of foramen magnum.
ATLANTOAXIAL JOINT

- It is a pivot joint.

- Atlas and Axis form a complex articular system that permits nodding and rotational movements of the head.

- Dens, *tooth like structure* act as central point to allow rotation for Atlas.

- *No intervertebral disc* between C1 and C2.
C3-C7 VERTEBRAE

- Sulcus for Spinal Nerve
- Body
- Transverse Process
- Transverse Foramen
- Superior Articular Facet
- Lateral Mass
- Pedicle
- Lamina
- Vertebral Foramen
- Bifid Spinous Process
C7 VERTEBRAE

- C7 VERTEBRAE IS REFERRED AS VERTEBRAE PROMINENS BECAUSE IT HAS LONGER AND LARGER SPINOUS PROCESS COMPARED TO OTHER CERVICAL VERTEBRAE.
- HERE SPINOUS PROCESS IS NOT USUALLY BIFID.
Normal Spinal Curves

- Cervical curve
- Thoracic curve
- Lumbar curve
- Sacral curve
Abnormal Spinal Curves

- Normal adult curvature
- Lordosis - kyphosis
- Scoliosis
Some Indications radiography

1. Fractures
2. Congenital abnormalities
3. Pathological disorders
   - Cervical spondylosis
   - Ankylosing spondylitis
   - Spondylolisthesis
   - Herniated (slipped) disc – protrusion or rupture of an Intervertebral disc
   - Infection e.g., Tuberculosis (Pott’s disease), Osteomyelitis
   - Tumors, e.g., metastases, primary bone tumors,
GOAL OF X-RAYS OF SPINE

- TO DIAGNOSE
- CAUSE OF BACK PAIN OR NECK PAIN
- FRACTURE
- ARTHRITIS
- SPONDYLOLISTHESIS
- DEGENERATION OF DISC
- TUMOR
- ABNORMALITIES OF CURVATURE
- CONGENITAL ABNORMALITIES
X-RAYS OF CERVICAL SPINE

- DIFFERENT VIEW FOR CERVICAL SPINE:
  -anteroposterior view
  -lateral view
  -odontoid (open mouth) view
  -swimmers view
  -lateral view with traction of both arm
  -functional view (lateral flexion and extension view)
NORMAL RADIOLOGICAL FINDING IN C-SPINE

- LATERAL VIEW CERVICAL SPINE
- F: FACET JOINT
- SP: SPINOUS PROCESS
- H: HYOID BONE
- Ph: PHARYNX
- Tr: TRACHEA
- PREDENTAL SPACE
- RETROPHARYNGEAL SPACE
- RETROTRACHEAL SPACE
- POSTERIOR CERVICAL LINE FROM C1 TO C3
NORMAL RADIOLOGICAL FINDING IN C-SPINE

- **ANTEROPOSTERIOR VIEW OF CERVICAL SPINE**
  - D: INTERVERTEBRAL DISC
  - U: UNCOVERTEBRAL JOINT
  - T: TRANSVERSE PROCESS
  - SP: SPINOUS PROCESS
OPEN MOUTH VIEW

Activate Windows
Go to Settings to activate View

Normal alignment
A
B

Normal alignment
To show pathology involving C1 and C2 (dens).

Patient supine (AP) or erect, chin elevated, the head adjusted so that with the mouth is open, a line from lower margin of upper incisors to the mastoid tips is 90° to couch. Mouth should be wide open during exposure. Grid is not essential for this view.

**Film:** HD 18x24 cm.

**CR:** 90° to film center. A wooden block must be used to hold the mouth open.

**CP:** Center of open mouth.
RADIOGRAPHIC ANATOMY
AP (C1 – C2) Open mouth

(A) Centrally located dens.
(B) Left transverse process of C1.
(C) Left lateral mass of C1.
(D) Inferior articular surface of C1.
(E) Left zygoapophyseal joint.
(F) Body of C2.
(G) Rt. superior articular surface of C2.
To show pathology of the mid and lower cervical spine

Patient supine (AP) or erect, a line from the Occlusal plane to the mastoid tips must be 90° to the couch.

**Film:** HD 24x30 cm.

**CR:** 15°- 20° cephalad.

**CP:** (C4) Level of the thyroid cartilage
(A)  First thoracic vertebra.
(B)  First rib.
(C)  C4
(D)  Lateral mass region of C3.
(E)  Spinous process of C3.
For pathology involving vertebral bodies, the Intervertebral spaces, Spinous processes, and zygoapophyseal joints.

Patient in erect lateral (stand or sit), shoulder depressed (with equal weights), forward, and against vertical film, cassette top margin 5 cm above EAM.

**Film:** HD 24x30 cm.

**CR:** 90° to film center, FFD 150 cm.

**CP:** Level of thyroid cartilage to pass through C4
(A) Odontoid process (dens).
(B) Posterior arch of atlas of C1.
(C) Body of C3.
(D) Zygoapophyseal joint between C4 and C5 (best shown on laterals).
(E) Body of C7.
(F) Spinous process of T7 (vertebral prominence).
PAO or APO Cervical spine

- Intervertebral foramina and pedicles.
- PAOs are preferred because of reduced thyroid doses.
- Patient erect, arms at sides, body and head rotated 45°, chin extended.

**Film:** HD 18x24 cm.

**CR:** PAO 15°- 20° caudally.
    APO 15°- 20° Cephalic.

**CP:** Level thyroid cartilage to pass through C4.

Note:
- **PAO** demonstrate Intervertebral foramina and Pedicles closest to IR
- **APO** demonstrate Intervertebral foramina and Pedicles farthest to IR
To show pathology in cervical spine (#s and Subluxation).

- Patient in supine on a stretcher or on couch.
- **Film**: HD 24x30 cm.
- **CR**: Horizontally 90° to film center
- **CP**: 2.5 cm above level of upper margin of thyroid cartilage, to pass through C4.
For cervical and thoracic vertebral bodies, Intervertebral disc spaces, zygoapophyseal joints of C4 – T3.

Patient erect (or sitting), patient’s arm and shoulder close to film raised up, elbow flexed, forearm resting on the head, other arm and shoulder by the side and slightly anterior.

Film: HD 24x30.

CR: Horizontally 90° to film center.

CP: 2.5 cm above the jugular notch (opposite T1)
Functional study (motion/ lack of motion) of the cervical vertebrae.

Patient sits or stands in the erect lateral, shoulders depressed (weights may be used), neck hyperflexed (chin touches the chest) or hyper extended (head leaned back), as required.

Film: HD 24x30 cm.

CR: Horizontally 90° to film (FFD: 180 cm

CP: Level thyroid cartilage to (C4).
HANGMAN FRACTURE: FRACTURE OF PEDICLE OF C2

JAEFFERSON FRACTURE: FRACTURE OF C1 VERTEBRAE WITH NO ALIGNMENT OF LATERAL MASSES
CT of the Cervical Spine, axial reconstruction. Level 1.

Image 1. 1, Intervertebral disc C3-C4. 2, Vertebral body (C3). 3, Uncinate process C4. 4, Transverse process of C4. 5, Lamina. 6, Superior articular process of C4.
CT of the Cervical Spine, sagittal reconstruction. Level 1.

Image 3 1, Anterior arch of l’ atlas (C1). 2, Intervertebral space (disc) C3-C4. 3, Vertebral foramen. 4, Spinous process of C2. 5, Posterior arch of C1. 6, Vertebral body C5.
THORACIC VERTEBRAE

- 12 VERTEBRAE
- NATURAL KYPHOTIC CURVE.
- PEDICLE HEIGHT INCREASES T1 TO T12.
- APEX IS PRESENT AT T7/T8, AT THIS LEVEL DISC HAVE MAJOR ROLE IN INFLUENCING THE CURVE.
- DIFFERENTIATING FEATURE-PRESENCE OF FACET FOR ARTICULATION WITH RIB.
THORACIC VERTEBRAE

- **2 Demi Facet** present near root of pedicle to accommodate the head of corresponding ribs.

- **Small Costal Facet** present on transverse process which articulate with tubercle of the rib.

- From T10-T12 only superior costal facet present, inferior costal facet absent.
Anatomy review (T.SPINE)

Inferior view of thoracic vertebra

Superior view of thoracic vertebra
X-RAYS OF THORACOLUMBAR SPINE

- **DIFFERENT VIEW FOR THORACOLUMBAR SPINE:**
  - ANTEROPOSTERIOR VIEW
  - LATERAL VIEW
  - FUNCTIONAL VIEW (LATERAL FLEXION AND EXTENSION VIEW)
  - OBLIQUE VIEW
  - FERGUSON VIEW: 20° CAUDEPHALIC ANTEROPOSTERIOR
  - ANGLED CAUDAL VIEW: FOR FACET OR LAMINAR PATHOLOGICAL CONDITION
For #s and pathology (compression, Kyphosis, and Subluxation).

Patient supine with head under anode side (the heel-effect), both knees and hips flexed and arms stretched by the side. Exposure at end of arrested expiration to reduce volume of air in thorax for more uniform density of whole dorsal vertebrae.

MSP: 90° to the film, with no rotation

Film: 35x43 cm, lengthwise.

CR: 90° Vertically to the thoracic spine

CP: T7 (3 – 5 cm / 1-2 inch) below the Sternal angle, or (8 – 10 cm /3-4 inches below jugular notch)
(A) First posterior rib.
(B) 10\textsuperscript{th} posterior rib.
(C) Spinous process of T11.
(D) Body of T12.
(E) Intervertebral disc (T8 – T9).
(F) Body of T7.
(G) Body of T1
Lateral thoracic (dorsal) spine

For pathology (compression, Kyphosis, or Subluxation).

Patient in a lateral recumbent, both knees flexed and arms stretched at right angles, waist supported, anode heel-effect should be well observed. Exposure at end of arrested expiration, or during quiet breathing using low mA and long exposure time (3 - 4 s) to diffuse the lung and ribs shadows.

A lead blocker sheet near patient’s back helps stop scatter rays from reaching the film, thus improves image quality. MSP: parallel to IR.

CR: 90° Vertically to the thoracic spine

CP: T7 (3 – 5 cm / 1-2 inch) below the Sternal angle, or (8 – 10 cm /3-4 inches below jugular notch).
(A) Body of T3.
(B) Body of T7.
(C) Intervertebral foramina between T11 - T12
To show Zygoapophyseal joints of the thoracic spine.

- **Patient** in a lateral recumbent or in lateral erect, body rotated 20° from true lateral, arm nearest couch must be down, arm nearest tube must be up and forward. Exposure at end of suspended full expiration.
- **Film:** HD 35x43 cm
- **CR:** 90° V/H to film center.
- **CP:** T7 (3 – 5 cm / 1-2 inch) below the Sternal angle, or (8 – 10 cm /3-4 inches below jugular notch).
RADIOGRAPHIC ANATOMY OF THORACIC SPINE

Additional feature in thoracic spine is articulation of rib with facet present over vertebral body.
Anatomy review (T.SPINE)
SCOLIOSIS

- ABNORMAL CURVATURE OF SPINE WITH LATERAL COMPONENT OF MORE THAN 10°.
- ASSESSED RADIOLOGICALLY WITH SINGLE AP LONG FILM OF THORACIC AND LUMBAR SPINE TAKEN IN PATIENT WITH ERECT POSITION.
- COBBS ANGLE OF 10° OR MORE IS CONSIDERED ABNORMAL.
- ROTATION OF VERTEBRAE WITH 1 PRIMARY AND 2 SECONDARY CURVES.
- FULCRUM BENDING RADIOGRAPH TO DETERMINE FLEXIBILITY OF SCOLIOTIC CURVE.
KYPHOSIS

- Excessive backward convexity of spine.
- Assessed radiologically with single lateral long film of thoracic and lumbar spine taken in patient with erect position.
- Cobb's angle is measure to evaluate severity.
- Hyperextension film to determine flexibility on hyperextension.
CT of the Thoracic Spine: Anatomy.

- Vertebral Body
- Spinal Cord
- Transverse Process
- Spinous Process
- Pedicle
- Lamina
- Costovertebral Articulation
- Apophyseal Joint

Axial and Sagittal views.
1-vertebral body, 2-neural foramen, 3-articular pillar 4-lamina, 5-spinous process.
LUMBAR VERTEBRAE

- 5 VERTEBRAE
- NATURAL LORDOTIC CURVE
- MOST WEIGHT IS CENTERED AND SUSTAIN GREATER STRESS.
- HAVE MAMILLARY PROCESSES WHICH GIVE ATTACHMENT OF THICK LOWER DIVISION OF DEEP PARASPINAL MUSCLES.
- SUPERIOR ARTICULAR SURFACE DIRECTED DORSOMEDIANALLY WHEREAS INFERIOR ARTICULAR SURFACE DIRECT TOWARDS VENTROLATERALLY.
LUMBAR VERTEBRAE

- **BODY** LARGE, FAIRLY FLAT AND BROAD IN SHAPE.

- **PEDICLES** ARE SHORTER, THICKER AND OVAL SHAPED.

- **SPINOUS PROCESS** ARE THICKER AND SQUARE SHAPED.

- **INTERVERTEBRAL FORAMEN** ARE LARGE BUT INCREASED INCIDENCE OF NERVE ROOT COMPRESSION.

- **VERTEXERAL FORAMEN** TRIANGULAR IN SHAPE.
Anatomy review (L.SPINE)

Inferior view of lumbar vertebra

Superior view of lumbar vertebra

- Spinous process
- Lamina
- Transverse process
- Pedicle
- Body (centrum)
- Inferior articular process
- Inferior articular facet
- Vertebral foramen

Superior articular process

Body (centrum)

Activate Windows
Go to Settings to activate View

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Anatomy review (L.SPINE)

Lateral view of lumbar vertebra

- Superior articular process
- Spinous process
- Transverse process
- Inferior articular facet
- Intervertebral foramen
- Invertebral disk
- Superior vertebral notch
- Inferior vertebral notch
- Body
- Pedicle
Patient supine, knees flexed with soles of feet on the couch top, arms at the sides or on the chest, exam can be done in the erect position, a compression band is used which will greatly improve contrast.

Exposure at end of full expiration.

Film: HD 35x43 cm

CR: 90° Vertical to film center.

CP: Large film (14x17 inch): L4 – L5 (level of iliac crest).
Small film (11x14 inch): L3 1-1.5 inch above iliac crest (level of lower costal margins).
**Lateral Lumbar Spine**

- **Patient** in a lateral recumbent, knees flexed, support between knees and ankles, pad under the waist, a piece of lead rubber behind the lumbar region on couch top to improve contrast (by absorbing scatter). Exposure at end of arrested expiration.
- **Film**: 35x43 cm
- **CR**: 90° Vertical to center of film
- **CP**: Large film: L4 – L5 (level of iliac crest). Small film: L3 (level of lower costal margins).

**NB/** Lateral for trauma can be done with patient in (dorsal decubitus), same CP using horizontal beam.
Lateral Lumbar Spine

Intervertebral Disk
Pedicle
Intervertebral Foramen
Inferior Vertebral Notch
Superior Vertebral Notch
Inferior Articular Process
Spinous Process
Vertebral Body (L4)
Iliac Crest
L5 S1 Joint
Sacrum
RADIOGRAPHIC ANATOMY OF LUMBAR SPINE

- LATERAL VIEW OF LUMBAR SPINE
  - B: BODY OF VERTEBRAE
  - D: INTERVERTEBRAL DISC
  - P: PEDICLE
  - F: FACET
  - Fo: INTERVERTEBRAL FORAMEN
  - I: INFERIOR ARTICULAR PROCESS
  - S: SUPERIOR ARTICULAR PROCESS
  - SP: SPINOUS PROCESS
For zygoapophyseal joints.

Patient semi supine (or semi-prone), body then rotated 45°, knee flexed, lower back supported with pads.

CR: 90° to film center

CP: Level of L3 (1-1.5 inch above level of iliac crest).

NB/

Semi-supine: 45° RPO
(for R downside apophyseal joints).

Semi-prone : 45° RAO
(for R upside apophyseal joints).
RADIOGRAPHIC ANATOMY OF LUMBAR SPINE

- ANTEROPOSTERIOR VIEW OF LUMBAR VERTEBRAE
  - I: INFERIOR ARTICULAR PROCESS
  - S: SUPERIOR ARTICULAR PROCESS
  - P: PEDICLE
  - L: LAMINA
  - T: TRANSVERSE PROCESS
  - SP: SPINOUS PROCESS
Anatomy review (L.SPINE)
RADIOGRAPH OF LS SPINE- AP/ LATERAL/ LATERAL FLEXION AND LATERAL EXTENSION VIEW
COMPRESSION FRACTURE OF L1 VERTEBRAE

TRANSVERSE FRACTURE AT L3 VERTEBRAE
SPONDYLOLISTHESIS

- Defect in Pars Interarticularis with displacement of one vertebrae over other (Anterior > Posterior)
- Oblique view of spine is important to show defect in Pars Interarticularis.
- Scottish Dog Head Away from the Body Sign Seen in X-Ray
TUMOR

SCLEROTIC LESION SECONDARY TO PRIMARY TUMOR FROM PROSTATE, BREAST, LUNGS ETC....

LYTIC LESION SECONDARY TO MULTIPLE MYELOMA
Oblique lumbar spine

Zygoanophyseal joints
SACROCOCCYGEAL VERTEBRAE

- Appears triangular
- Consist of 5 fused sacral vertebrae and 4 coccygeal vertebrae.
- Transmit body weight to hip.
- Medial sacral crest: present posteriorly over fused spinous process, articular process and transverse process.
- Sacral promontory: 1st sacral vertebrae with profile ridge.
- Sacral ala: flat broad area where sacrum articulate with ilium and pelvis.
Anatomy review (SACRUM & COCCYX)

- Sacral canal
- Superior articular process & facet
- Sacral tuberosity
- Median sacral crest
- Posterior sacral foramen
- Coccygeal transverse process
- Coccyx

- Posteriors view of the sacrum

- Sacral promontory
- Ala
- Transverse line
- Pelvic foramen
- Coccyx

- Anterior view of the sacrum
For pathology at (L5 – S1) articulation
Patient supine, legs extended, both knees flexed slightly, support arms at sides or on the chest.
Film: 18x24 cm
CR: Cephalic 30° (males), 35° (females).
CP: Level of ASIS to mid line of the body.
Lateral lumbosacral spine (L5 – S1)

For lat L5 – S1 joint space, to show Spondylolisthesis or other pathologies of L4 to L5, or L5 to S1

Patient in a lateral recumbent, the knees flexed, support between knees and the ankles, pad under the waist, rubber sheet behind the lumbar region.

**CR:** 90° Vertical to film center

**CP:** 4 cm below iliac crest and 5 cm posterior to ASIS

**NB/** Close collimation is necessary because of the high amount of secondary radiation in this view.

CT of lumbar Spine, axial reconstruction. Level 1.
Image 1. 1, Vertebral body (L4). 2, Transverse process. 3, Facet joint. 4, Spinous process. 5, Inferior articular process L3. 6, Superior articular process of L4. 7, Intervertebral disc L3-L4.
CT of lumbar Spine, coronal reconstruction. Level 1.

Image 2. 1, Transverse process L1. 2, Lamina. 3, Inferior articular process of L3. 4, Superior articular process of L2.
CT of lumbar Spine, sagittal reconstruction.
Level 1.

For S.I. joints, and L5 –S1 junction.
- Patient supine, legs extended, support under the knees.
- Exposure during arrested expiration.
- CR: 15° cephalic.
- CP: 2 inch superior to symphysis pubis.
  ( midway between symphysis pubis
   And ASIS)
- NB/ For lateral sacrum:
  Patient in true lateral recumbent, CR 90°
  vertically 5 cm anterior to posterior sacral
  surface at level of ASIS.
For pathology of the coccyx.
Urinary bladder should be Emptied before this examination.
Cleaning enema must be done to clean the colon from fecal material.
Patient supine, legs extended, support under the knees.
CR: 10° caudal.
CP: 2 inches superior to Symphysis pubis.
For pathology of the coccyx. (urinary bladder should be emptied before examination + Cleansing enema is used for the colon.

Patient in a lateral recumbent, knees flexed, support under the waist

CR: 90° vertical to film center.

CP: 2 inches distal to level of ASIS, and 2 inches anterior to posterior surface of sacrum and coccyx. (To coccyx which can be palpated the base of the spine
SPINAL MR IMAGING TECHNIQUES:

Sagittal and axial magnetic resonance images should be acquired through the cervical, thoracic, and lumbar segments of the spine, as they are generally considered complementary, and imaging the spine in only one plane may result in misinterpretation. The addition of coronal images may also be useful, especially in patients with scoliosis. Stacked axial images and/or angled images through the discs can be obtained, often useful when the indication for imaging is pain, degenerative change, and/or radiculopathy. Although imaging in the axial plane is a matter of personal preference, using only angled axial images through the discs may be inadequate, as portions of the spinal canal will not be imaged axially. Slice thickness from 3 to 4 mm is generally optimal for imaging of the spine. Axial gradient-echo images through the cervical spine are typically 2 mm thick.
Parasagittal T2: thoracic neural foramen. 1, Foraminal vein; 2, Thoracic paravertebral intercostal vein and artery; 3, Foraminal nerve root; 4, Superior articular process; 5, Inferior articular process; 6, Facet joint; 7, Pars interarticularis; 8, Pedicle; 9, Ligamentum flavum; 10, Erector spinae muscle group; 11, Trapezius muscle.
Axial T2-weighted image, thoracic spine. 1, Costovertebral joint; 2, Head of rib; 3, Ligamentum flavum; 4, Pedicle; 5, Lamina; 6, Transverse process; 7, Spinous process; 8, Costotransverse joint; 9, Tubercle of rib; 10, Hemiazygous vein; 11, Posterior longitudinal ligament.
Sagittal T1-weighted image, lumbar spine. 1, Spinal cord; 2, Conus medullaris; 3, Cauda equina; 4, Subarachnoid space; 5, Posterior epidural fat; 6, Ligamentum flavum; 7, Interspinous ligament; 8, Supraspinous ligament; 9, Basivertebral venous plexus; 10, Epidural venous plexus; 11, Anterior epidural fat; 12, Aorta.
INTERVERTEBRAL JOINT

- Allow proper functioning of vertebral column.
- Consist of:
  - Vertebral end plates
  - Intervertebral disc
  - Apophyseal joint
VERTEBRAL END PALTES

- Intervertebral disc
- End plate
  - Cartilaginous layer
  - Bony layer
- Apophyseal ring

- Consist of hyaline cartilage and fibrocartilage in young.
- In adults consist of fibrocartilage.
- Thickness 0.6-1 MM
- Weakest part of disc
- Function:
  - Nutrition of disc
  - Prevent bulging of nucleus into vertebral body
INTERVERTEBRAL DISC

- COMPOSED OF-
  1. **ANNULUS FIBROSUS** - (TOUGH RING)
    - Consist of concentric laminal layer of type 1 collagen.
    - It contains and limit the expansion of nucleus.
  1. **NUCLEUS PULPOSUS** - (SEMI FLUID GEL)
    - Consist of type 2 collagen arranged in loose mesh semi fluid proteoglycan gel.
    - Makes 40-60%.
    - Able to change shape and transmit pressure in all directions.
    - It provide elasticity and compressibility.
INTERVERTEBRAL DISC

- Cushion like structure.
- Prevent against compressive forces.
- Overall body height decreases by 15-20 mm during the day which is recuperated during the night.
- Nutrition: Disc is avascular after 10 yrs and relies on diffusion of nutrient such as oxygen, glucose and sulfate.

3 Biomechanical Goal-

- Weight distribution from 1 vertebrae to another.
- Flexibility allow flexion, extension, lateral bending and rotation.
- Strength to prevent any injury during movement.
LIGAMENTS

- It is connecting tissue from one bone to another.
- Maintain stability in upright position, protect against tensile force.
- 6 ligaments are there:
  - Anterior longitudinal ligament
  - Posterior longitudinal ligament
  - Supraspinous ligament
  - Interspinous ligament
  - Ligamentum flavum
  - Facet or articular capsule (surrounds zygapophyseal joint, allow movement in sagittal plane)
ANTERIOR LONGITUDINAL LIGAMENT

- Extends from anterior aspect of base of occiput via the atlas down the anterior surface of each vertebrae and disc up to sacrum.
- 20 mm wide
- Prevent anterior separation of each vertebral body when in extension and flexion.
POSTERIOR LONGITUDINAL LIGAMENT

- POSTERIOR TO BODY AND DISC
- EXTENDS FROM POSTERIOR ASPECT OF BASE OF OCCIPUT VIA ODONTOID PEG DOWN UPTO COCCYX.
- BROADER OVER DISC AND NARROWER OVER BODY.
LIGAMENTUM FLAVUM AND INTERSPINOUS LIGAMENT

**LIGAMENTUM FLAVUM:**
- SHORT AND THICK
- PROTECT DISC BY LIMITING MOVEMENT.
- YELLOW LIGAMENT DUE TO DISTINCTIVE COLOUR.
- MOST ELASTIC TISSUE IN BODY

**INTERSPINOUS LIGAMENT:**
- SERIES OF SHORT LIGAMENT THAT CONNECT ADJACENT SPINOUS PROCESS
- IT LACKS CONTINUITY
ligamenta flava
(singular: ligamentum flavum) are paired ligaments which run between adjacent laminae of the vertebral bodies and are present from C2/3 to the sacrum
SUPRASPINOUS LIGAMENT AND INTERTRANSVERSE LIGAMENT

- **SUPRASPINOUS LIGAMENT:**
  - Fibrous cord attaches at tip of each spinous process.
  - It ceases between L4-L5 vertebrae.
  - Below this thoracolumbar fascia takes over role of providing strength and sagittal movement of LS spine.

- **INTERTRANSVERSE LIGAMENT:**
  - It limits lateral flexion of spine.
Radiological anatomy of the brain.
CT brain anatomy

Skull bones and sutures
The brain is located inside the cranial vault, a space formed by bones of the skull and skull base. Everything inside the cranial vault is 'intra-cranial' and everything outside is 'extra-cranial'.

Skull bones
Bones of the skull and skull base - frontal, parietal, occipital, ethmoid, sphenoid and temporal bones - all ossify separately and gradually become united at the skull sutures. The skull has inner and outer tables of cortical bone with central cancellous bone called 'diploe.'
Cranial fossae - CT brain - (bone windows)

Anterior cranial fossa - accommodates the anterior part of the frontal lobes

Middle cranial fossae - accommodate the temporal lobes

Posterior cranial fossa - accommodates the cerebellum and brain stem

Pituitary fossa (PF) - accommodates the pituitary gland
CT Advantages

- Fast
- Available
- (Relatively) inexpensive
- Sensitive for intracranial hemorrhage
CT Limitations

- There is radiation
- Bone artifact obscures visualization, especially posterior fossa and spinal cord
- Not very sensitive to intraparenchymal lesions or brain edema
- Noncontrast CT misses many abnormalities
- Risk of allergic reaction to iodinated contrast media
Brain.
The brain is composed of the cerebrum, cerebellum, and brain stem.
• The cerebrum is the largest part of the brain and is composed of right and left hemispheres. It performs higher functions like interpreting touch, vision and hearing, as well as speech, reasoning, emotions, learning, and fine control of movement.
• The cerebellum is located under the cerebrum. Its function is to coordinate muscle movements, maintain posture, and balance.
• The brainstem includes the midbrain, pons, and medulla. It acts as a relay center connecting the cerebrum and cerebellum to the spinal cord. It performs many automatic functions such as breathing, heart rate, body temperature, wake and sleep cycles, digestion, sneezing, coughing, vomiting, and swallowing. Ten of the twelve cranial nerves originate in the brainstem.
• The surface of the cerebrum has a folded appearance called the cortex. The cortex contains about 70% of the 100 billion nerve cells. The nerve cell bodies color the cortex grey-brown giving it its name – gray matter. Beneath the cortex are long connecting fibers between neurons, called axons, which make up the white matter.
Meninges

The brain and spinal cord are covered and protected by three layers of tissue called meninges. From the outermost layer inward they are: the dura mater, arachnoid mater, and pia mater.

**The dura mater** is a strong, thick membrane that closely lines the inside of the skull; its two layers, the periosteal and meningeal dura, are fused and separate only to form venous sinuses. The dura creates little folds or compartments. There are two special dural folds, the falx and the tentorium. The falx separates the right and left hemispheres of the brain and the tentorium separates the cerebrum from the cerebellum.

**The arachnoid mater** is a thin, web-like membrane that covers the entire brain. The arachnoid is made of elastic tissue. The space between the dura and arachnoid membranes is called the subdural space.

**The pia mater** hugs the surface of the brain following its folds and grooves. The pia mater has many blood vessels that reach deep into the brain. The space between the arachnoid and pia is called the subarachnoid space. It is here where the cerebrospinal fluid bathes and cushions the brain.
Meninges

The meninges are thin layers of tissue found between the brain and the inner table of the skull. The meninges comprise the dura mater, the arachnoid, and the pia mater. The dura mater and arachnoid are an anatomical unit, only separated by pathological processes. The falx cerebri and the tentorium cerebelli are thick infoldings of the meninges which are visible on CT imaging. Elsewhere the meningeal layers are not visible on CT as they are closely applied to the inner table of the skull.
The meninges

Is the fibrous membrane covered the brain and the spinal cord, which Protect the central nervous system (CNS).

Are three layers of tissue:
1. **Dura mater** (outer layer)
2. **Arachnoid** (middle layer)
3. **Pia mater** (inner layer)
The meninges - CT brain

The meninges
- **Dura mater** = tough outermost layer, closely applied to the inner table of the skull
- **Arachnoid** = thin layer closely applied to the dura mater
- **Subarachnoid space** = space between the arachnoid mater and the pia mater which contains delicate trabeculated connective tissue and CSF
- **Pia mater** = very thin layer applied to the surface of the brain

The meninges - clinical significance
- Knowledge of anatomy of the meninges is essential for understanding the CT appearances of intracranial bleeding
Tentorium cerebelli

The tentorium cerebelli - an infolding of the dura mater - forms a tent-like sheet which separates the cerebrum (brain) from the cerebellum. The tentorium is anchored by the petrous bones.
Tentorium cerebelli

On axial slice CT images of the brain the tentorium is faintly visible passing over the cerebellum.

Tentorium cerebelli - clinical significance

In the context of subarachnoid hemorrhage or subdural hematoma the tent may become more dense due to layering of blood.
Falx cerebri

The falx is an infolding of the meninges which lies in the midline and separates the left and right cerebral hemispheres.

Falx cerebri - clinical significance

Pathological processes may cause 'mass effect' with deviation of the falx towards one side.
Falx and tentorium
Coronal slice CT images show that the tentorium cerebelli is continuous with the falx cerebri.

Falx and tentorium - clinical significance
Meningiomas are benign intracranial tumours which may arise from any part of the meninges, including the falx or tentorium.
The brain

is the main part of C.N.S found in the cranial cavity, is divided into:

1. Cerebrum.
2. Brain stem
3. Cerebellum.
1. cerebrum
The cerebrum divided into lobes:

- **Frontal lobe** - speech, motor center
- **Parietal lobe** – sensation (temperature, taste and touch).
- **Temporal lobe** - hearing and smell.
- **Occipital lobe** - vision
The anatomic origin of the foot fetish. K. Clark
Brain parenchyma and lobes

The brain consists of grey and white matter structures which are differentiated on CT by differences in density. **White matter** has a high content of myelinated axons. **Grey matter** contains relatively few axons and a higher number of cell bodies. As myelin is a fatty substance it is of relatively low density compared to the cellular grey matter. White matter, therefore, appears blacker than grey matter.

**Key points**

Grey matter appears grey
White matter appears blacker
Sulci and gyri

Gyrus = a fold of the brain surface (plural = gyri)
Sulcus = furrow between the gyri which contains CSF (plural = sulci)
Grey matter v white matter

White matter is located centrally and appears blacker than grey matter due to its relatively low density.

Clinical significance

Pathological processes may increase or decrease the differentiation in density between grey and white matter.
Lobes of the brain

The cerebral hemispheres have distinct fissures, which divide the brain into lobes. Each hemisphere has 4 lobes: frontal, temporal, parietal, and occipital. Each lobe may be divided, once again, into areas that serve very specific functions. It's important to understand that each lobe of the brain does not function alone. There are very complex relationships between the lobes of the brain and between the right and left hemispheres.

**Frontal lobe**
- Personality, behavior, emotions
- Judgment, planning, problem solving
- Speech: speaking and writing (Broca’s area)
- Body movement (motor strip)
- Intelligence, concentration, self awareness

**Parietal lobe**
- Interprets language, words
- Sense of touch, pain, temperature (sensory strip)
- Interprets signals from vision, hearing, motor, sensory and memory
- Spatial and visual perception

**Occipital lobe**
- Interprets vision (color, light, movement)

**Temporal lobe**
- Understanding language (Wernicke’s area)
- Memory
- Hearing
- Sequencing and organization
Brain lobes

The brain has paired, bilateral anatomical areas or 'lobes'. These do not exactly correlate with the overlying bones of the same names.

Brain lobes - CT brain (superior slice)
On both sides the frontal lobes are separated from the parietal lobes by the central sulcus (arrowheads)
Note: The frontal lobes are large and the parietal and occipital lobes are relatively small
Brain lobes - CT brain (inferior slice)

The most anterior parts of the frontal lobes occupy the anterior cranial fossae.
The temporal lobes occupy the middle cranial fossae.
The cerebellum and brain stem occupy the posterior fossa.
White matter structures
White matter of the brain lies deep to the cortical grey matter.
The internal capsules are white matter tracts which connect with the corona radiata and white matter of the cerebral hemispheres superiorly, and with the brain stem inferiorly.
The corpus callosum is a white matter tract located in the midline. It arches over the lateral ventricles and connects white matter of the left and right cerebral hemispheres.

Key points
The internal capsules and corpus callosum are clinically important white matter tracts.
Cerebral White Matter

• Types of tracts
  1. Commissures – composed of commissural fibers
     • Allows communication between cerebral hemispheres
     • Corpus callosum – the largest commissure
  2. Association fibers
     • Connect different parts of the same hemisphere
  3. Projection fibers – run vertically
     • Descend from the cerebral cortex
     • Ascend to the cortex from lower regions
Corpus callosum - CT brain - sagittal image

Sagittal CT images show the corpus callosum as a midline structure arching from anterior to posterior.
Cerebral vascular territories

Different areas of the brain are supplied by the anterior, middle and posterior cerebral arteries in a predictable distribution. The posterior fossa structures are supplied by the vertebrobasilar arteries. The arteries of the brain are not well visualized on conventional CT, but a knowledge of the areas of the brain they supply is helpful in determining the source of a vascular insult.

Key points

The cerebral and vertebrobasilar arteries supply regions of the brain in a predictable distribution.
Vascular territories - (above lateral ventricles)

The anterior cerebral arteries supply a narrow band of the cerebral hemispheres adjacent to the midline.
The middle cerebral artery supplies the largest area of the brain.

ACA = Anterior Cerebral Artery territory
MCA = Middle Cerebral Artery territory
PCA = Posterior Cerebral Artery territory
Deep structures

Hypothalamus - is located in the floor of the third ventricle and is the master control of the autonomic system. It plays a role in controlling behaviors such as hunger, thirst, sleep, and sexual response. It also regulates body temperature, blood pressure, emotions, and secretion of hormones.

Pituitary gland - lies in a small pocket of bone at the skull base called the sella turcica. The pituitary gland is connected to the hypothalamus of the brain by the pituitary stalk. Known as the “master gland,” it controls other endocrine glands in the body. It secretes hormones that control sexual development, promote bone and muscle growth, respond to stress, and fight disease.

Pineal gland - is located behind the third ventricle. It helps regulate the body’s internal clock and circadian rhythms by secreting melatonin. It has some role in sexual development.

Thalamus - serves as a relay station for almost all information that comes and goes to the cortex. It plays a role in pain sensation, attention, alertness and memory.

Basal ganglia - includes the caudate, putamen and globus pallidus. These nuclei work with the cerebellum to coordinate fine motions, such as fingertip movements.

Limbic system - is the center of our emotions, learning, and memory. Included in this system are the cingulate gyri, hypothalamus, amygdala (emotional reactions) and hippocampus (memory).
The Diencephalon

- Forms the center core of the forebrain
- Surrounded by the cerebral hemispheres
- Composed of three paired structures:
  - 1. Thalamus, 2. hypothalamus, and 3. epithalamus
- Border the third ventricle
- Primarily composed of gray matter
Between the cerebrum and brain stem lie the **Thalamus** and **hypothalamus**.

**Thalamus**

The thalamus is superior to the hypothalamus and inferior to the cerebrum. Thalamus – main relay station for sensory impulses (except smell) to the cerebral cortex.

**Hypothalamus**

Sits under the thalamus and above the **pituitary gland**.

- Regulates body temperature.
- Regulates food intake.
- Regulates water balance and thirst.
- Controls sleep-wake cycles.
- Controls endocrine system.
Basal nuclei

- A group of nuclei deep within the cerebral white matter
  - Caudate nucleus – arches over the thalamus
  - Lentiform nucleus – “lens shaped”
  - Amygdala – sits on top of the caudate nucleus
    - *Functionally belongs with the limbic system*
Basal ganglia and thalamus

The basal ganglia and the thalamus are important grey matter structures which are located deep to the insula.

Basal ganglia and thalamus - CT Brain

The thalamus and the basal ganglia are readily identifiable with CT.

Basal ganglia = lentiform nucleus + caudate nucleus

Basal ganglia - clinical significance

Insults to the basal ganglia may result in disorders of movement.

Thalamus - clinical significance

Insults to the thalamus may result in thalamic pain syndrome.
Basal nuclei

• Cooperate with the cerebral cortex in controlling movements
• Receive input from many cortical areas
• Evidence shows that they:
  • Start, stop, and regulate intensity of voluntary movements
  • In some way estimate the passage of time
Grey matter structures

Important grey matter structures visible on CT images of the brain include the cortex, insula, basal ganglia, and thalamus.

Cortical grey matter
The grey matter of the cerebral cortex is formed in folds called gyri. Note that the cortex appears whiter (denser) than the underlying white matter.
**Insula**

The insula forms an inner surface of the cerebral cortex found deep to the Sylvian fissure.

**Insula - clinical significance**

Loss of definition of the insular cortex may be an early sign of an acute infarct involving the middle cerebral artery territory.
Internal capsules

- The **internal capsules** are narrow white matter tracts which contain a high number of axons connecting the corona radiata and cerebral hemisphere white matter superiorly to the brain stem inferiorly.

- Each internal capsule has an **anterior limb** and a **posterior limb** connected at the 'genu' ([asterisks](#)).

Internal capsule - clinical significance

- The internal capsules are supplied by perforating branches of the middle cerebral artery.

- As these vessels are small, they are susceptible to lacunar infarcts.

- Even a small insult to the internal capsule can have a profound effect on motor and sensory function.
Ventricles and cerebrospinal fluid

The brain has hollow fluid-filled cavities called ventricles. Inside the ventricles is a ribbon-like structure called the choroid plexus that makes clear colorless cerebrospinal fluid (CSF). CSF flows within and around the brain and spinal cord to help cushion it from injury. This circulating fluid is constantly being absorbed and replenished.

There are two ventricles deep within the cerebral hemispheres called the lateral ventricles. They both connect with the third ventricle through a separate opening called the foramen of Monro. The third ventricle connects with the fourth ventricle through a long narrow tube called the aqueduct of Sylvius. From the fourth ventricle, CSF flows into the subarachnoid space where it bathes and cushions the brain. CSF is recycled (or absorbed) by special structures in the superior sagittal sinus called arachnoid villi. A balance is maintained between the amount of CSF that is absorbed and the amount that is produced. A disruption or blockage in the system can cause a build up of CSF, which can cause enlargement of the ventricles (hydrocephalus) or cause a collection of fluid in the spinal cord (syringomyelia).
Cerebrospinal Fluid

• A clear, colorless liquid that circulates in the 1. ventricles and 2. subarachnoid space.
• Bathes the exposed surfaces of the central nervous system and completely surrounds it.
• Performs several important functions.
  • protection
  • environmental stability
• Formed by the choroid plexus in each ventricle.
• Produced by secretion of a fluid from the ependymal cells
• originate from the blood plasma.
• Is similar to blood plasma.
Ventricles of the Brain

• **lateral ventricles** - (2) in each hemisphere
• **third ventricle** - in slit between thalamic halves
• **fourth ventricle** - between brain stem and cerebellum

  Foramen of Monro – channel between lateral -> 3rd
cerebral aqueduct – channel between 3rd -> 4th
median & lateral apertures - 4th -> other spaces
Ventricles of the Brain

(a) Anterior view

(b) Left lateral view
Third ventricle

The third ventricle is located centrally. The lateral ventricles communicate with the third ventricle via small holes (foramina of Monro).
CSF spaces

The brain is surrounded by cerebrospinal fluid (CSF) within the sulci, fissures and basal cisterns. CSF is also found centrally within the ventricles. The sulci, fissures, basal cisterns and ventricles together form the 'CSF spaces', also known as the 'extra-axial spaces'.

CSF is of lower density than the grey or white matter of the brain, and therefore appears darker on CT images. An appreciation of the normal appearances of the CSF spaces is required to allow assessment of brain volume.

Sulci

The brain surface is formed by folds of the cerebral cortex known as gyri. Between these gyri there are furrows, known as sulci, which contain CSF.
Ventricles
The ventricles are spaces located deep inside the brain which contain CSF.

Lateral ventricles
The paired lateral ventricles are located on either side of the brain. The lateral ventricles contain the choroid plexus which produces CSF.

Note: The choroid plexus is almost always calcified in adults.
Ventricular system
Fourth ventricle

The fourth ventricle is located in the posterior fossa between the brain stem and cerebellum. It communicates with the third ventricle above via a very narrow canal, the aqueduct of Sylvius (not shown).

Basal cisterns

CSF in the basal cisterns surrounds the brain stem structures.
Posterior fossa

The posterior fossa accommodates the cerebellum and brain stem. Superiorly the cerebellum is separated from the cerebral hemispheres by the tentorium cerebelli.
Calcified structures

There are several structures in the brain which are considered normal if calcified. Knowledge of these structures helps avoid confusion, especially when considering if there is intracranial hemorrhage present. The commonly calcified structures include the choroid plexus, the pineal gland, the basal ganglia, and the falx.

Key points

Commonly calcified structures of the brain include the choroid plexus, pineal gland, basal ganglia and falx. Use of CT 'bone windows' is helpful in differentiating calcified structures from acute hemorrhage.
Calcified choroid plexus

In adults the choroid plexus of the lateral ventricles is almost always calcified.
Calcified pineal gland

The pineal gland is located immediately posterior to the third ventricle. It is very commonly partly or fully calcified in adults.
Calcified basal ganglia
Calcification of the basal ganglia is common in elderly patients.
Calcified falx cerebri

The falx is commonly calcified in adults. If viewed on brain windows only, calcification of the falx can be mistaken for acute intracranial blood. Use of CT 'bone windows' show calcification of the falx more clearly.
NORMAL ANATOMY

A = ORBIT, B = SPHENOID SINUS, C = TEMPORAL LOBE, D = EXTERNAL AUDITORY CANAL
E = MASTOID AIR CELLS, F = CEREBELLAR HEMISPHERES
A=Frontal Lobe, B=Frontal Bone (Superior Surface of Orbital Part), C=Dorum Sellae, D=Basil Artery E=Temporal Lobe F=Mastoid Air Cells G=Cerebellar Hemisphere
A = FRONTAL LOBE
D = SUPRASELLAR CISTERN
B = SYLVIAN FISSURE
E = MIDBRAIN
C = TEMPORAL LOBE
F = FOURTH VENTRICLE
G = CEREBellar HEMISPHERE
2- Brain stem

Connects cerebral hemispheres, cerebellum and Spinal cord. The brain stem consist of 3 part:

1. Mid brain
2. pons
3. Medulla oblongata

The brain stem controls the basic functions of:

- breathing
- heart rate
- swallowing
- sweating
- blood pressure
- sleep and balance
Brainstem – The brainstem is the lower extension of the brain, located in front of the cerebellum and connected to the spinal cord. It consists of three structures: the **midbrain**, **pons** and **medulla oblongata**. It serves as a relay station, passing messages back and forth between various parts of the body and the cerebral cortex. Many simple or primitive functions that are essential for survival are located here.

The **midbrain** is an important center for ocular motion while the **pons** is involved with coordinating eye and facial movements, facial sensation, hearing and balance. The **medulla oblongata** controls breathing, blood pressure, heart rhythms and swallowing. Messages from the cortex to the spinal cord and nerves that branch from the spinal cord are sent through the pons and the brainstem. Destruction of these regions of the brain will cause "brain death." Without these key functions, humans cannot survive.

The reticular activating system is found in the midbrain, pons, medulla and part of the thalamus. It controls levels of wakefulness, enables people to pay attention to their environments, and is involved in sleep patterns.

Originating in the **brainstem** are 10 of the 12 cranial nerves that control hearing, eye movement, facial sensations, taste, swallowing and movements of the face, neck, shoulder and tongue muscles. The cranial nerves for smell and vision originate in the cerebrum. Four pairs of cranial nerves originate from the **pons**: nerves 5 through 8.
3- Cerebellum

The cerebellum is situated at the base of the skull, above the brain stem.

Outer cortex made of gray matter and inner region made of white matter.

**Functions:**
- 1. Balance
- 2. Coordination of muscles
Posterior fossa - sagittal plane image

- Imaging software allows visualisation of the structures of the brain in different planes.
- The sagittal plane can be useful to show the anatomy of the brain stem.
- Note: MRI may be required if there is specific concern regarding brainstem pathology.

Brain stem:
- MB = Mid Brain
- MO = Medulla Oblongata
The Peripheral Nervous System

• What are the Twelve Pairs Of Cranial Nerves?
  • *Olfactory* (CN I)
    • Sense of smell
  • *Optic* (CN II)
    • Sense of vision
  • *Oculomotor* (CN III)
    • Eye movement
The Peripheral Nervous System

• What are the Cranial Nerves? (continued)
  • *Trochlear* (CN IV)
    • Eye movement
  • *Trigeminal* (CN V)
    • Eye, jaws sensation/movement
  • *Abducens* (CN VI)
    • Eye movement
  • *Facial* (CN VII)
    • Face, scalp, tongue sensation/movement
  • *Vestibulocochlear* (CN VIII)
    • Hearing, balance
The Peripheral Nervous System

• What are the Cranial Nerves? (continued)
  • Glossopharyngeal (CN IX)
    • Taste, swallowing
  • Vagus (CN X)
    • Autonomic control of viscera
  • Accessory (CN XI)
    • Swallowing, pectoral girdle movement
  • Hypoglossal (CN XII)
    • Tongue movement
• The Cranial Nerves

The Peripheral Nervous System

- Olfactory bulb (termination of olfactory nerve, NI)
- Olfactory tract
- Optic nerve (II)
- Oculomotor nerve (III)
- Pons
- Medulla oblongata
- Cerebellum
- Spinal cord

- Optic chiasm
- Optic tract
- Trochlear nerve (IV)
- Trigeminal nerve (V)
- Abducens nerve (VI)
- Facial nerve (VII)
- Vestibulocochlear nerve (VIII)
- Glossopharyngeal nerve (IX)
- Vagus nerve (X)
- Accessory nerve (XI)
- Hypoglossal nerve (XII)

Figure 8-25(a)
The Peripheral Nervous System

- The Cranial Nerves

Figure 8-25(b)
CHEST X-RAY
Indication for a chest X-Ray.

1- Evaluation of chest symptoms (cough, chest pain, shortness of breath, hemoptysis, fever, unexplained weight loss.

2- Evaluation of physical sign (e.g. hypoxemia, abnormal pulmonary examination.

3- Evaluation of nasogastric, endotracheal tubes and central venous lines.

4- Screening for pneumothorax after lung biopsy, central line and pacemaker placement.

5- Evaluation of pacemaker lead fracture

6- Pre-employment and physical examination.
Contents:

- Techniques
- Densities
- Orientation
- Rotation
- Penetration
- Anatomy
- CXR Interpretation
- Common Pathologies
Introduction

Chest X-Ray is one of the most frequently requested hospital investigations. It is readily available and inexpensive in comparison to other imaging studies.

The basic interpretation is of utmost importance in answering several clinical questions at hand. It is an important tool to complement both history and initial clinical examination.
• Most of the chest x-rays you will see will be normal
• In order to recognise abnormality, you need to know what a normal CXR looks like
Systematic Approach

- Name/marker/rotation/ penetration
- Lines/metal work
- Heart
- Mediastinum
- Lungs
  - Zones (upper/middle/lower)
- Bones
- Diaphragm
- Soft Tissues
Systematic Approach

- Clavicles equidistant from spinous processes of thoracic spine
- Can just see lower thoracic spine
Systematic Approach

- Lines/metal work

Look for:

- Sternal wires (implies previous thoracic surgery)
- Tip of endotracheal tube (2cm above carina)
Systematic Approach

- Lines/metal work

Tip of central venous lines at origin of superior vena cava. See tubes and lines presentation.
Systematic Approach

- Heart

- Occupies up to 50% of the maximum internal thoracic diameter on a standard PA erect view
- Cannot comment on heart size on AP view because of magnification of heart
Systematic Approach

- Mediastinum
- Hilar vascular structures should be crisply defined
- No widening of mediastinum
- Trachea should be central
Systematic Approach

- Lungs
  - Compare upper, mid and lower zones
  - Look between ribs for lung detail
  - Remember to look “behind” the heart

upper zone
middle zone
lower zone
Systematic Approach

- Bones
  - Look at each rib in turn
  - Clavicles
  - Scapulae and humeri if visible
  - Lower cervical and thoracic spine
Systematic Approach

• Diaphragm

• Both diaphragms should form a sharp margin with the lateral chest wall
• Both diaphragm contours should be clearly visible medially to the spine

Position of stomach gas bubble (not present on this CXR)
Systematic Approach

- Soft Tissues

- Supraclavicular fossae (enlarged nodes)
- Lateral chest wall (surgical emphysema)
- Under diaphragm (pneumoperitoneum)
How would you summarise this?
“This is an erect chest X-Ray of an adult male. The heart is not enlarged, the mediastinal contours are normal and the lungs are clear”
Take Home Points

• Be systematic
• Review with history and physical examination in mind
A. Patient details
  - Name of the patient
  - Age
  - Date
B. Quality

• Image quality influences interpretation

• Quality is influenced by radiographic technique and patient factors.

• First determine if the clinical question can be answered.

• Check the image for – Projection, rotation, inspiration, penetration and artefacts.
1. Projection

- Look to see if the film is antero-posterior (AP) or postero-anterior (PA) view
- With an AP view the X-ray beam is in front the patient and the X-Ray placed at the back, and the other way round for PA.
- The standard CXR is PA but many emergency CXRs are AP.
- The CXR projection has an important bearing on the interpretation of the structures.
**Projection**

**Posterior-Anterior (PA) projection**

The standard chest radiograph is acquired with the patient standing up, and with the X-ray beam passing through the patient from Posterior to Anterior (PA).

The chest X-ray image produced is viewed as if looking at the patient from the front, face-to-face. The heart is on the right side of the image as you look at it.

**Key points**
- Posterior-Anterior (PA) is the standard projection
- PA projection is not always possible
- Both PA and AP views are viewed as if looking at the patient from the front
- PA views are of higher quality and more accurately assess heart size than AP images
- If an AP projection is performed, ask yourself if the clinical question can still be answered

**PA projection**

X-rays pass from the posterior to the anterior of the patient - hence Posterior-Anterior (PA) projection. The image is viewed as if looking at the patient face-to-face.
Techniques - Projection

• P-A (relation of x-ray beam to patient)

Distance 180 cm.
Anterior-Posterior (AP) projection

Sometimes it is not possible for radiographers to acquire a PA chest X-ray. This is usually because the patient is too unwell to stand.

The chest X-ray image is still viewed as if looking at the patient face-to-face.

AP projection

X-rays pass from the anterior to the posterior of the patient - hence Anterior-Posterior (AP) projection. The image is still viewed as if looking at the patient face-to-face.
Techniques - Projection (continued)

• A-P Supine/Erect

Distance 90 cm.
Techniques - Projection (continued)

• Lateral
Techniques - Projection (continued)

• Lateral Decubitus
2. Orientation

- Identify the left/right markings
- Identify the anatomical structures, erect/supine.
- Do not always assume that the heart will always be on the left because certain pathologies can result with mediastinal shift, dextrocardia can also be a possibility.
- You do not have to solely rely on just the CXR markings.
Orientation

Check the left/right markings. Do not assume that the heart is always on the left. Dextrocardia is a possibility but more commonly the mediastinum can be pushed or pulled to the right by lung pathology. Radiographers always safeguard against this by marking the film left and right. Always check these markings when you first look at the film but remember the radiographer can sometimes make mistakes — if there is any doubt re-examine the patient.
3. Rotation

- Identify the medial ends of the clavicles and select one of the thoracic vertebra spinous processes that falls between them.
- The medial ends of the clavicles should be equidistant from the spinous process, if that’s not the case then the X-Ray is rotated.
A well-centred X-ray. Medial ends of clavicles are equidistant from the spinous process.
Chest X-ray quality - Rotation

Rotation:

- The spinous processes should lie half way between the medial ends of the clavicles.

- Rotation affects heart size & shape, aortic tortuosity, tracheal position and density of lung fields.

- Rotation can obscure a pneumothorax. Can also mimic a mediastinal shift.

- Rotation may cause an increase in the transradiancy (blackness) of the lung on the side to which the patient is rotated.

- Rotation will also alter the relative appearance on the hila and can mimic hilar asymmetry.
Well centred PA chest X-ray

- Find the medial ends of the clavicles
- Find the vertebral spinous processes
- The spinous processes should lie half way between the medial ends of the clavicles
4. Inspiration (Degree of inspiration)
- To judge the degree of inspiration, count the number of ribs above the diaphragm.
- The midpoint of the right hemi-diaphragm should be between the 5\textsuperscript{th} and 7\textsuperscript{th} ribs anteriorly.
- The anterior end of the 6\textsuperscript{th} rib should be above the diaphragm as should the posterior end of the 10\textsuperscript{th} rib.
- If more ribs are visible the patient is hyperinflated
- If fewer it indicates inadequate inspiration
- Poor inspiration will make the heart look larger, give appearance of basal shadowing and cause the trachea to appear deviated to the right
• If six complete anterior or ten posterior ribs are visible then the patient has taken an adequate inspiratory effort.
• Conversely, fewer than six anterior ribs implies a poor inspiratory effort and more than six anterior ribs implies hyper-expanded lungs.
Ribs

The ribs play a role in assessing the adequacy of inspiration taken by the patient. The anterior end of approximately 5-7 ribs should be visible above the diaphragm in the mid-clavicular line. Less than this indicates an incomplete breath in, and more than 7 ribs or flattening of the diaphragm, suggests lung hyper-expansion. On this normal x-ray the anterior end of the 7th rib (*) intersects the diaphragm at the mid-clavicular line.

This chest x-ray also demonstrates the subcostal grooves (red) on the underside of the ribs. These grooves contain the neurovascular bundles that accompany each rib. To avoid damaging the nerves or vessels, the superior edge of a rib is used as the landmark for needle insertion during procedures such as chest drain insertion or lung biopsy.

Also note the spine can be seen through the heart, indicating adequate x-ray penetration.
Expiration
(Same patient as next image)
Anteriorly only the third rib intersects the diaphragm at the mid-clavicular line
The lung bases are white - Is there consolidation?
How big is the heart?
Inspiration

- (Same patient as previous image)
- Anteriorly the sixth rib intersects the diaphragm at the midclavicular line
- The lungs are not consolidated
- The heart size is clearly normal
5. Penetration

- To check the penetration, look at the lower part of the cardiac shadow.
- The vertebral bodies should be barely visible through the cardiac shadow at this point.
- If they are clearly visible then the film is over penetrated and you may miss low density lesion.
- If you cannot see them at all then the film is under penetrated and the lung fields will appear falsely opaque (white).
- The left hemidiaphragm should be visible to the edge of the spine.
- When comparing X-Rays first determine if the level of penetration is similar.
On a high quality radiograph, the vertebral bodies should just be visible through the heart.
Penetration: Is the image over or under exposed? Under means the image is too white (the radiation is not getting through adequately and more of the X-ray is appearing white or similar to bone than it should be), and over exposure is too dark. To tell which you have look for the intervertebral disks.
Under penetration
Hover over image to show findings

Under penetration
- The left hemidiaphragm is not visible to the spine
- Lung tissue behind the heart cannot be assessed
- Re-windowing the image using digital software can compensate

Re-windowing (hover over image)
- The diaphragm (long arrows) is visible to the spine.
- The left paravertebral soft tissues are visible (short arrows), and the right side of the spine is clear (arrowheads).
- There is no abnormality of lung tissue behind the heart.

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CHEST X-RAY ANATOMY

Normal chest x-ray

Hover over image

Chest x-ray anatomy
- How many anatomical structures can you see on this x-ray?
- Can you think of any important structures in the chest that are difficult to see on the x-ray?

Visible structures
- 1 - Trachea
- 2 - Hila
- 3 - Lungs
- 4 - Diaphragm
- 5 - Heart
- 6 - Aortic knuckle
- 7 - Ribs
- 8 - Scapulae
- 9 - Breasts
- 10 - Stomach

Important obscured/invisible structures
- Sternum
- Oesophagus
- Spine
- Pleura
- Fissures
- Aorta
Anatomy

- Aortic arch
- Pulmonary trunk
- Left atrial appendage
- Cardiac apex (LV)
- SVC
- RA
- RV
- LV
Five Radiographic Opacities

<table>
<thead>
<tr>
<th>Air</th>
<th>Fat</th>
<th>Soft tissue</th>
<th>Bone</th>
<th>Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>least opaque</td>
<td>to</td>
<td>most opaque</td>
<td>least lucent</td>
<td>White</td>
</tr>
<tr>
<td>Black</td>
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</tbody>
</table>
The main regions where a chest X-ray may identify problems may be summarized as **ABCDEF** by their first letters:

- **Airways**, including hilar adenopathy or enlargement
- **Bones**, e.g. rib fractures and lytic bone lesions
- **Cardiac silhouette**, detecting cardiac enlargement
- **Costophrenic angles**, including pleural effusions
- **Diaphragm**, e.g. evidence of free air, indicative of perforation of an abdominal viscus
- **Edges**, e.g. apices for fibrosis, pneumothorax, pleural thickening or plaques
- **Extrathoracic tissues**
- **Fields** (lung parenchyma), being evidence of alveolar filling
- **Failure**, e.g. alveolar air space disease with prominent vascularity with or without pleural effusions
Identify the lesion → localise the lesion → describe the lesion → give DD

Never stop looking, carry on with your systematic approach!!
CR Interpretation:

Lung abnormalities:
- Abnormal whiteness (increased density)
  1. Consolidation
  2. Atelectasis
- Nodule or mass
- Interstitial
- Abnormal blackness (decreased density):
  1. Cavitary lesion
  2. Cyst
  3. Emphysema
1. **TRACHEA**
   - It should be central or slightly deviated to the right.
   - In case of deviation decide if it is due to rotation or pathology.
   - View the carina, angle should be between 60 – 100 degrees.
   - Because it contains air, it appears darker (blacker/radiolucent).
   - Trachea normally narrows at the vocal cords (T3/T4)
2. HILAR STRUCTURES

- Also called lung root, consists of the major bronchi and pulmonary vessels (veins/arteries).
- The hila are not symmetrical but consist of the same basic structures.
- The lymph nodes are also present but no visible unless abnormal.
Normal hilar position

The hilar points
By convention the hilar points are the angle formed by the descending upper lobe veins, as they cross behind the lower lobe arteries. Not every normal patient has a very clear hilar point on both sides, but if they are present then they can be useful in determining the position of the hila.
3. LUNGS

- The lungs occupy the largest portion of the thoracic cavity.
- The lungs are assessed and described by dividing them into upper, middle and lower zones.
- The lung zones do not equate to lung lobes e.g. The lower zone on the right consists of middle and lower lobes.
- Compare left with right.
- Compare an area of abnormality with the rest of the lung on the same side.
- If there is any asymmetry decide which side is abnormal.
4. PLEURA AND PLEURAL SPACES

• The pleura are only visible when there is an abnormality present.
• This can be due to pleural thickening and fluid or air accumulating in the pleural spaces.
• Lung markings should reach the thoracic wall.
Normal invisible pleura

- Trace round the entire edge of the lung where pleural abnormalities are more readily seen
- Start and end at the hila
- Is there pleural thickening?
- Is there a pneumothorax? The lung markings should be visible to the chest wall
- Is there an effusion? The costophrenic angles and hemidiaphragms should be well defined
5. COSTOPHRENIC ANGLE AND RECESS

- The costophrenic recesses are formed by hemidiaphragms and chest wall.
- They contain the rim of the lung bases which lie over the dome of each hemidiaphragm.
- These angles are known as the costophrenic angles.
- Costophrenic angles should form acute angles that are sharp to the point.
Costophrenic angles

On a PA view, the costophrenic recesses are seen on each side as the costophrenic angles. The costophrenic angles consist of the lateral chest wall and the dome of each hemidiaphragm.
6. HEMIDIAPHRAGM

**Hemidiaphragms**

Here you can see the right hemidiaphragm lying slightly higher than the left. The liver is located immediately inferior to the diaphragm on the right.

The stomach bubble can be seen below the left hemidiaphragm, and through this, normal lung is seen. If you look closely you can see lung markings below the diaphragm on both sides.

Medially the hemidiaphragms form an angle with the heart. These are called the cardiophrenic angles (asterisks), which are often smooth rather than sharp.

On both sides the contour of the hemidiaphragm should be seen passing medially as far as the spine.
Hemidiaphragms
The left and right hemidiaphragms are almost superimposed on a lateral view. Anteriorly the left hemidiaphragm blends with the heart and becomes indistinct.
7. HEART

- The heart lies more to the left of the thoracic cavity.
- The heart is assessed by means of the cardio-thoracic ratio (CTR).
  - CTR = Cardiac width : Thoracic width
  - CTR > 50% is abnormal – PA view only
- The left hemidiaphragm should be visible behind the heart.
- The hemidiaphragms do not represent the lowest point of the lungs.
Normal heart size

Cardiothoracic ratio (CTR)
Cardiac size is measured by dropping parallel lines down both sides of the heart, at the most lateral points on each side, and measuring between them. Thoracic width is measured by dropping parallel lines down the inner aspect of the widest points of the rib cage, and measuring between these. The cardio-thoracic ratio can then be stated.

Here the CTR is approximately $15:33$ (arbitrary units) and is therefore within the normal limit (expressed as a percentage) of 50%.
Normal cardiac contours

Cardiac contours
The left heart contour (red line) consists of the left lateral border of the Left Ventricle (LV). The right heart contour is the right lateral border of the Right Atrium (RA).
8. THE MEDIASTINUM

- The mediastinum contains the heart and great vessels (Middle mediastinum) and potential spaces in front of the heart (anterior mediastinum), behind the heart (Posterior mediastinum) and above the heart (superior mediastinum).

- These potential spaces are not defined on a normal CXR, but their awareness can help in describing location of disease processes.

- There are several structures in the superior mediastinum that should always be checked. These include aortic knuckle, aorto-pulmonary window and the right para-tracheal stripe.
Aortic knuckle
The aortic knuckle (red line) represents the left lateral edge of the aorta as it arches backwards over the left main bronchus, and pulmonary vessels. The contour of the descending thoracic aorta (orange line) can be seen in continuation from the aortic knuckle.
Displacement or loss of definition of these lines can indicate disease, such as aneurysm or adjacent lung consolidation.
Aorto-pulmonary window

The aorto-pulmonary window lies between the arch of the aorta and the pulmonary arteries. This is a potential space in the mediastinum where abnormal enlargement of lymph nodes can be seen on a chest x-ray.

In this chest x-ray, which is entirely normal, the curved arrow points towards the aorto-pulmonary window between the Aortic Knuckle (AK) and the Left Pulmonary Artery (LPA). The descending aorta (DA) marks its posterior boundary. The right lateral edge of the Ascending Aorta (AA) is also marked.
Right para-tracheal stripe

From the level of the clavicles to the azygous vein the right edge of the trachea is seen as a thin white stripe. This appearance is created by air of low density (black) lying either side of the comparatively dense (whiter) tracheal wall. If this stripe is thickened (normally less than 3mm) this may represent pathology such as a paratracheal mass or enlarged lymph node.

The left side of the trachea is not so well defined because of the position of the aortic arch and great vessels.

Azygous vein

Right para-tracheal stripe
9. SOFT TISSUE

- Normal fat planes are clearly defined in the soft tissues.
- They appear as smooth layers of low density (black), between layers of relatively dense (whiter) muscles.
- Irregular low density within soft tissues may be as a result of tracking air as a result of injury to the airways or pleura.
- This is known as surgical emphysema and produces the distinctive clinical sign of palpable subcutaneous ‘bubble wrap’.
**Soft tissue fat**

This close-up demonstrates a normal fat plane between layers of muscle. Fat is less dense than muscle and so appears blacker.

Note that the edge of fat is smooth. Irregular areas of black within the soft tissues may represent air tracking in the subcutaneous layers. This is known as surgical emphysema.
10. BONES

- The most dense tissue visible on CXR.
- Look for fractures, dislocation, subluxation, osteoblastic or osteolytic lesions etc.

**Clavicle, scapula, and humerus**

The clavicle, scapula and humerus are often clearly seen on a chest x-ray. Occasionally you will see evidence of important disease such as metastases in these bones.

**Key**
- 1 - Clavicle
- 2 - Acromioclavicular joint
- 3 - Acromion process of scapula
- 4 - Body of scapula
- 5 - Glenoid fossa of scapula
- 6 - Head of left humerus
- 7 - Gleno-humeral joint
- 8 - Coracoid process of scapula
The CXR is an important tool to complement both history and initial clinical examination.

Low density structures appear dark (black/radiolucent) and high density are whitish (opaque).

Abnormalities need to be described in detail.

Identify the most striking abnormality first. However, once you are done with this, it is vital to check the rest of the image.
Describing abnormalities

'Shadows, opacities, densities'

These opacities can be described as:

- Tissue involved - Lung
- Size - Small (<2cm)
- Side - Bilateral
- Number - Multiple
- Distribution - Widespread
- Position - Mainly middle to lower zones
- Shape - Round
- Edge - Irregular
- Pattern - Nodular
- Density - Soft-tissue

Diagnosis

Description helps with diagnosis. Once you have put all the above terms together, there can only be one diagnosis.

- Metastatic disease
ABNORMAL CXRs

Unilateral black lower zone

- Asymmetrical lower zones
- Left darker than right
- Lung hyperexpansion

Clinical information
- Chronic smoker with increasing shortness of breath

Diagnosis
- Chronic obstructive pulmonary disease with a large left lower zone lung bulla
Pneumothorax

Hover over image to show findings

Air in pleural space - Pneumothorax
- Visible pleural edge (blue line)
- Lung markings not visible beyond this edge
- Distance from lung edge to chest wall >2cm
- Healing rib fracture with callus (arrowhead)

Clinical information
- Fall from height - trauma to chest

Diagnosis
- Large left pneumothorax due to a rib fracture
- The trachea and mediastinal structures are not displaced so there is no 'tension'
Pleural effusions

Hover over image to show findings

Pleural effusions
- The left lower zone is uniformly white
- At the top of this white area there is a concave surface - meniscus sign
- The left heart border, costophrenic angle and hemidiaphragm are obscured
- Slight blunting of the right costophrenic angle indicates a small pleural effusion on that side

Clinical information
- Life long smoker
- Weight loss and increasing shortness of breath

Diagnosis
- Large left pleural effusion
- Underlying bronchogenic carcinoma
Pneumoperitoneum on an erect chest x-ray

Hover over image to show findings

Pneumoperitoneum on an erect chest x-ray

- The lungs are normal
- The diaphragm is crisply defined on both sides (arrowheads)
- Air under the diaphragm (*) is seen as crescents of relatively low density (black)
- Black air can be seen on both sides of the bowel wall (blue line) - this is known as the double-wall sign or Rigler’s sign (usually only seen on abdominal x-rays)

Clinical information

- Acute, severe abdominal pain
- Abdominal guarding on examination
- Risk factors for peptic ulceration included smoking, high alcohol intake, and long term use of non-steroidal anti-inflammatory drugs

Diagnosis

- Pneumoperitoneum - at laparotomy a perforated duodenal ulcer was found
Diaphragmatic rupture

Hover over image to show findings

Diaphragmatic rupture
- The left hemidiaphragm is not visible
- There is bowel in the lower half of the left hemithorax
- The mediastinum is displaced to the right

Clinical information
- History of severe chest trauma

Diagnosis
- Left hemi-diaphragmatic rupture with herniation of bowel into the left-hemithorax
CONCLUSION

Systematic CXR interpretation is important.

The NB! Question is ‘Can the clinical question be answered?’
REFERENCES
