Lecture – Basic Anatomical nomenclature & Anatomy of the chest wall

The anatomical position

- Anterior (ventral)
- Posterior (dorsal)
- Superior (cranial, rostral- beak of spine)
- Inferior (caudal- tail of spine)
- Midline (median) means the mid-sagittal
  - The para-sagittal plane is topography lateral to the midline
- Medial (towards the midline)
- Lateral (away from the midline)
- Proximal (think proximity – towards the beginning)
- Distal (think distance – towards the end)
- Superficial (outside e.g. skin)
- Deep (inside e.g. organs)
- Sagittal
- Frontal (coronal)
- Horizontal (transverse or axial)

The thoracic skeleton and its boundaries

- Thoracic skeleton consists of:
  - 12 thoracic vertebrae
  - 12 pairs of ribs
  - 12 pairs of costal cartilages
  - Sternum

The ribs

- 12 pairs, with the 1st thoracic vertebra associated with the 1st rib
- 1-7 form direct articulations with the sternum via costal cartilage (true)
- Ribs 8-10 reach costal cartilage above, forming indirect articulations (false)
- 11 and 12 lack anterior attachment (floating)
- Articulations (= joints)
  - with vertebral column – heads (inferior to anterior articulations with costal cartilage)
  - with costal cartilages – tubercles
LSS Anatomy of the Thorax

The Sternum

- Consists of:
  - Manubrium
  - Body
  - Xiphoid
- 1st costal cartilage forms articulation with manubrium
- 2nd costal cartilage forms articulation with manubrosternal joint
- 3rd-7th costal cartilage forms articulations with the body of the sternum
  - The 7th rib forms its articulation at the body-xiphoid joint
- 8th-10th ribs form articulations with costal cartilage above
- Ribs 11 and 12 do not form articulations with the sternum, and are known as floating ribs
- The costal cartilage forms articulations with the sternum via articular facets
  - The attachment site for rib 1 is different than the rest, as it is a NON-sinovial joint
  - Superior of the sternum is the articular site for the clavicle, as well as the jugular notch

The thoracic inlet

- Also known as the superior thoracic aperture
- Ring formed of:
  - T1 (first thoracic vertebra)
  - 1st ribs
  - Manubrium

Contents

- Great vessels heading for neck and upper limb
  - Common carotid artery
  - Internal jugular vein
  - Subclavian artery and vein (vein tends to be anterior to artery)
- Esophagus
- Trachea
- Nerves and lymphatic system
- Also apex of the right lung is superior to the clavicle

Muscles expanding chest and lung volume

- The inferior thorax is larger in size to the superior thorax
- Most lung tissue and capacity for lung expansion is in the inferior thorax
- The diaphragm has a flat central tendon with muscle radiating to costal margin and vertebrae. On inhalation:
  - Dome flattens to increase vertical diameter of chest
Costal margin is pulled up to increase transverse (horizontal) and antero-posterior diameters

- The intercostals muscles have a secondary role: they stiffen the chest wall to improve efficiency of breathing movements
- The ribs move in ways to either increase or decrease chest volume. In order to increase chest volume:
  - The sternum moves superior and anterior
  - There is elevation of the lateral shaft of the ribs

The intercostals muscles

There are three layers of muscles:
- **External intercostals** – form inferiorly and laterally from lower border of rib above to rib below (lateral if considering origin to be vertebral column)
  - Replaced by anterior external intercostal membrane at costo-chondral (rib-cartilage) junction
- **Internal intercostals** – attachments begin anteriorly at the sternum - from lower border of rib above to rib below - fibres directed at right angles to external intercostals
  - Replaced by membrane posteriorly
- **Innermost intercostals** – relatively trivial

Intercostals neurovascular branches

- Consist of:
  - Vein – most superior
  - Artery
  - Intercostals nerve – most inferior
- Runs just inferior to each rib, deep to the internal intercostals superficial to the innermost intercostal (i.e. between the internal and innermost)
- There are also collateral branches
- **INTERCOSTAL NERVES**
  - 11 pairs (relating to thoracic vertebrae 1-11)
    - 1 subcostal nerve which relates to T12
  - May be motor and/or sensory
  - Consists of two main branches:
    - Lateral cutaneous branch – which then subdivides into the posterior and anterior branch
    - Anterior cutaneous branch – which then subdivides into the medial and lateral branch
  - Supple the intercostals spaces and muscles
- **VASCULAR COMPONENTS:**
  - Each intercostals artery joins (ANASTOMOSES) with a major artery at each end of the intercostals space
  - Posteriorly the intercostals arteries joins the aorta
  - anteriorly the intercostal arteries join the thoracic artery
The internal thoracic arteries are branches of the subclavian arteries.

The Thoracic cavity

- Filled laterally by the lungs - each lying in its pleural cavity
- Space between the pleural cavities = mediastinum
  - Heart (lying in its pericardial sac)
  - Great vessels
  - Oesophagus
  - Trachea
  - Thymus
  - Thoracic duct and other major lymph trunks
  - Lymph nodes
  - Phrenic and vagus nerves
Living Anatomy - Bones & landmarks of the chest wall

The axial skeleton

- The bones surrounding the CNS – the skull and vertebrae, as well as some related bones in the thoracic region (ribs and sternum)
- The thoracic components:
  - 12 thoracic vertebrae (T1-T12)
  - 12 pairs of ribs
  - Sternum

Thoracic vertebrae

- The vertebral column is a chain of 31 bones all based on the same general plan, with a commonly known arrangement:
  - 7 cervical vertebrae (neck region)
  - 12 thoracic vertebrae (thorax region)
  - 5 lumbar vertebrae (abdominal region)
  - 5 sacral vertebrae (pelvic region – usually fused into a single mass called the sacrum)
  - 4 coccygeal vertebrae (tail – very small and usually fused into 2 pairs)

- General features:
  - Main body
  - Vertebral canal present (for spinal cord) surrounded by vertebral arch
  - The arch joins with the body at the pedicle
  - The arch consists of two flat regions known as lamina which join together at the posterior to form the spinous process
  - There are also two lateral protrusions known as the transverse processes
  - Vertebrae are attached to their neighbours via intervertebral discs, which are fibrous tissue consisting of:
    - Annulus fibrosus
    - Nucleus pulposus

- Specific features:
  - CERVICAL
    - each transverse process has a hole in the middle through which an artery passes through (when lined up these form the vertebral foramenae)
    - the spinous process is small, and may split into 2
    - the first and second cervical vertebrae are named atlas and axis respectively
  - THORACIC
    - Only ribs that form articulations with the ribs on the transverse processes and vertebral body
  - LUMBAR
    - Very large kidney shaped body
    - Very large FLAT spinous process
    - Superior articular fascets face medially
    - Inferior articular fascets face laterally
The ribs

- Consist of a posterior and anterior end; the posterior end forming articulations with the thoracic vertebrae, and the anterior end attached to the sternum via costal cartilage
- The posterior end consists of:
  - Head with a superior and inferior articular facet
  - Neck
  - Tubercle with 1 articular facets
  - Articular facets form synovial joints with the thoracic vertebrae
- The anterior end forms a primary cartillagenous joint with costal cartilage (no movement between rib and cartilage)
  - The costal cartilage then forms a synovial joint with the articular facets on the sternum
- The superior surface of the rib is rounder than the inferior surface
- There is a costal groove on the inferior internal surfaces
- The articular facet on the rib tubercle associates with the articular facet on the transverse process
- The inferior articular facet on the posterior head of the rib associates with the superior demi-facet on the vertebral body
- The superior articular facet on the posterior head of the rib associates with the inferior demi-facet on the vertebral body superior to its associated vertebra
The sternum

- Consists of 3 parts:
  - Manubrium
  - Body
  - Xiphoid
- The mammary joint forms the sternal angle; this is important as it can be palpated
- The jugular notch is a suprasternal notch which can also be palpated
- Ribs are counted from the 2nd costal cartilage downwards

The Upper Limb Girdle

- The clavicle forms an articulation with the sternum anterior to the first rib at the sternoclavicular joint
- The scapula forms an articulation with the upper limb (arm) and the lateral end of the clavicle
  - however it does not form an articulation with the axial skeleton, but rather is attached via muscles

Dissection – The chest wall and intercostal spaces

- Skin incisions made:
  - Midline incision extending from the jugular notch to the xiphoid process
  - Incision along the lower costal margin
  - Incision along the clavicle from the jugular notch to the acromion process, which extends downwards to the middle of the arm
Muscles of the pectoral region

**Pectoralis major**

- On pulling back the skin flaps, the pectoralis major muscle is seen. This is the largest and most superficial of the pectoral region muscles, and covers the anterior aspect of the chest wall.
- It has a broad origin with two heads:
  - The clavicular head which originates from the anterior surfaces of the medial half of the clavicle
  - The sternocostal head which originates from the sternum and its related costal cartilages
- The muscle fibres converge to form a flat tendon, which inserts into the lateral lip of the intertubular sulcus of the humerus
- The origin of the muscle is the fixed point and it is the insertion that moves to allow the muscle to carry out its specific action. The pectoralis major adducts, flexes and medially rotates the arm

**Subclavius and pectoralis minor**

- On turning the pectoralis muscle laterally, the pectoralis minor can be identified. Both the pectoralis muscle and the subclavius underlie the pectoralis major:
  - The subclavius is small and passes laterally from the junction between rib I and the costal cartilage on the inferior surface of the middle third of the clavicle
    - Its function is to pull the clavicle medially to stabilise the sternoclavicular joint
  - The pectoralis minor passes from the anterior surface of the ribs III – V to the coracoids process of the scapula
    - Its function is to depress the tip of the shoulder, protecting the scapula
The intercostals muscles

- Peel back the pectoralis major, and turn the pectoralis minor muscle superiorly. Palpate the ribs to feel the intercostals space between adjacent ribs.
- The intercostals muscles are then arranged in 3 layers:
  - External – run inferiorly and anteriorly from the rib above in an oblique direction
  - Internal - run inferiorly and posteriorly from the rib above in an oblique direction at right angles to the external intercostals
  - Innermost – poorly developed but extend in the same direction as the internal intercostals

Intercostals nerves and vessels

- Using a saw and bone cutters, cut through the manubrium between the 1st and 2nd ribs, then cut ribs 2-6 as far posteriorly as possible on both sides. Cut the body of the sternum just above its inferior end. Cut through the muscles etc with scissors to free and remove a panel of sternum and ribs from the body. Examine the detached panel to identify the internal intercostal muscle and the intercostal nerve and vessels.
- The intercostals neurovascular bundles are protected by the inferior projection of the inferior border of the rib forming the costal groove
  - They run between the internal and innermost intercostals muscles
  - There are also collateral bundles within the intercostals space, therefore when inserting a chest drain or needle into an intercostals space, it is placed in the central to lower part of the space so as to protect the nerves and vessels

Intercostals nerves

- The intercostals nerves are the anterior primary rami of the first 11 thoracic nerves
  - The posterior rami supply the deep back muscles and the skin of the posterior aspect of the thorax
- The nerve then consists of:
  - Lateral cutaneous branch
  - Anterior cutaneous branch
**Intercostals arteries**

- Arteries enter intercostal spaces both anteriorly and posteriorly and run in the eleven intercostal spaces.
- Arteries supplying the posterior part of each space are known as posterior intercostal arteries, the majority of which are direct branches from the descending thoracic aorta.
- The anterior part of each space is supplied by anterior intercostal arteries which are branches of the internal thoracic artery in the upper six intercostal spaces.
- In the seventh to ninth intercostal spaces anteriorly, the internal thoracic arteries have divided into their end branches and it is one of these end branches that give rise to the anterior intercostal arteries in these spaces.
  - There are no anterior intercostal arteries in the last two intercostal spaces.
- **Clinical importance**: Coarctation of the aorta is a congenital malformation in which the aorta is constricted. The constriction normally occurs in the region of origin of the left subclavian artery.
  - In coarctation the intercostal arteries enlarge to facilitate blood flow to the lower part of the body beyond the obstruction. Notching of the ribs is an important radiological sign caused by erosion of the ribs by the dilated intercostal arteries.
Bronchi, lungs, pleura and diaphragm
Anatomy of the Thorax 2 - Dr Paul Strutton (p.strutton@imperial.ac.uk)

Lecture – Organisation of the chest contents

The Bronchial Tree

Branching of the bronchial tree

- **Trachea**
  - Extends from vertebral level C6 to T4/5
  - Held open by C-shaped cartilage rings
  - Lowest ring has a hook; called the CARINA
- **Primary bronchi**
  - Formed at T4/5
  - Right is wider and more vertical than the left
- **Secondary bronchi**
  - Also known as LOBAR bronchi
  - Formed within the lungs
  - Supply the lobes of the lungs
- **Tertiary bronchi**
  - Also known as SEGMENTAL bronchi
Supply the bronchopulmonary segments

- Bronchioles
- Terminal bronchioles

- Plates of cartilage gradually replace the incomplete rings of cartilage in primary bronchi and finally disappear in the distal bronchioles.
- As the amount of cartilage decreases, the amount of smooth muscle increases. Smooth muscle encircles the lumen in spiral bands.

**Segmental (tertiary) bronchi**

- Supply the bronchopulmonary segments
- There are 10 segments in each lung
- Each segment is small, and a functionally independent region

**The lungs**

- Essential organ of respiration
- Situated in the thorax
- Separated from each other by the heart and other contents of the mediastinum
- Each lies freely in its pleural cavity – apart from its attachment to the heart (via PULMONARY VESSELS) and the trachea at the lung root (HILUM)
- From the mediastinum, vessels, nerves and bronchi pass though the lung roots into the lungs
- Apex of each lung is oblique to the thoracic inlet, and rises 3-4cm above the level of the first costal cartilage
- Base of each lung is concave and rests of the convex surface of the diaphragm
- Each lung consists of:
  - 3 borders – anterior, posterior and inferior
  - 3 surfaces – costal, medial (mediastinal), inferior (diaphragmatic)
Mediastinal surface

- Posterior part is in contact with thoracic vertebrae
- Anterior part is deeply concave, and accommodates the heart
  - Cardiac impression is much larger on the left lung than the right because of the position of the heart
  - above and behind the cardiac impression is the HILUM
    - this is where vessels, bronchi and nerves enter and leave the mediastinum

The left lung

- Consists of two lobes separated by OBLIQUE FISSURE
  - Superior
  - Inferior
- Superior lobe includes the apex and most of the anterior part of the lung
- Mediastinal aspect →

The right lung

- Consists of 3 lobes:
  - Superior
  - Middle
  - Inferior
- The OBLIQUE fissure separates the inferior lobe from the other 2 lobes
- The HORIZONTAL fissure separates the superior from the middle lobe
- Slightly larger than the left lung
The hilum of the lung

- Connects the mediastinal surface to the heart and trachea
- Formed by structures that enter or leave the hilum:
  - Principal (primary) bronchus
  - Pulmonary artery – which carries deoxygenated blood from the right ventricle
  - 2 pulmonary veins – which carry oxygenated blood to the left atrium
  - Bronchial arteries (which carry oxygenated blood from the descending aorta) and veins
  - Pulmonary plexus of ANS
  - Lymph vessels and nodes
- All enveloped in pleura
- Diagram shows hilum of left lung →

The Pleura
• A thin layer of flattened cells supported by connective tissue that lines each pleural cavity and covers the exterior of the lungs
• Consists of 2 layers:
  o VISCERAL - covers surface of the lungs, lines fissures between the lobes
  o PARIETAL – lines the inner surface of chest walls
• Pleura are continuous with each other at the hilum

Breathing

• Controlled by nervous system and produced by skeletal muscle
• Brings about inhalation and exhalation of air into/out of the lungs, to ventilate the gas exchange areas - alveolar sacs
• capacity of thoracic cavity can be increased:
  o by movements of the diaphragm
  o by movements of the ribs
• Pleural cavity is expanded by muscles in walls
• Elastic lungs expand with the pleural cavity, sucking air down trachea and bronchi into lungs

The diaphragm

• Main inspiratory muscle
• Contraction of the diaphragm increases the vertical dimension of the thoracic cavity.
• When it contracts, the diaphragm presses on the abdominal viscera which initially descend (because of relaxation of the abdominal wall during inspiration)
• Further descent is stopped by the abdominal viscera, so more diaphragm contraction raises the costal margin
• Increased thoracic capacity produced by diaphragm and rib movements in inspiration, reduces intrapleural pressure, with entry of air through respiratory passages and expansion of the lungs
• The margin of the diaphragm is attached to the:
  o costal margin (lower border of the rib cage)
  o xiphoid process
  o ends of ribs 11 and 12
  o lumbar vertebrae
• The dome of the diaphragm bulges high inside the rib cage.
  o So high abdominal organs such as liver are covered by diaphragm, pleura and lung

Movement of the ribs

• Ribs elevated - anterior ends thrust forward and upwards - increases antero-posterior dimension of thoracic cavity.
• At same time ribs are everted, increasing transverse diameter of thoracic cavity
• Internal and external intercostal muscles stiffen the rib cage to increase efficiency of diaphragm
• Raising the costal margin also raises drooping anterior ends ribs, tilting sternum upwards to increase antero-posterior diameter of pleural cavities

Breathing Out

• Quiet expiration is a passive activity not requiring muscles
• It depends on elastic recoil in the elastic tissue throughout the lungs and in the rib cage
• In deep or forced expiration, this is assisted by the muscles of the abdominal walls that squeeze the abdominal organs against the diaphragm and pull the lower ribs downward
Living Anatomy – Chest wall landmarks and the lungs

Landmarks of the living chest

- The jugular notch - lies above the manubrium
  - Between the medial ends of the clavicles
- Sternal angle – lies at same level as body of T4/2nd costal cartilage
  - Marks the top of the aortic arch, tracheal bifurcation
- 4th intercostal space – usually at same level as male nipple
  - Female nipple lower
- Midlength of clavicle – MIDCLAVICULAR LINE
  - The nipple is lateral to this line
- Lateral end of clavicle – MIDAXILLARY LINE

Posterior chest wall

- C7 – first palpable vertebra
- T2 – superior angle of scapulae
- T3 – medial ends of scapulae
- T7 – level with inferior angles of scapulae
- L4 – run level with Iliac Crusts (top of hip bones on side)
- T12 – half way between T7 and L4

NB: the tips of each vertebral spine lie about one space below their vertebral body

Anterior chest wall

- Costal margin – from 6th costal cartilage
  - Then down RVIII medial to the mid-clavicular line
  - Then down to RX at mid-axillary line
- Floating ribs – inferior to the costal margin
  - RXI and RXII

Parietal Pleural Markings

- **Right side**
  - Just lateral to the medial line, from apex of lung
  - 2cm superior to the medial 3rd of the clavicle
  - Follows costal margin anteriorly to RX, meeting the lateral abdominal at RIX
  - Posteriorly, pleural line runs horizontally just above the costal margin to T12
  - Then follows just lateral to the midline up to T3

- **Left side**
  - Same as right, except at 4th costal cartilage there is a lateral deviation of 4-5cm – CARDIAC NOTCH
  - This deflects the anterior margin of the left pleura lateral to the sternum between the 4th and 7th costal cartilage
Lung Markings

- Anterior surface – runs just laterally of the pleura down to the 6th costal cartilage, but then follows the costal margin 2 ribs superior to the parietal pleural line (i.e. meets the mid-axillary line at RVIII instead of R10)
- Posterior surface – runs horizontally to the vertebral column at the level of RX
- Inferiorly on both sides there is a pleural recess, the COSTODIAPHRAGMATIC RECESS, into which the sharp inferior border of the lung can expand as the diaphragm flattens during inspiration
- On the left there is a similar collapsed pleural recess; the COSTOMEDIASTINAL RECESS, into which the sharp anterior lung border can expand as the chest enlarges and the heart and pericardium move inferiorly during inspiration

Lung Fissures

- Oblique fissure – posterior lung margin just below the spine of T3 → 6th costal cartilage anteriorly
  - Also can draw a line at the medial border of the abducted scapula
- Horizontal fissure – start anteriorly at the 4th costal cartilage running horizontally to the oblique fissure
  - Meets oblique fissure at the mid-axillary line

Percussion

- Tapping the chest wall produces a hollow, drum-like sound over air-filled spaces such as the lung but a dull sound over solid organs (such as the heart) or over liquids.
- Place the fingers of one hand spread out flat against your partner’s chest and tap the middle phalanx of the middle finger with the tip of the bent middle finger of the other hand.
- Explore the chest surface in this way and decide whether the resonant areas defined by percussion coincide with the lung outlines you have already marked. If not, how do they differ and can you explain this?
  - Superior lobe – most resonant
  - Inferior lobe – most dull sounding

Auscultation of the Lungs

- Auscultation is listening to body noises, usually with a stethoscope.
- First listen to the recordings of normal breath sounds. Now listen to your partner’s breath sounds during normal and deep breathing and write a short description of what you hear.
- Normal breathing quietly – known as VESICULAR breathing
  - Sound is quiet and rustling
  - Inspiration is louder than expiration
    - This is heard particularly in inferior lobes
- Near the heart, the heart sounds are heard in addition to breath sounds
- Near the trachea, breathing is louder and higher pitched
  - Expiration and inspiration are of the same volume
**Dissection – study of the bronchi, lungs, pleura and diaphragm**

- The thoracic cavity contains on either side the right and left lungs surrounded by the pleural cavities and the mediastinum lies in between.
- Insert a hand into the pleural space that separates the chest wall from the lung. Explore this space with your fingers. Identify the root of the lung and cut it as cleanly as possible with a scalpel, keeping your fingers well clear. Free the lung carefully from the walls of the pleural cavity, breaking down any adhesions found. Repeat on the other side then examine the pleural cavities and lungs.
- The right lung is usually subdivided into three lobes and the left lung into two.
- The left lung is divided into upper and lower lobes by the oblique fissure.
- The right lung has an oblique fissure and a horizontal fissure, dividing it into upper, middle and lower lobes.
- Each lung has an apex that extends 2 – 3 cm above the clavicle and therefore the apex of the lung extends into the neck.
- Each lung also has a costal, mediastinal and diaphragmatic surface.
  - The latter surface is also referred to as the base of the lung.
- The anterior border of the lung separates the costal from the mediastinal surface whereas the lower border is between the costal and diaphragmatic surface.
- The lung is connected to the mediastinum by the root of the lung. The root of the lung contains the main bronchus branching off from the trachea, one pulmonary artery, two pulmonary veins, bronchial arteries supplying the bronchus and lymph nodes draining the lung.
- The right bronchus is shorter, wider and more vertical than the left and therefore foreign bodies getting into the trachea tend to go more easily into the right bronchus than the left.
- The lung is surrounded by the pleural cavity, the potential space between the two layers of pleura.
- The two layers of pleura become continuous with each other at the root of the lung.
**The Superior Mediastinum**

*Anatomy of the Thorax 3 - Dr Paul Strutton (p.strutton@imperial.ac.uk)*

**Lecture - The superior mediastinum and its great vessels**

**Introduction to the mediastinum**

- Thick midline partition that separates the two pleural cavities of the thorax
- It extends from the sternum anteriorly to the thoracic vertebrae posteriorly, from the superior thoracic aperture (inlet) to the inferior thoracic aperture
- acts as a conduit for structures that pass through the thorax from one body region to another and for structures that connect thoracic organs to other body regions

**Principle contents**

- **trachea** - from larynx to bifurcation into principal (right and left main) bronchi
- **oesophagus** - from pharynx - muscular tube – pierces diaphragm at level of T10
- **heart** and **pericardium**
- **thoracic duct** - lymphatic drainage
- **nerves**
- **great vessels**

**Divisions of the mediastinum**

- A horizontal plane passing through the sterna angle and the intervertebral disc between vertebrae TIV and TV separates the mediastinum into:
  - **Superior**
  - **Inferior**
- The inferior mediastinum is then further subdivided by the pericardial sac into:
  - **Anterior** – lies between the sternum and the pericardium
  - **Middle** – contains the pericardium, heart, origins of the great vessels, various nerves, and smaller vessels
  - **Posterior** – lies between the pericardial sac and the anterior of the vertebrae

**The Superior Mediastinum**

- posterior to the manubrium of the sternum and anterior to the bodies of the first four thoracic vertebra
- its superior boundary is an oblique plane passing from the jugular notch upward and posteriorly to the superior border of vertebra T1
inferiorly, a transverse plane passing from the sterna angle to the intervertebral disc between vertebra
TIV/TV separates it from the inferior mediastinum
laterally, it is bordered by the mediastinal part of the parietal pleura on either side
continuous with the neck superiorly and the inferior mediastinum inferiorly

Contents

- thymus,
- right and left brachiocephalic veins,
- left superior intercostal vein,
- superior vena cava,
- arch of the aorta with its three large branches,
- trachea,
- esophagus,
- phrenic nerves,
- vagus nerves,
- left recurrent laryngeal branch of the left vagus nerve,
- thoracic duct, and
- other small nerves, blood vessels, and lymphatics

The great veins

- **Superior Vena Cava (SVC)**
  - Enters the right atrium from above
  - Formed by the asymmetric union of the right and left brachiocephalic veins
    - Each brachiocephalic vein branches from an internal jugular vein and a subclavian vein
    - The left brachiocephalic vein crosses posterior to the manubrium to join the right brachiocephalic vein to form the SVC
  - The azygos vein drains the posterior wall of the thorax and abdomen, arching over the right lung root into the SVC
- **Inferior Vena Cava (IVC)**
  - Enters the right atrium from below, through a central tendon of the diaphragm
  - The iliac, testicular, hepatic, renal and suprarenal veins all drain into the IVC
Arteries of the Superior Mediastinum

- Ascending aorta
- Arch of aorta
- Descending aorta

Branches of the aorta

- **Ascending aorta**
  - Branches into the right and left coronary arteries – supply the heart muscle

- **Aortic arch**
  - Three branches arise from the superior border of the arch of the aorta; at their origins, all three are crossed anteriorly by the left brachiocephalic vein.
  - The first branch (right) is the brachiocephalic trunk – largest, point of origin behind manubrium, slightly anterior to the other branches. It ascends posteriorly and to the right, and upon reaching the right sternoclavicular joint it branches into:
    - **Right common carotid artery** – supplies the right side of the head
    - **Right subclavian artery** – supplies the right upper limb
  - The second branch is the left common carotid artery - arises from the arch immediately to the left and slightly posterior to the brachiocephalic trunk and ascends through the superior mediastinum along the left side of the trachea.
    - Supplies the left side of the head and neck
  - The third branch is the left subclavian artery - arises from the arch of aorta immediately to the left of, and slightly posterior to, the left common carotid artery and ascends through the superior mediastinum along the left side of the trachea.
    - Supplies the left upper limb

**NB: Relation of the aorta and great arteries to the airway**

- The aortic arch arises anterior to the trachea, arching over the left main bronchus at the lung root
- The trachea lies between the brachiocephalic and left common carotid arteries
Distribution of the common carotids

- Each common carotid artery divides into:
  - **External** – supplies the skin of the head
  - **Internal** – supplies the brain

- These are the main arteries of the head and neck, with additional supply from the vertebral arteries which branch from the subclavian arteries

Pulmonary Circulation

The Pulmonary Trunk

- Outflow of the right ventricle
- Carries deoxygenated blood via left and right pulmonary arteries to the lungs
- **Ligamentum arteriosum** connects the pulmonary trunk to aortic arch. Is remnant of the *ductus arteriosus* – bypasses lungs in foetal life.

Pulmonary veins

- Oxygenated blood flows into the left atrium through 4 pulmonary veins:
  - Right superior
  - Right inferior
  - Left superior
  - Left inferior

Nerves of the Superior Mediastinum

Vagus nerves

The *vagus nerves* pass through the superior and posterior divisions of the mediastinum on their way to the abdominal cavity. As they pass through the thorax, they provide parasympathetic innervation to the thoracic viscera and carry visceral afferents from the thoracic viscera.

- Both sensory and motor function

  - **Right vagus nerve**
    - Enters the superior mediastinum and lies between the right brachiocephalic vein and the brachiocephalic trunk.
    - It descends in a posterior direction toward the trachea, crosses the lateral surface of the trachea and passes posteriorly to the root of the right lung to reach the esophagus. Just before the esophagus, it is crossed by the arch of the azygos vein.
As the right vagus nerve passes through the superior mediastinum, it gives branches to the esophagus, cardiac plexus, and pulmonary plexus. Recurrent laryngeal branch – recurs (turns back) around right subclavian artery

**Left vagus nerve**
- The **left vagus nerve** enters the superior mediastinum posterior to the left brachiocephalic vein and between the left common carotid and left subclavian arteries.
- As it passes into the superior mediastinum, it lies just deep to the mediastinal part of the parietal pleura and crosses the left side of the arch of aorta.
- It continues to descend in a posterior direction and passes posterior to the root of the left lung to reach the esophagus in the posterior mediastinum.
- Cross arch of aorta
- The left vagus nerve also gives rise to the **left recurrent laryngeal nerve**, which arises from it at the inferior margin of the arch of aorta just lateral to the ligamentum arteriosum. The left recurrent laryngeal nerve passes inferior to the arch of aorta before ascending on its medial surface. Entering a groove between the trachea and esophagus, the left recurrent laryngeal nerve continues superiorly to enter the neck and terminate in the larynx.
- Breaks up into many branches round oesophagus

**Phrenic Nerves**
- Formed in the cervical plexus from C3, 4, 5, and descend through the thorax.
- Motor to the diaphragm.
- Sensory to the mediastinal pleura, pericardium and peritoneum of central diaphragm.
- **Right phrenic nerve** reaches diaphragm lying on surface of the right brachiocephalic vein, superior vena cava and the right side of the pericardium (heart) to the front of the right lung root.
- The **left phrenic nerve** leaves the thorax by piercing the diaphragm near the apex of the heart, lying on the surface of the left brachiocephalic vein, left lateral surface of the aortic arch and the left side of the pericardium (heart) to the front of the left lung root.
Living Anatomy – Imaging of the Lung & Mediastinum

Introduction to medical imaging

*Use of medical imaging:* non-invasive exploration of the living body, to investigate:

- Anatomical structures
- Congenital and other abnormalities
- Tumours, Fractures, Changes due to disease and injury

*Imaging of the chest* - used to look at lung fields and the mediastinum:

- **Lung fields** –
  - Diaphragm
  - Diaphragmatic recesses
  - Lung fissures
  - Hilar region
  - Thoracic cage
- ** Mediastinum** –
  - Heart
  - Great vessels
  - Trachea
  - Soft tissues

*Commonly used techniques:*

- Radiography
- Computed axial tomography (CT or CAT)
- Magnetic resonance imaging (MRI)
- Also ultrasonography and nuclear medical imaging (radionuclides)

*Principles:*

- Body tissues selectively limit the passage of radiation through them
- The density of the body tissue determines the density of the image on the film seen
- **RADIOLUCENT** tissues allow full penetration of radiation → black image on film
- **RADIOOPAQUE** tissues do not allow much penetration → white image on film

*Radiography*

- A patient is placed between an X-ray tube/source and a photographic film
- Markers on the film are used to mark the right and left side of the patient
- X-rays are then passed through the patient, exposing the photographic film

*Basic projections of the X rays*

- Postero-anterior (PA) view
- Erect antero-posterior (AP) view
- Supine antero-posterior (AP) view
- Lateral view

*Postero-anterior view of the lungs*

- Routinely used
- The heart is close to the film, with the spine closer to the source
- In the example opposite, the scapula is rotated away from the lung which is why it is not obstructing the view of the lungs
- The clavicles are visible as they cross the lung fields
Antero-posterior view of the lungs

- Mainly used for supine (lying down) patients
- Heart is magnified as it is closer to the X-ray source
- The scapula overlaps the lung fields in the example opposite, and the clavicles are projected above the apex of the lungs

What to look for?

- Lung fields
- Mediastinal shadow
- Cardiac silhouette
- Ribs
- Clavicles
- Vertebrae
- Diaphragm
- Diaphragmatic recesses
- Cardiophrenic angle
- Hilar of lung
- Vessel markings in lung
- Ratio of transverse diameter of heart: thorax – should not exceed 50% (cardiomegaly)

NB: Bronchograms used to use a radio-opaque contrast to coat the interior surface of the airways to improve the detail seen in the image, but this is no longer used

Pneumothorax

- “an accumulation of air in the pleural cavity, between the visceral and parietal pleural linings of the lungs”
- In the example opposite, note the difference between the right and left side
- The right lung has collapsed, and has no vascular markings – this is known as HYPERLUCENT
- The left lung (normal) has vessel markings which obscure the definition of the ribs

Pleural effusion

- “an accumulation of fluid in the pleural cavity, between the visceral and parietal pleural linings of the lungs”
- In the example opposite, there is fluid collection in the cardiophrenic angle and middle fissure of the right lung
- As fluid is more radio-opaque than lung tissue, this has lead to the obliteration of the right costodiaphragmatic recess
**Lung-Hilar Lymphadenopathy**
- Lymph node masses present in the lung fields by the lung hilar (roots)
- Usually due to sarcoid or lymphoma
- Lymph node masses are radio-opaque when compared to rest of the lung tissue (hence → whiter image)

**Lung spread from cervical carcinoma**
- Leads to the spread of malignant masses which are more radio-opaque than normal lung tissue
- In the example opposite, a mass is visible in the right middle lobe and in hilar nodes
- The example is also a female patient, as breast shadows can be seen

**Pulmonary Artery Angiogram**
- Radio opaque material is injected into the pulmonary artery and imaged as it passes through the arterial tree
- Arteries are more vertical than veins
- Pulmonary venous angiogram is used to observe venous tree within lung tissue

**Imaging of the Mediastinum**
- A postero-anterior view is used to evaluate the heart
- If the oesophagus is being evaluated, a barium meal is used to coat the inner surface
- With a barium meal, an impression is seen on the oesophagus by the aortic arch, left bronchus and left atrial impression
Images of the heart – cardiac outlines

- The great vessels are in the superior mediastinum, with the rest of the heart in the middle
- On the right border, both vena cava can be seen, the right atrium, the diaphragm and cardiophrenic angle (which should be acute, obtuse angle indicates enlargement of the right atrium)
- On the left border, the aortic arch, pulmonary artery, left atrial appendage and left ventricle/apex of the heart can be seen

Digital Subtraction angiography can be used to look at the arteries more specifically, they are digitally subtracted so that the image is reversed (with regards to black white scale)

Computerized Tomography

- X-ray tube moves in an arc around the body
- The image detectors moves in opposite direction in the same arc
- Only the axial point is in focus
- Images are taken in slices
- The signals are put into a computer
- The image is reconstructed by the computer and displayed
- Images in axial (transverse) sections (with some exceptions)
- Images viewed from inferior side (normal convention)
- X-rays used for imaging
- Good details and relations
MRI

- MRI images similar to CT but more details and tissue differentiation
- Uses strong magnetic field
- Depends on the protons of hydrogen in water
- Radiowaves are used to excite the protons which then ‘flip’
- Flipped protons give measurable energy (signal) when they flip back when the pulsing is removed
- More protons (water in tissue) emit larger signal
- Signals are processed by a computer and image formed
- This has a capacity to image in any plane

Dissection – Examination of the great vessels

*The Mediastinum*

Consists of the heart, great vessels, trachea and oesophagus. The mediastinum is divided into four parts for descriptive purposes:

- The superior mediastinum – lies above a plane joining the sternal angle to the lower border of T4
- The middle mediastinum – contains the heart and pericardium
- The anterior mediastinum – lies in front of the heart and behind the sternum
- The posterior mediastinum – lies behind the heart and extends down posteriorly to the diaphragm

*The great vessels*

- Lie within the superior mediastinum
- The pericardium is the membrane that surrounds and protects the heart; consists of two main parts: the fibrous pericardium and the serous pericardium (which forms the pericardial sac)

- The external connective tissues of each great vessel blend with the superficial fibrous pericardium; composed of tough, inelastic, dense irregular connective tissue. The fibrous pericardium prevents overstretching of the heart, provides protection, and anchors the heart in the mediastinum.
- The pericardial sac itself is lined by smooth serous pericardium. The deeper serous pericardium is a thinner, more delicate membrane that forms a double laye around the heart. The outer parietal layer of the serous pericardium is fused to the fibrous pericardium. The inner visceral layer (also known as the epicardium) is one of the layers of the heart wall and adheres tightly to the surface of the heart.
- Between the parietal and visceral layers of the serous pericardium is a thin film of lubricating serous fluid
called pericardial fluid; it reduces friction between the layers of serous pericardium as the heart moves.

- The **ascending aorta** leaves the left ventricle of the heart
- The **pulmonary trunk** leaves the right ventricle, and divides into the right and left **pulmonary artery**
- The ascending aorta becomes continuous with the aortic arch which curves backwards and to the left over the pulmonary artery. When the aortic arch reaches the left side of T4 body, it descends as the descending (thoracic) aorta
- The left phrenic and left vagus nerve cross the aortic arch. The phrenic nerves send sensory nerves to the fibrous pericardium, diaphragmatic pleura + peritoneum, as well as both motor and sensory nerves to the diaphragm (where they terminate).

- **Superior vena cava** – formed by the left and right **brachiocephalic veins** (left lies behind the manubrium and is anterior to the aortic arch). Each brachiocephalic vein forms from the union of the subclavian vein (drains upper limb) and the **internal jugular** (drains head and neck). The **azygos vein** also joins to form the SVC; it arches forward over the root of the right lung, draining the posterior and lateral parts of the thoracic cage
- All the great vessels EXCEPT the inferior vena cava lie beneath, and are protected by, the manubrium

- **Branches of the aorta** – the first branch is the **brachiocephalic artery**, which passes upwards and crosses to the right side of the trachea; it divides into the **right subclavian artery** (passes laterally over the first rib to enter the axilla) and the **right common carotid artery** (passes upwards into the neck lying to the right of the trachea)
- The second major branch is the **left common carotid artery** (passes up the neck to the left side of the trachea)
- The third branch is the **left subclavian artery** (cross the first rib to enter the axilla)
- **NB**: A fourth branch – the **thoidea ima artery** – may run from the arch up to the thyroid gland, but this is inconsistent

**The heart in situ**

- The surface of the heart is covered in visceral pericardium
- There are locations on the heart; both superiorly and inferiorly, where the visceral pericardium becomes continuous with the parietal pericardium
- The pericardial cavity is enclosed between the visceral and parietal layers and surrounds most of the heart
- The visceral and parietal cavity is continuous between the great arterial vessels and the great veins.

- **Transverse pericardial sinus** - There is a passage between the superior and posterior reflections of the serous pericardium. It lies posteriorly to the ascending aorta and the pulmonary trunk, anteriorly to the superior vena cava, and superiorly to the left atrium.
- **Oblique pericardial sinus** – the pericardium also passes upwards on the posterior wall of the left atrium to
cover the part of the wall between the pulmonary veins. This arrangement creates a passage that allows “friction-free” movement between the left atrial wall and the overlying pericardium.

- **Right border of the heart** – formed by the right atrium
- **Inferior border** – predominantly the right ventricle, but also some of the left ventricle
- **Left border** – left ventricle
- **Posteriorly** – the left atrium, cannot be viewed with the heart in situ
- **Apex** – to the left, found where the inferior border meets the left border.

- On the lower right hand corner of the pericardial sac the IVC can be identified; pierces the diaphragm to gain access to the right atrium of the heart
Lecture – Organisation of nerves in the thorax

Types of Nerves

- **Somatic** – innervates skin and skeletal muscle
  - *Motor* fibres supplie skeletal muscle only (e.g. in the thorax – intercostal muscles, diaphragm)
  - *Sensory* nerves supply sensation from the skin (dominant sensory area), muscles, bones, the parietal pleura + the parietal pericardium. Much of the non-cutaneous (non-skin) sensation is proprioceptive (i.e. gives feedback on the function in muscles, tendons + joints)
  - The main somatic nerves of the thorax are:
    - the intercostal nerves (11 pairs)
    - The phrenic nerves (1 pair)

- **Autonomic** (also known as visceral) – innervates organs, viscera, smooth muscle, glands
  - *Motor* fibres supplie smooth muscle, cardiac muscle and many exocrine glands (e.g. muscle of the heart, blood vessels, bronchi, bronchial + sweat glands)
  - *Sensory* fibres supply sensation of various kinds to the viscera

The autonomic nerves can then be sub-divided:

- **Sympathetic**
  - Motor nerves to smooth muscle, the cardiac pacemaker + many exocrine glands
  - Pain sensation to the viscera
  - NOT limited to the viscera – also supply somatic smooth muscle (particularly blood vessel walls) and the sweat glands
  - Chest wall obtains sympathetic supply mainly via thoracic spinal nerves T1-T11
  - Thoracic viscera mainly supplied from thoracic spinal nerves T3-T6

- **Parasympathetic**
  - Motor to smooth muscle, the cardiac pacemaker + many exocrine glands
  - Sensory monitoring feedback from the visceral organs (known as *enteroception*)
  - Distribution limited to the viscera
  - Entire supply to the thoracic viscera comes from the brainstem in the Vagus nerves (cranial nerve X)

Thoracic somatic nerves

The intercostal nerves

- Arise as the main branches of the thoracic somatic spinal nerves T1-T11
- These nerves are often described as **segmental nerves** – each pair supplies a single body segment – i.e. each pair form a repeating unit containing a single vertebrae with its associated skeletal muscle and skin
- Each segmental spinal nerve forms from rots emerging from the spinal cord:
  - anterior (ventral) root – all motor fibres
  - posterior (dorsal) root – all sensory fibres
• the cell bodies of the sensory neurones all form a swelling called the **dorsal root ganglion** (found on the dorsal root just prior to its join with the ventral root to form the spinal nerve)
  o the dorsal root ganglion and the junction of the roots lie within the **intervertebral foramen** – a lateral gap between the pedicles of adjoining vertebrae

• There is no corresponding motor neurone ganglion, as the cell bodies are within the spinal cord

• Each spinal nerve then divides into two unequal-sized **rami** (sing. **Ramus**)
  o The **posterior ramus** is smaller, and supplies motor fibres to the column of muscle posterior to the transverse spinal processes (often called the erector spinae complex), and sensory fibres to the skin overlying these muscles
  o The **anterior ramus** is larger, and runs anteriorly between the muscle layers, supplying muscle right round to the anterior midline.
  ▪ It gives 2 cutaneous branches from each which carry sensation from the skin; one lateral and one anterior
  ▪ The intercostal nerves are simply the anterior rami of T1-T11

• Many different spinal nerves may combine to form **plexi** supplying specialised areas (e.g. cervical, brachial, lumbosacral)

**Dermatome** – an area of skin which is supplied by a single spinal nerve/spinal cord level

**Myotome** – part of a skeletal muscle which is supplied by a single spinal nerve/spinal cord level

There is usually considerable overlap between adjoining dermatomes

**Intercostal nerves:**
- 11 pairs + 1 subcostal
- Both motor + sensory
- Anterior primary rami of the spinal nerves T1-T11 supply the intercostal spaces
  - Lateral cutaneous branch supply both anteriorly and posteriorly
  - Anterior cutaneous branch supply both medially and laterally

**The phrenic nerves**

• Derived from the anterior rami of spinal nerves C3, C4 + C5 (C4 main contributor)

• Somatic nerves – no autonomic function or visceral distribution

• Motor fibres supply the skeletal muscle of the diaphragm – the most important inspiratory muscle therefore damage to the motor tracts of the spinal cord at/above the C4 segment disconnects the inspiratory muscles from the respiratory centre in the brainstem (likely to cause death from asphyxia)

• Sensory fibres supply the central diaphragm, its pleural covering, mediastinal pleura + pericardium, as well as the peritoneum on the inferior surface of the central diaphragm

• Spinal nerves C2-C5 produce several nerves other than the phrenic, though these are of much less importance. Such areas of shared distribution of several pairs of spinal nerves are called plexi – this one is called the **cervical plexus**

• The phrenic nerves run down the neck on the muscles arising from the cervical transverse processes to enter the thorax.
  o They then pass on either side of the mediastinum down to the diaphragm

• The **right phrenic nerve** follows the course of the great veins, running successively on the right brachiocephalic vein, the superior vena cava, and the fibrous pericardium covering the sinus venous of the right atrium and inferior vena cava
- The left phrenic nerve crosses the arch of the aorta then rubs across the fibrous pericardium overlying the left ventricle
- Diaphragmatic pain – the brain doesn’t have a map of the viscera, so pain from the diaphragm is interpreted as coming from the part of the body surface supplied by C3-C5 – the top of the shoulder and the base of the neck – this is known as referred pain

Thoracic autonomic nerves

- In the autonomic nervous system, there are two tiers of motor neurones:
  - Pre-ganglionic neurones – cell bodies in the spinal cord/brain with axons that fun to swellings on the nerves called autonomic ganglia. In these ganglia, the pre-ganglionic axons synapse with the much more numerous post-ganglionic neurones
  - Post-ganglionic neurones – axons run to target (cardiac muscle, smooth muscle, glands)
- This two-stage arrangement greatly reduces the number of cell bodies needing space within the CNS, though it reduces the precision of successful targeting of specific nerves
- Sensory innervation is to visceral organs (same as somatic)
Autonomic nerves are divided into parasympathetic and sympathetic divisions; each of which has different origins and distributions, and are often (NOT always) opposite in motor effects.

**Sympathetic nerves**

- All the sympathetic ganglionic neurones of the body live in the spinal cord between T1-L2, but the axons have to reach virtually all parts of the body (except the CNS itself)
- Sympathetic motor fibres mainly travel with the somatic motor fibres. However their autonomic ganglia (containing the synapses between pre + post) need to be accommodated somewhere.
  - The fibres come out in the spinal nerve like somatic motor fibres, but then briefly leave the nerve in a slender bundle to form a paravertebral ganglion on the side of the vertebrae (thus each spinal nerve pair will \( \rightarrow \) ganglion on either side of the vertebra)
  - At the paravertebral ganglion, the pre-synaptic fibred synapse with the post-synaptic fibres, and then the slender bundle of post-synaptic fibres return to the spinal nerve to be distributed.
  - These slender bundle of nerves which join the sympathetic ganglia to the spinal nerves are called rami communicantes.
    - The pre-ganglionic fibres are wrapped in myelin so form a white ramus communicans
    - The post-ganglionic fibres are unmyelinated so form a grey ramus communicans
- Sympathetic sensory fibres behave in a similar way to somatic sensory fibres; they just travel through the paravertebral ganglion without synapsing and go through the white ramus communicans to the dorsal horn of the spinal cord.
- The paravertebral ganglia are connected longitudinally (vertically up/down the spine) forming a paravertebral chain. This chain extends beyond the T1-L2 range of sympathetic neurones by allowing preganglionic fibres to run up or down the chain for one or two segments \( \rightarrow \) sympathetic supply through the branches of all the spinal nerve pairs
  - Visceral sensory fibres mediate visceral pain via the sympathetic chains (also known as trunks)
- REMEMBER: the spinal nerves do not run to the viscera. Therefore any viscerally directed pre-ganglionic fibres pass through the white rami, through the paravertebral ganglia without synapsing, and exit the sympathetic chain.
  - These then go on to synapse in ganglia closer to the target organs, known as prevertebral ganglia
  - E.g. 1 – thoracic visceral supplies mainly arise from spinal nerves T3-T6, and after exiting the paravertebral chain they reach areas called the cardiac and pulmonary plexi, where they synapse to send postganglionic fibres to the heart and lungs
  - Ed 2 – abdominal visceral supplies arise from spinal nerves from lower T5-T12, and after they branch from the paravertebral chains they form splanchnic nerves which run inferomedially to pass behind the diaphragm into the abdomen
Parasympathetic nerves

- Parasympathetic nerves also save CNS space by having a small number of pre-ganglionic neurones, which supply ganglia (with synapses) containing a much larger number of postganglionic cells.
- However, the bid differences from the thoracic sympathetic are:
  - The parasympathetic is only distributed to the viscera (heart and respiratory system) — no somatic supply.
  - The entire parasympathetic supply to the thorax is delivered in one pair of cranial nerves — the Vagus nerves.
- However, 5 sets of nerves contain parasympathetic fibres:
  - Occulomotor (III) cranial nerves
  - Facial (VI) cranial nerves
  - Glossopharyngeal (IX) cranial nerves
  - Vagus (X) cranial nerves
  - Sacral (S2-S4) spinal nerves

Vagus nerves

- Leave the skull with the internal jugular veins through the jugular foramina and run down the whole length of the neck close to the internal jugular veins and common carotid arteries.
- They then pass through the thoracic inlet into the superior mediastinum (like the phrenic nerves, the asymmetry of the mediastinum means that the left and right vagi have different relations).
- The right vagus runs posterior to the SVC and passes posterior to the root of the lung (useful for distinguishing it from the more slender phrenic nerve) — it then breaks up into a plexus of branches surrounding the oesophagus.
  - The inferior continuation of the right vagus through the oesophageal plexus is the posterior oesophageal nerve, which takes fibres through the diaphragm to the abdominal viscera.
- The left vagus crosses the aortic arch to pass posterior to the left lung root before joining the right vagus to form the oesophageal plexus that supplies the oesophagus itself and accompanies it into the abdomen as the anterior oesophageal nerve.
- Both vagi contribute branches to the pulmonary and cardiac plexi, which like the corresponding sympathetic branches, synapse in small ganglia before reaching their cardiac and respiratory targets.
- The sensory visceral fibres of the vagus, more numerous than the motor fibres, carry feedback information about the functional state of the cardiovascular, respiratory and alimentary systems to the vital centres of the brain.
- NB: the recurrent laryngeal branch of the vagus nerve (NOT PARASYMPATHETIC) — runs back up the neck to supply the skeletal muscles of the larynx.

Plexi of the Thorax

- The pulmonary plexi
  - Sympathetic nerves dilate the bronchioles.
- Parasympathetic (vagus) nerves constrict bronchioles

- **Cardiac plexi**
  - Sympathetic efferents increase heart rate and force of contraction
  - Parasympathetic (vagus) efferents decrease heart rate via the pacemaker tissue and constrict coronary arteries
  - Sympathetic afferents relay pain sensation from the heart
  - Parasympathetic afferents (vagus) relay blood pressure and chemical information from the heart

- **Oesophageal plexus**
  - After surrounding the oesophagus, the vagus nerves separate to form anterior and posterior oesophageal/gastric nerves
  - Sympathetic afferents relate pain sensations from the oesophagus
  - Parasympathetic afferents (vagus) senses normal physiological information from the oesophagus

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**Living Anatomy – The heart and arteries**

**Chest wall surface landmarks**

- NB: Sternal angle + manubriosternal joint – 2nd costal cartilage (in line with 2nd rib as well)
- Nipple (men) – 4th intercostal space just lateral of the mid-clavicular line
- Nipple (women) – depend on size
- Xiphoid process – 7th costal cartilage (in line with 6th rib)
**Position of the heart**

- The right border of the manubrium and sternum down to the 3rd costal cartilage (1cm from sternal border) overlies the superior vena cava.
- A line continuing down just lateral to the sternum (1cm from border) to the 6th costal cartilage approximately marks the right border of the heart; formed by the right atrium.
- A nearly horizontal line from here to the 5th intercostal space in the mid-clavicular line marks the horizontal border of the heart (formed mainly by the right ventricle) down to the apex (8cm from the sternal border).
- The oblique border; formed mainly by the left ventricle, runs from the left 5th ICS in the mid-clavicular line up to the medial end of the left 2nd intercostal space (1cm from the sternal border).
- NB: the pericardial sac surrounding the heart is attached to the diaphragm, so the heart moves with the diaphragm during breathing.

**The apex beat**

- The heart apex lies at meeting point of the horizontal and oblique borders, in the 5th left ICS in the mid-clavicular line.
  - In children, this is slightly higher on the 5th rib.
  - This is just below and medial to the left nipple in men, and at the lower border of the breast in women.
- Skin pulsations by ventricular contraction can often be felt here.
- Apex “beat” should be easy to palpate.
  - If difficult to palpate, jog on the spot so that the heartbeat is stronger, therefore making the apex beat stronger and easier to feel.

**The great vessels**

**The aortic arch and its branches**

- When supine, the aortic arch starts and ends at the level of the sternal angle (2nd CC) at maximal expiration.
- When standing, it is lower, and moves inferiorly on inspiration.
- From its superior aspect arise the brachiocephalic (which then branches to form right subclavian and right common carotid), left common carotid and left subclavian arteries.
  - All of these lie posterior to the manubrium before ascending the neck just lateral to the trachea.
  - The common carotid arteries then ascend further and lie just lateral to the trachea.
  - The subclavian arteries then cross the 1st rib to enter the axilla (armpit).
**The great veins**
- The internal jugular veins descend the neck just lateral to the common carotid arteries. They join with the subclavian veins just posterior to the medial ends of the clavicles to form the brachiocephalic veins.
  - The left brachiocephalic vein cross to the right posterior to the manubrium to join the right brachiocephalic veins forming the superior vena cava.

**Heart valve locations and auscultation positions**
- The four heart valves are embedded in the fibrous atrioventricular septum of the heart, lying on a line running from the medial end of the left 3rd costal cartilage to the medial end of the right 4th intercostal space.
  - The order superior-inferior = pulmonary, aortic, mitral (think ends in L = LA → LV), tricuspid.
- The normal heart sounds consists of two sounds (“lub dub”) produced by closure of the atrioventricular valves and the atrial valves respectively.
- The principle of heart valve auscultation is to place the stethoscope over a blood-filled space downstream of the valve of interest. The usual sites are:
  - Pulmonary – left upper sternal border, 2nd intercostal space
  - Aortic – right upper sternal border, 2nd intercostal space
  - Tricuspid – left 5th costo-sternal border
  - Mitral – left 5th intercostal space at apex beat

**Vessels in the neck**
- Internal jugular vein runs lateral to the common carotid arteries, and joins with the subclavian veins just superior and posterior to the sternoclavicular joint to form brachiocephalic veins.
- The left brachioccephalic vein then crosses to the right just posterior to the manubrium to form the superior vena cava.
- The internal jugular vein runs from the ear lobe to the sternoclavicular joint just posterior to the sternomastoid muscle.
- The internal carotid artery runs from just behind the ear, and drains into the common carotid artery (along with all the facial veins) just lateral to the trachea.

**Pulse palpitations**
- **In the head and neck**
  - *Carotid pulse* can be felt in between the anterior border of the sternomastoid muscle and the thyroid cartilage.
  - *Superficial temporal pulse* can be felt in front of the tragus of the ear (just inferior to the cheek bone).
LSS Anatomy of the Thorax

- **Upper limb**
  - *Subclavian pulse* can be felt in the supraclavicular fossa
  - *Radial pulse* can be felt on the lateral side of the wrist joint
  - *Brachial pulse* can be felt either in the cubital fossa of the elbow joint, or just superior to this next to the bicep

- **Lower limb**
  - *Posterior tibial pulse* can be felt just behind medial malleolus of tibial bone at distal end (medial side of heel)
  - *Dorsalis pedis pulse* felt lateral to the flexor hallucis longus tendon on the superior aspect of the foot
  - *Femoral artery pulse* felt at the mid-point between the anterior superior iliac spine and the pubic symphysis (top of the femur)

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**Dissection – Examination of the heart**

The pericardium

- Provides the heart with a friction free surface to accommodate its sliding movements
- The fibrous pericardium is a collagenous layer fused with the central tendon of the diaphragm
- The serous pericardium consists of a parietal layer; which lines the fibrous pericardium, and a visceral layer; which lines the outer surface of the heart and the commencement of the great vessels
- The pericardial cavity is the space between the parietal and visceral layers of the serous pericardium

The heart
Surfaces of the heart:
- Anterior/sternocostal – formed mainly by the right ventricle (also right atrium)
- Inferior/diaphragmatic – formed mainly by the left ventricle (also right ventricle)
- Posterior – formed mainly by the left atrium
- Apex – formed entirely by the left ventricle

The right atrium
- Superior vena cava enters its upper extremity
- Inferior vena cava enters it inferiorly almost immediately after passing through the diaphragm
- Coronary sinus (vein that drains the heart) enters close to the IVC
- The right auricle is a small ear-like extension of the right atrium that overlaps the root of the pulmonary trunk on its right side

The right atrioventricular groove
- Line of demarcation between the right atrium and right ventricle
- Right coronary artery lies in this groove

The right ventricle
- The pulmonary trunk leaves the right ventricle by passing upwards and left for a short distance before dividing into the right and left pulmonary arteries just inferior to the aortic arch

The anterior interventricular groove
- Running obliquely downwards and to the left from the root of the pulmonary trunk is the anterior interventricular groove, which demarcates the right ventricle from the left ventricle and in which lies a branch of the left coronary artery

The left ventricle
- The ascending aorta leaves the upper aspect of the left ventricle under the pulmonary trunk, which then curves under the aortic arch and branches under the arch
- The ascending aorta has an outward bulge in its wall; the three aortic sinuses, which accommodate the cusps of the aortic valve during systole
  - Both the right and left coronary arteries originate from 2 of the 3 cusps of the aortic valve

The left atrium
- Pulmonary veins enter the left atrium on the posterior surface of the heart
- Both left and right pulmonary veins; each consisting of a superior and inferior vein
Coronary vessels

Coronary arteries
- The right and left coronary arteries originate from 2 aortic sinuses
- The right coronary artery emerges from the aorta and runs down the atrioventricular groove (towards the right on the anterior surface of the heart) to the inferior border and then to the diaphragmatic surface.
  - Before it branches, the right coronary artery supplies small atrial branches to the right atrium
  - At the diaphragmatic surface, the artery then descends down the posterior interventricular sulcus as the posterior interventricular artery, supplying the walls of the ventricles with blood. The posterior interventricular artery is also known as the posterior descending artery (PDA)
  - At the inferior border of the heart, the right coronary artery also branches to form the marginal artery, which runs along the inferior margin of the heart supplying blood to the right ventricle
- The left coronary artery emerges from the aorta and runs down to the atrioventricular groove just inferior to the left auricle, where it divides into two main branches: the anterior interventricular branch and the circumflex branch
  - The anterior interventricular branch (or left anterior descending LAD) lies in the interventricular groove down to the apex and the diaphragmatic surface, supplying oxygenated blood to the walls of both ventricles
  - The circumflex branch lies in the coronary sulcus, and can be traced down the left margin to the diaphragmatic surface; delivers blood to left atrium and ventricle

Coronary veins
- After blood passes through the coronary arteries, it flows into capillaries and then moves into coronary veins. Most of the deoxygenated blood from the myocardium drains from different coronary veins into a large vascular sinus in the coronary sulcus on the posterior surface of the heart; called the coronary sinus.
  - The coronary sinus empties into the right atrium
- The principle tributaries carrying blood into the coronary sinus are the great cardiac vein, middle cardiac vein, small cardiac vein and the anterior cardiac veins.
- The great cardiac vein lies in the anterior interventricular sulcus, which drains the areas of the heart supplied by the left coronary artery (left and right ventricles + left atrium)
- The middle cardiac vein lies in the posterior interventricular sulcus, which drains the areas supplied by the posterior interventricular branch (PDA) of the right coronary artery (left and right ventricles)
- The small cardiac vein lies in the coronary sulcus, which drains the right atrium and right ventricle
- The anterior cardiac veins drain the right ventricle and open directly into the right atrium
Lecture 1 - Overview of the lymphatic system

**Function**

- More fluid leaves blood capillaries than returns to them, and uncompensated fluid movement from the blood to the ECF would result in oedema and loss of blood volume
- Lymphatic vessels drain excess extracellular fluid back into the blood
- This ensures any foreign particles (e.g. bacteria, contaminants of wounds) come into contact with the immune system

**Structural components**

**Lymphatic vessels**

- Blind ended, thin walls vessels that are lined by endothelial cells permeable to fluid, proteins, particles + cells
- They carry pathogens, hormones, cell debris and fats along with excess interstitial fluid to lymph nodes (pass through at intervals) to ultimately drain back into the venous system
- E.g. Fats absorbed in the small intestine are packaged into chylomicrons (protein coated lipids), and are released into interstitial fluid. These then drain into the blind ended lymphatic capillaries known as lacteals, and then return to the venous system via the neck
- Larger lymph vessels possess valves like veins

**Lymph**

Contains:

- Fluid from tissues (isotonic salts etc)
- Some protein
- Particulate matter (e.g. cell debris, carbon from lungs)
- Cells (e.g. lymphoid cells, infecting microorganisms, metastatic tumour cells)
- Fats (as chylomicrons) from intestines
  - In most vessels, lymph is clear and odourless, but is opaque and milky from the small intestine due to the chylomicrons (known as chyle lymph)

**Movement of lymph**

- Maintained by the action of adjacent structures e.g. skeletal muscle contraction and arterial pulse pressures
- In larger vessels, the valves ensure that lymph flow is unidirectional
LSS Anatomy of the Thorax

Lymph node
- Small (<2.5cm long)
- Found along lymph vessels
- Contain lymphocytes and macrophages
- Can act upon foreign bodies in the lymph
- Drainage from infected regions detectable in enlargement lymph nodes
- Found in the armpit, groin, neck

The lymphatic system

Principle anatomical organisation
- Consists of both superficial and deep lymphatics, which stay largely separate
- All lymphatic vessels rarely penetrate the deep fascia; superficial lymphatics follow superficial veins towards the lymph nodes in axillary (armpit), inguinal (groin) or cervical (neck) areas. These then penetrate the deep fascia and drain into the deep lymphatics, which tend to follow the main arteries
- The deep lymphatics ultimately drain into the venous system near the formation of the brachiocephalic veins at the sternoclavicular joint

Superficial lymphatic drainage
- The trunk of the body drains according to 4 quadrants defined by vertical and horizontal lines through umbilicus (navel)
  - right upper
    - Right lower
    - Left upper
    - Left lower
- Each quadrant drains to axillary or inguinal nodes along with the nearby limb
- The head and neck drains to the superficial cervical lymph nodes just both the mandible on either side of the neck
- Lymph from all these groups of superficial lymph nodes then penetrates the deep fascia to drain into the adjacent deep lymph nodes

Deep lymphatic drainage
- Lymph from the deep inguinal nodes drain along the path of the iliac arteries to the para-aortic nodes (either side of the aorta) along with lymph from the abdominal organs with systemic blood supply
  - Lymph from the intestines drain to pre-aorta nodes which are anterior to the aorta
  - These nodes then all drain into a collecting vessel; the cisterna chyli, and then continue onwards via the thoracic duct
- The thoracic duct drains into the left brachiocephalic vein along with lymph from the adjacent left axillary, left broncho-mediastinal and left deep cervical nodes
- The lymph from the right axillary, right broncho-mediastinal and right deep cervical nodes drain into the right lymphatic duct, and hence into the right brachiocephalic vein
LSS Anatomy of the Thorax

Lymphatic drainage of the thorax

Involves drainage from the breast, thoracic wall, thoracic duct, lungs and heart

- **Lymphatics of the breast** – covered in lecture 2
- **Lymphatics of the thoracic wall**
  - Lymph drains into *parasternal nodes* associated with internal thoracic arteries, *intercostal nodes* associated with the ribs, and *diaphragmatic nodes* associated with the diaphragm
  - Parasternal nodes drain the *broncho-mediastinal trunks*, as well as the upper intercostal nodes
  - The lower intercostal nodes drain the *thoracic duct*
  - The diaphragmatic nodes drain the *brachiocephalic, aortic and lumbar vessels*
  - The superficial nodes of the thoracic wall are the *axillary nodes*
- **Lymphatics of the thoracic duct**
  - The thoracic duct is the main lymph channel draining most of the body, beginning at the cisterna chyli
    - The *cisterna chyli* drains lymph from the abdomen, pelvis, perineum and lower limbs
  - Thoracic duct begins at L2 vertebral level, and enters the thorax posterior to the oesophagus through the diaphragm
  - It ascends the thorax just right of the midline between the aorta and azygos vein, and then crosses over onto the left at T5
  - Once cross over, it empties into the left subclavian vein
- **Lymphatics of the lungs**
  - Vessels include:
    - *Tracheobronchial* – around the bronchi and trachea; drain from within the lung through the hilum.
    - These then unite with vessels from *parasternal and brachiocephalic nodes* to form:
    - *Broncho-mediastinal trunks*
- **Lymphatics of the heart**
  - Vessels follow the coronary arteries and drain into the *brachiocephalic* and *tracheobronchial* vessels
- **Lymphatics of the posterior mediastinum**
  - Pre-aortic and para-aortic nodes receive lymph from the oesophagus, diaphragm, liver and pericardium
  - These then drain into:
    - The *thoracic duct*
    - *Posterior mediastinal vessel*
Lecture 2 – the Breast, lymphatic drainage and breast cancer
Breast development

Embryonic development

- Involves the development of two components: mammary ridges and mammary glands
- **Mammary ridges** (also known as milk ridges) develop in the 4\textsuperscript{th} week after gestation, from a thickened strip of ectoderm that extends from axillary to inguinal region (but only persists in the pectoral area)
- **The mammary gland** develops in the 6\textsuperscript{th} week from primary bud; involves solid growths of the epidermis into the underlying mesenchyme alone the mammary ridges
  - The primary bud gives rise to secondary bud, which then develops into lactiferous ducts and their branches
  - The surrounding mesenchyme of the ducts gives rise to fibrous connective tissue and fat
  - In the late foetal period, the epidermis at the origin of the mammary gland becomes indented/depressed to form a mammary pit. The mammary pit is the primordium of the nipple.
    - At birth the nipples are poorly formed and depressed, but they arise from the proliferation of the surrounding connective tissue of the areola

Post-natal development

- **At birth**
  - The rudimentary mammary glands are identical in males and females
  - Main lactiferous ducts are formed
  - Secretion from the breasts occurs caused by transitory changes by maternal hormones
- **At puberty (in females)**
  - Fat and connective tissue development occurs
  - Growth of the duct system
- **At pregnancy**
  - There is an increase in oestrogens and progesterone
  - This causes intra-lobular ducts to develop and form buds which become alveolar ducts
Abnormalities of the mammary gland

- **Athelia**: absence of nipples
- **Amastia**: absence of breasts
- **Polymastia**: extra breast
- **Polythelia**: extra nipple
- **NB**: nipples or breasts can occur anywhere along the mammary ridge from extra primary buds
- **Gynaecomastia**
  - Definition: excessive development of male breast
  - May have a physiological or pathological cause

The Breast

**Anatomy**

- The breast is “comma-shaped” and can be divided into 5 portions + axillary tail which leads to the axilla
- The 5 portions are:
  - Upper outer
  - Lower outer
  - Upper inner
  - Lower inner
  - Central – consist of the nipple and surrounding areola
- Within each breast is a mammary gland, consisting of 12-16 lobes separated by a variable amount of adipose tissue. In each lobe there a several smaller compartments called lobules, composed of grapelike clusters of milk-secreting glands termed alveoli that are arranged radially around the nipple, with lactiferous ducts to the surface – openings are present on the area of pigmented skin surrounding the nipple known as the areola
  - The lactiferous ducts have expansions just deep to the skin – these are called lactiferous sinuses and these are squeezed during suckling
- The breast can be summarised as an organisation of glandular and adipose tissue, duct system and suspensory ligaments
  - Contains little glandular tissue until the late stages of pregnancy
• The structure of the breast is supported by radial interlobular fibrous partitions that extend between the skin and the muscle bed underlying the breast. The superior partitions are strong and maintain breast shape against the effect of the gravity – the suspensory ligaments
• The breast overlies the muscles of the anterior chest wall between ribs 2 and 6
  o Pectoralis major – tensing the pectoral muscles puts traction on the suspensory ligaments to lift the breast, but this does not work when the trunk is horizontal
  o Serratus anterior
  o External oblique
• The breast location is also related to the axillary walls of the thorax (See diagram opposite)
  1. Clavicle
  2. Anterior axillary fold – pectoralis major
  3. Posterior axillary fold – latissimus dorsi
  4. Medial axillary wall – serratus anterior

**Blood supply**

Most of the blood supply reaches the breast from branches of the axillary artery and the internal thoracic artery. This is important because lymphatic drainage usually follows the same pathways as arterial supply.

**Lymphatic drainage**

• The fine, superficial lymphatic vessels draining the breast form a sub-areolar plexus, and a submammary plexus between the breast and the pectoralis major muscle.
• The main routes of the normal lymph drainage are therefore into about 5 distinct axillary nodes, and to the parasternal nodes. The 5 distinct key nodes include:
  o **Lateral** nodes – behind the axillary vein
  o **Anterior** (pectoral) nodes – along the inferior border of the pectoralis minor
  o The **posterior** (subscapular) nodes – in the posterior axillary fold
  o **Central** medial nodes – near the base of the axilla, they receive lymph from the preceeding nodes
Apical subclavicular nodes – medial to the axillary vein and superior to the pectoralis minor; they receive the lymph from all other nodes and drain into the subclavian trunks, or join the lymphatic duct or empty into the deep cervical nodes

**Lymph drainage and cancer**
- Lymph drainage parallels blood supply
- Axillary and internal thoracic nodes are main normal routes
- Cancer can block lymphatic drainage, raising lymph pressure forces lymph through unusual drainage route

**Breast cancer**
- Commonest cancer in women
- Primary tumour may arise in the main part of the breast or the axillary tail within the duct epithelium
- It may be felt locally by pulling on the skin or the ligaments of the breast, and may spread through the lymphatics to colonise adjacent lymph nodes
- Prognosis much better if diagnosed early, therefore self-examination of breast and axilla recommended and mammography screening program used in UK
- REMEMBER – can occur in men

**Symptoms**
- Mass or pain in the axilla
- Palpable mass
- Thickening of the skin
- Pain
- Skin changes on breast e.g. ulceration
- Nipple discharge
- Nipple retraction
- Oedema or erythema of the skin

**Assessment of breast lump**
- Triple assessment includes:
  - Clinical breast examination and axilla examination
  - Imaging (mammography, ultrasound)
  - Needle biopsy
    - Fine needle aspirate for cytology
    - Core needle biopsy for histology
The Posterior Mediastinum

Anatomy of the Thorax 6 - Dr Paul Strutton (p.strutton@imperial.ac.uk)

The posterior mediastinum is posterior to the pericardial sac and diaphragm and anterior to the bodies of the mid and lower thoracic vertebrae:

- Its superior boundary is a transverse plane passing from the sternal angle to the vertebral disc between vertebra TIV – TV
- Its inferior boundary is the diaphragm
- Laterally, it is bordered by the mediastinal part of the parietal pleura on either side
- Superiorly, it is continuous with the superior mediastinum

**Major structures** in the posterior mediastinum include:

- Oesophagus and its associated nerve plexus
- Thoracic aorta and its branches
- Azygos system of veins
- Thoracic duct and associated lymph nodes
- Sympathetic nerve trunks
- Thoracic splanchnic nerves
The oesophagus

- Begins at level of C7 vertebra at the inferior border of the cricoid cartilage
- Ends at stomach, level of T11 vertebra
- At T7, it bends more anteriorly
- Above T7, lies to the right of the aorta
- Below T7, it deviates to the left and progressively anterior to the aorta
- Passes through the diaphragm at T10
- There are 4 constrictions of the oesophagus:
  - At the junction with the pharynx
  - Where it is crossed by the aortic arch
  - Where it is compressed by the left main bronchus
  - At the esophageal hiatus (when it crosses through the diaphragm)

Arterial + venous supply and lymphatic drainage

- **Arterial supply** – arise from the thoracic aorta, bronchial arteria, posterior intercostal arteries and ascending branches of the left gastric artery in the abdomen.
- **Venous drainage** - involves small vessels returning to the azygos vein (branch of SVC), hemiazygous vein, and oesophageal branches to the left gastric vein in the abdomen
- **Lymphatic drainage** of the oesophagus returns to the posterior mediastinal and left gastric lymph nodes

Oesophageal nerve plexus

- After passing posteriorly to the root of the lungs, the right and left vagus nerves approach the oesophagus
- As they reach the oesophagus, each nerve divides into several branches that spread over this structure, forming a plexus
- The plexus then continues inferiorly on the oesophagus toward the diaphragm. Just over the diaphragm, fibres of the plexus converge to form two trunks:
  - The anterior vagal trunk – mainly from fibres originally in the left vagus nerve
  - The posterior vagal trunk – mainly from fibres originally in the right vagus nerve

Thoracic aorta

- The thoracic portion of the descending aorta begins at the lower edge of T4, where it is continuous with the arch of the aorta
- It ends anterior to the lower edge of vertebra T12, where it passes through the aortic hiatus posterior to the diaphragm
- Superiorly it is situated to the left of the vertebral column, but on descending it approaches the midline and then lies directly anterior to the vertebral column
- Throughout its descent it gives off a number of branches

Azygous venous system

- Consists of a series of longitudinal vessels on each side of the body
- Drains the posterior chest wall, upper abdomen and posterior mediastinal organs – arches over right lung root and enters SVC just above the right atrium
On the left, there are usually a lower hemiazygous vein and accessory upper hemiazygous vein which cross the thoracic vertebrae to join the single azygos vein on the right before entry into the atrium.

There is significant variation in the origin, course, tributaries, anastomoses and termination of these vessels.

**Azygos vein**
- Arises opposite vertebra L1 or L2 at junction between right ascending lumbar vein and the right subcostal vein, as well as perhaps being a direct branch of the IVC.
- It enters the thorax through the aortic hiatus, and ascends through the posterior mediastinum usually to the right of the thoracic duct. At approximately T4, it arches anteriorly over the root of the right lung to join the SVC before it enters the pericardial sac.
- Tributaries of the azygos vein include the right superior intercostal, hemiazygous vein, accessory hemiazygous, oesophageal, mediastinal, pericardial and right bronchial veins.

**Hemiazygous vein**
- Usually arises at the junction between the left ascending lumbar vein and the left subcostal vein (or one alone).
- Usually enters the thorax through the left crus of the diaphragm, and ascends through the posterior mediastinum on the left side to approx. T4.
- At T4 vertebral level, it crosses the vertebral column posterior to the thoracic aorta, oesophagus and thoracic duct to enter the azygos vein.
- Tributaries include: the lowest posterior intercostal veins, oesophageal veins, mediastinal veins.

**Accessory hemiazygous vein**
- Descends on the left side from the superior portion of the posterior mediastinum to approx. level T8, where it crosses the vertebral column to join the azygos vein/hemiazygous vein/both.
- It also has a connection superiorly to the left superior intercostal vein.
- Tributaries include the 4-8 posterior intercostal veins, and sometimes the left bronchial veins.

**Thoracic duct**
- The principle channel through which lymph from most of the body is returned to the venous system. It drains the abdominal viscer and walls, pelvis, perineum, left thoracic wall and lower limbs to the blood.
- It begins below the diaphragm at the cisterna chyli, and extends from vertebra L2 to the root of the neck.
- It enters the thorax through the aortic hiatus, posterior to the aorta.
Is ascends through the posterior mediastinum to the right of the midline between the thoracic aorta on the left and the azygos vein on the right. It lies posterior to the diaphragm and oesophagus, and anterior to the vertebral bodies.

At level T5, the thoracic duct moves to the left of the midline and enters the superior mediastinum, where it continues into the neck.

The thoracic duct then drains into the left subclavian and left internal jugular veins.

**Thoracic sympathetic trunks**

- Receive branches from spinal nerves T1-L2
- Distribute sympathetic nerves to smooth muscle and glands throughout the body
- The trunks consist of sympathetic ganglia connected to the adjacent spinal nerves by white and grey rami communicantes
- Nerve innervation to internal organ viscera synapse in ganglia local to the target
- The trunks also bring sensory pain fibres back to the CNS from viscera
- There are two types of medial branches given off by the ganglia; first from the upper 5, and the second from T5-T12
- The second type consists mainly of preganglionic sympathetic fibres supplying abdominal and pelvic viscera, as well as visceral afferent fibres. They form the three splanchnic nerves.

**Splanchnic nerves**

- **Greater** – on each side, arise for T5-T9/10, descends in a medial direction, passing through the crus of the diaphragm ending in the coeliac ganglion
- **Lesser** – arises from T9+T10 or T10+T11; descends medially, passes through the crus of the diaphragm to end in the aorticorenal ganglion
- **Least** – arises from T12; descends to end in the renal plexus

Nerves within the posterior mediastinum include phrenic and vagus nerves – see Anatomy session 4 for detail.