

Structure of the thorax and mechanics of ventilation

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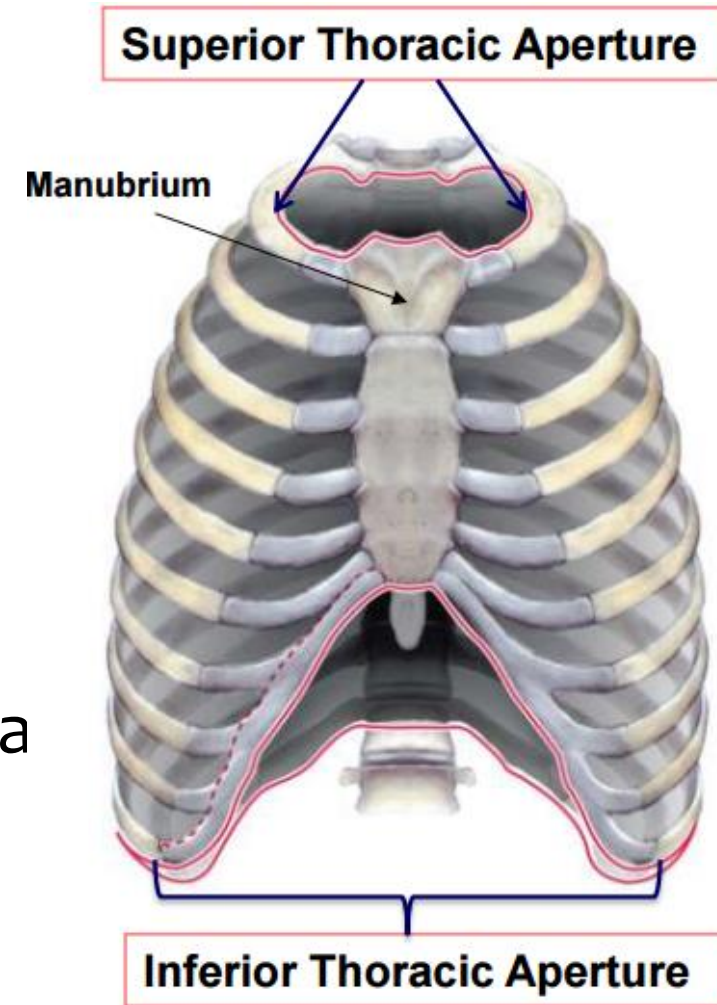
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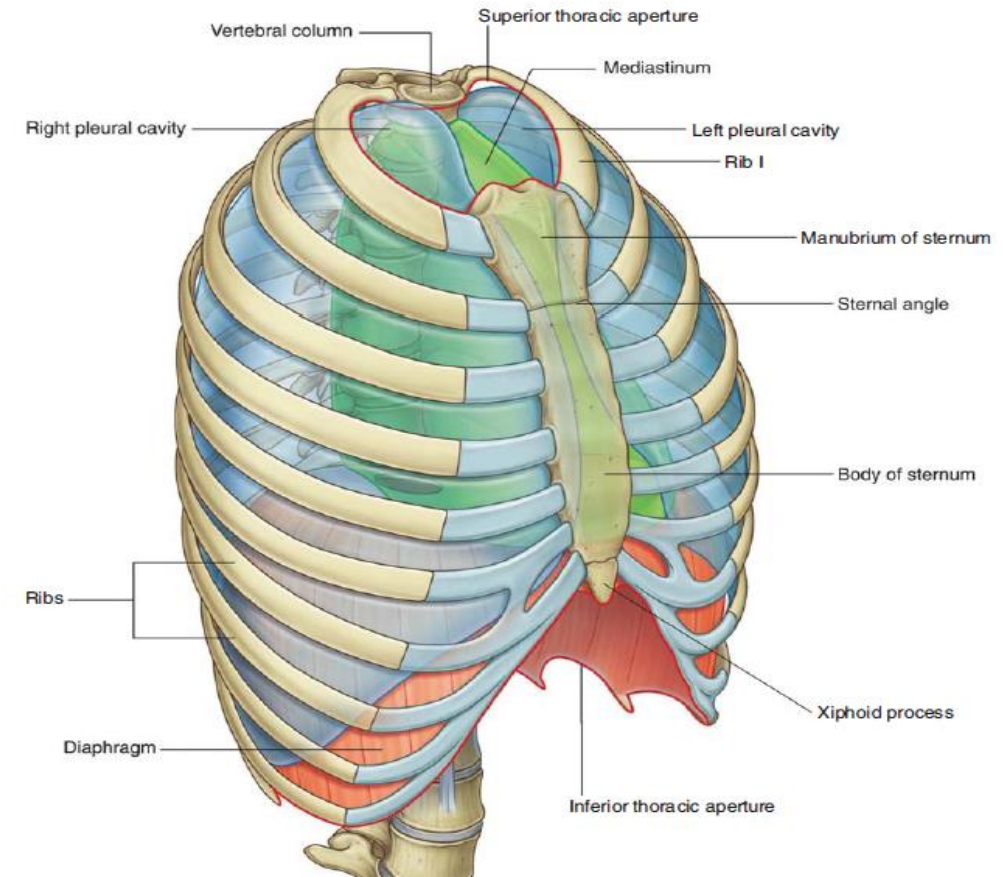
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Thorax

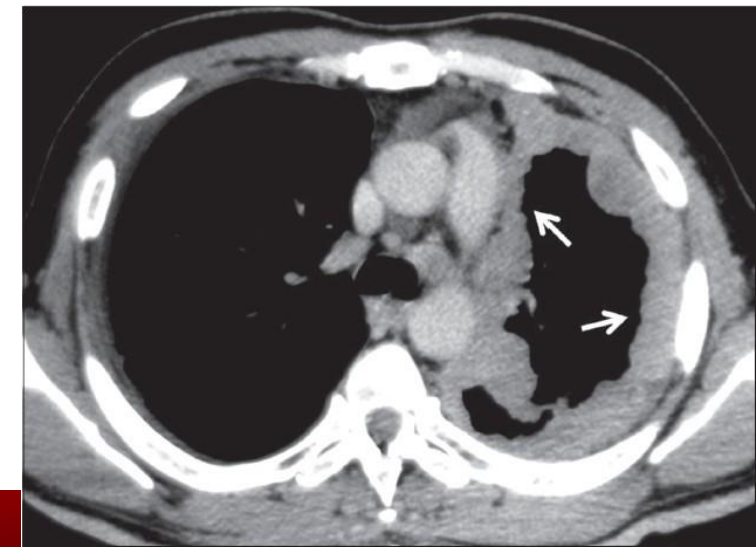
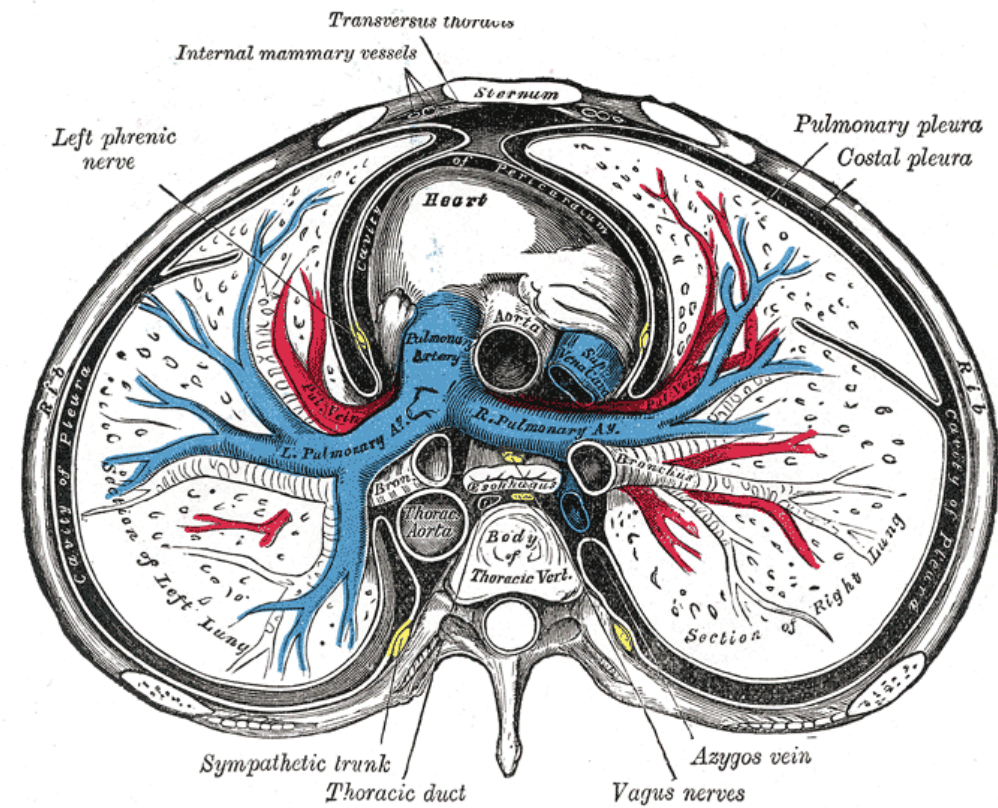
- The closed cavity which contains the lungs, trachea/bronchi, heart, great vessels, oesophagus, nerves etc.
- An cylindrical cavity
- Has a narrow opening (thoracic inlet) superiorly and a relatively large opening (inferior thoracic aperture) inferiorly



- Formed by ,
 - Vertebral column and scapula
 - Ribs and intercostal spaces
 - Sternum and costal cartilages
- Superiorly- 'thoracic inlet' communicates with the root of the neck
- Inferiorly -separated from the abdominal cavity by the diaphragm

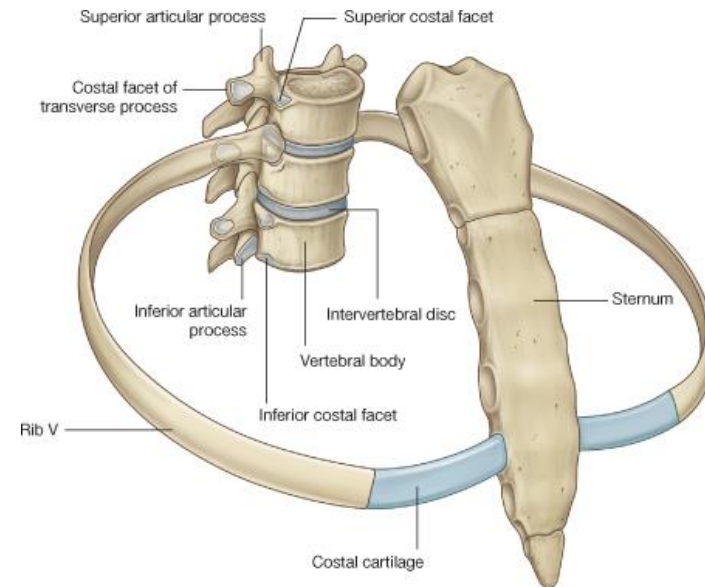


- Thoracic cavity has 03 main compartments
- Right and left pleural cavities containing the lungs
- Mediastinum containing the heart and great vessels
- Mediastinum separates the two pleural cavities
- Clinical importance ?



Thoracic wall

- Consists of skeletal elements and muscles
- Posteriorly – 12 thoracic vertebrae and intervening intervertebral discs
- Laterally – 12 pairs of ribs and 03 layers of flat muscles
- Anteriorly - Sternum

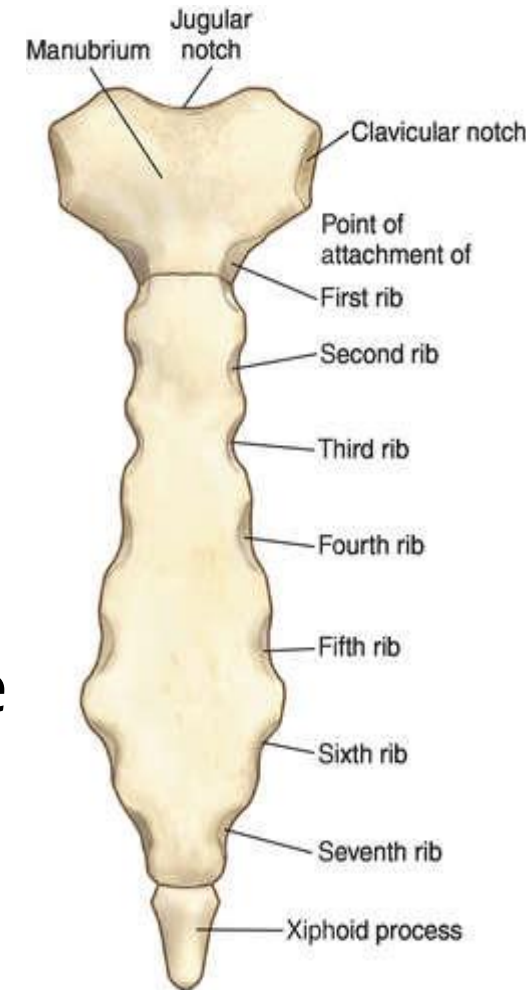


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Anterior boundary of the chest-Sternum

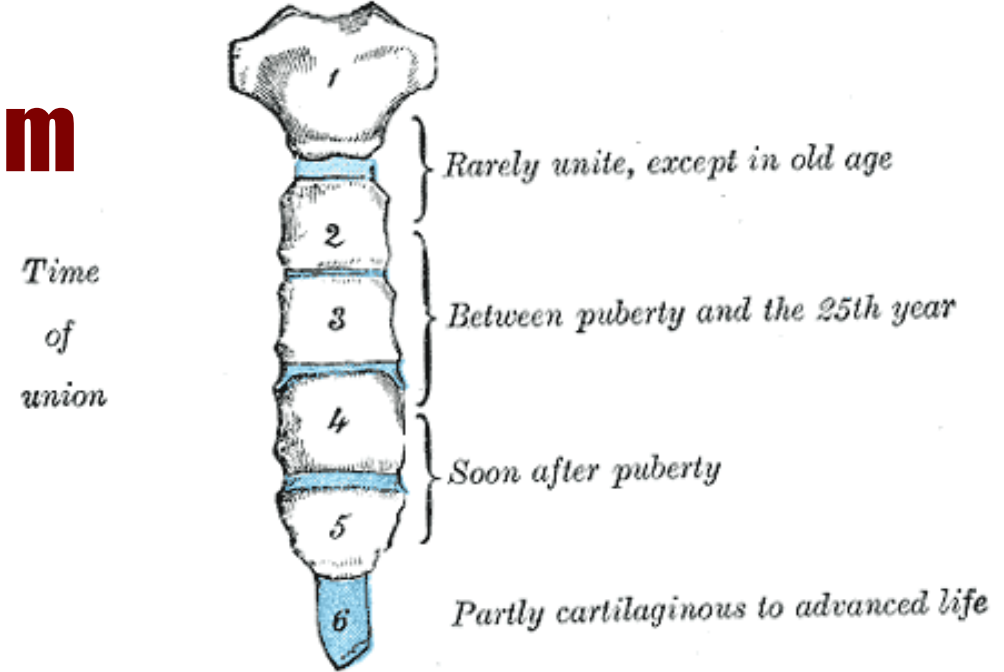
- Long, flat, bony plate that forms the most anterior part of the rib cage.
- Primary function of the sternum is the protection of the heart, lungs, and blood vessels from physical damage.
- The sternum is made of the manubrium, the body, and the xiphoid process.
- Highly vascular and covered with a thin layer of compact bone providing a degree of flexibility.



Anterior boundary of the chest-Sternum

Function of the Sternum

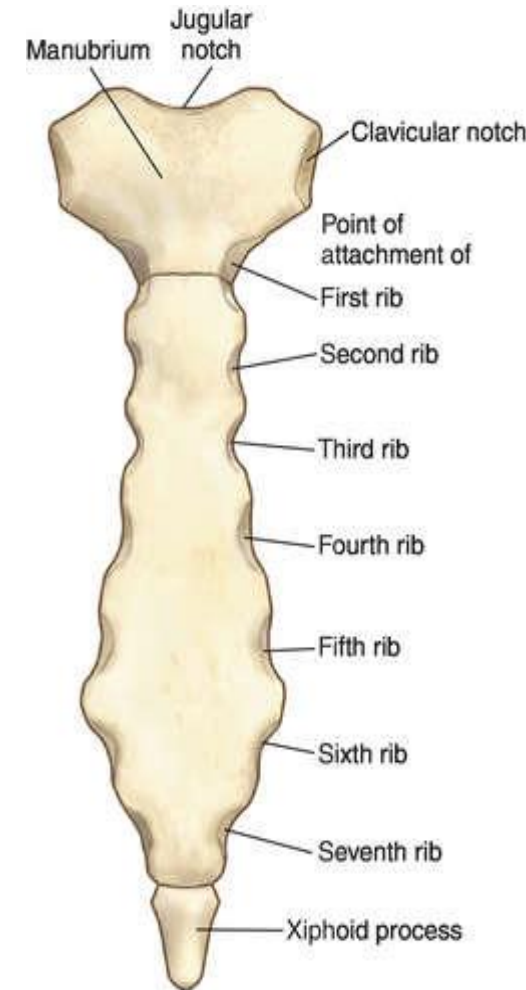
- Together with the anterior ribs -helps to protect the heart and lungs from damage,
- Facilitates the expansion and contraction of the thoracic cavity during respiration.
- During development the sternum is comprised of 4 individual ossification centers, which fuse to form the sternum in adulthood.
- Centers of ossification appear in the sternum before birth
- A site for bone marrow aspiration.



Anterior boundary of the chest-Sternum

The sternum is divided into three regions:

- The manubrium.
- The Body
- The xiphoid process.



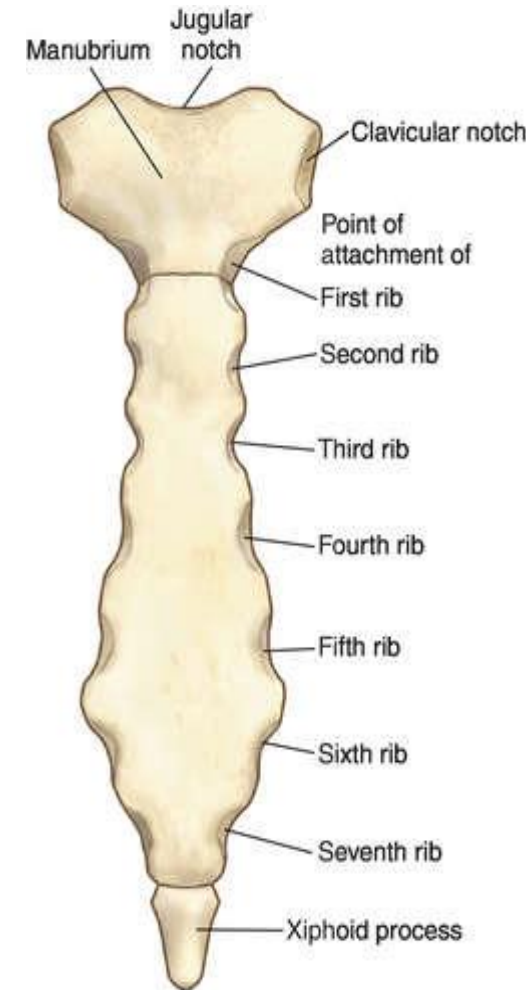
Anterior boundary of the chest-Sternum

Manubrium

- Most superior region of the sternum
- Articulates with the clavicles and the first pair of ribs.
- Thickest portion of the sternum as it carries the greatest physical load

Body

- Longest portion of the sternum
- Articulates with the ribs, Either directly or indirectly, through the costal cartilages



Lateral boundary of the chest-Ribs

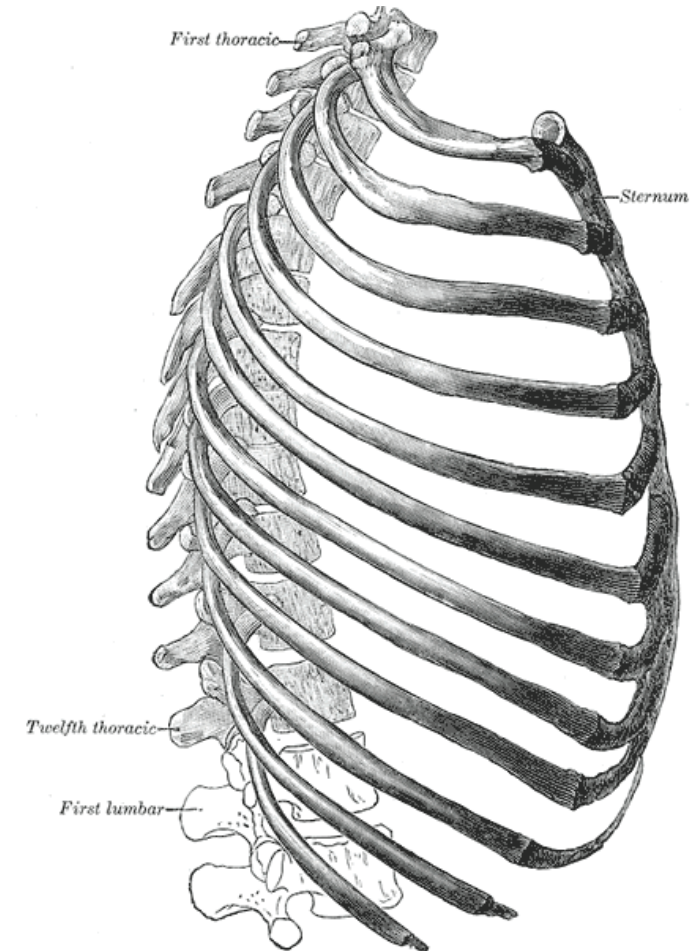
- Articulating from the spine, the majority attach to the sternum either directly or indirectly.
- 12 rib pairs.
- 1-7 (True ribs)directly attach to the sternum through the costal cartilage
- 8–10 attach next higher cartilage and then to the sternum.
- 11–12 (floating ribs) –anterior ends are free- do not attach to sternum.



Lateral boundary of the chest-Ribs

Structure of a Rib

- Consists of a head, neck, and shaft.
- Head -most posterior region of the rib and articulates with the vertebral column.
- Neck- Provides an attachment point for muscles located within the back.
- Shaft -curves around the thoracic cavity forming the rib cage.



Lateral boundary of the chest-Ribs

Home work

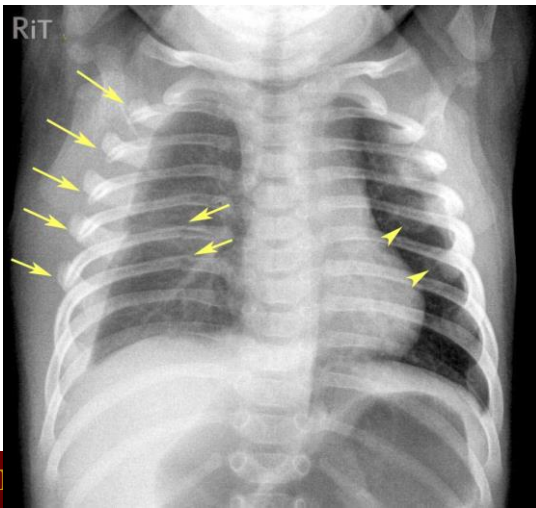
- Briefly describe the anatomical features of a typical rib using a diagram (40 marks)
- Briefly describe the first rib and its attachments (30 marks)



Lateral boundary of the chest-Ribs

Clinical points

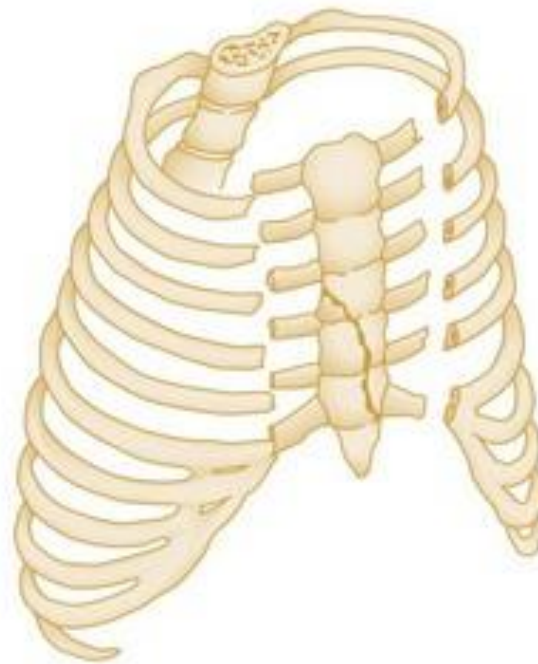
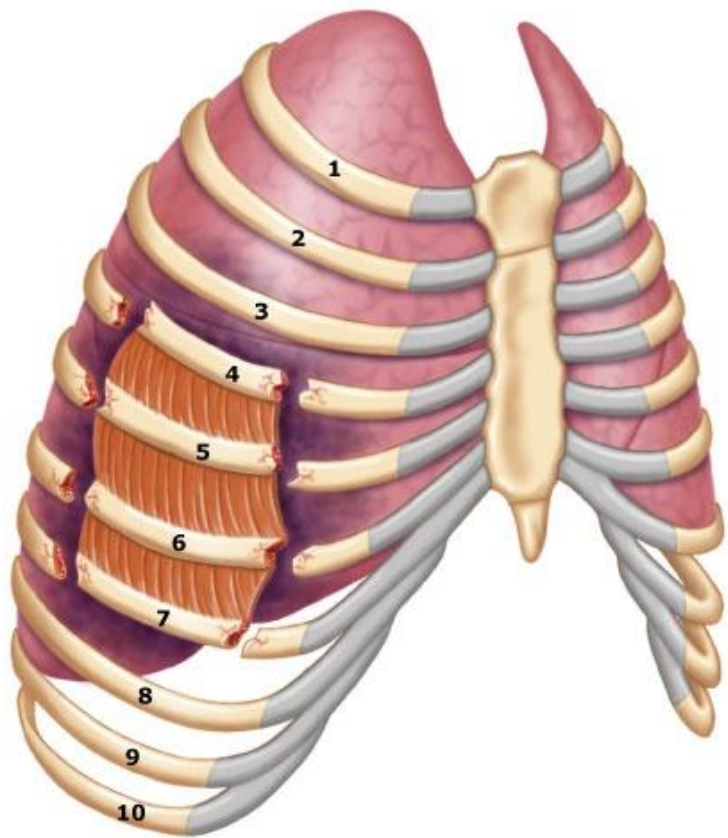
- Weakest area of the rib is its angle- Common site for fracture
- Cervical Rib- 0.5 % -May cause pressure on lower trunk of brachial plexus
- Rickets – deposition of unmineralised bone at costochondral junctions
“Rachitic rosary”
- ≤ 11 ribs – A Feature of Downs syndrome



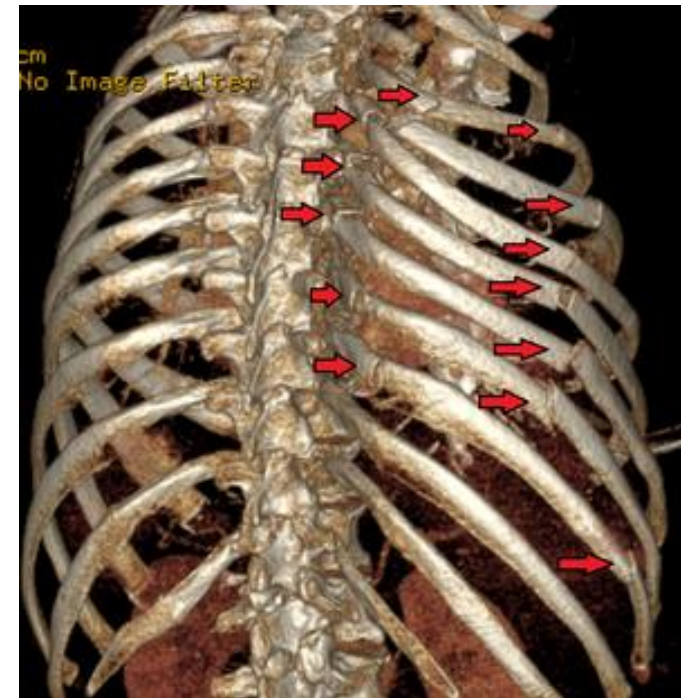
Flail chest

- Usually caused by blunt chest trauma
- Occurs when two or more ribs are fractured at two or more places
- Rarely occurs when two or more ribs fractured at one place with an associated sternal fracture
- The fractured segment loses the bony continuity with rest of the thoracic wall





Flail chest



- The fractured segment show paradoxical movements with rest of the chest
- It goes in during inspiration or stays still when rest of the chest expands, showing a relative indrawing
- The segment of the lung beneath can not expand as the rest of it, causing poor ventilation of that part
- Blood flows as usual in to the affected segment
- Causes a V/Q mismatch-Poor ventilation of a well perfused segment
- Results in a pathological shunt



- Management is usually with administration of Oxygen, adequate analgesia and physiotherapy
- Ventilation is reserved for cases going in to respiratory failure despite conservative measures
- Surgical correction is not commonly done
- Surgical stabilization and fixation is used in extreme cases with massive chest injuries and severe lung contusions

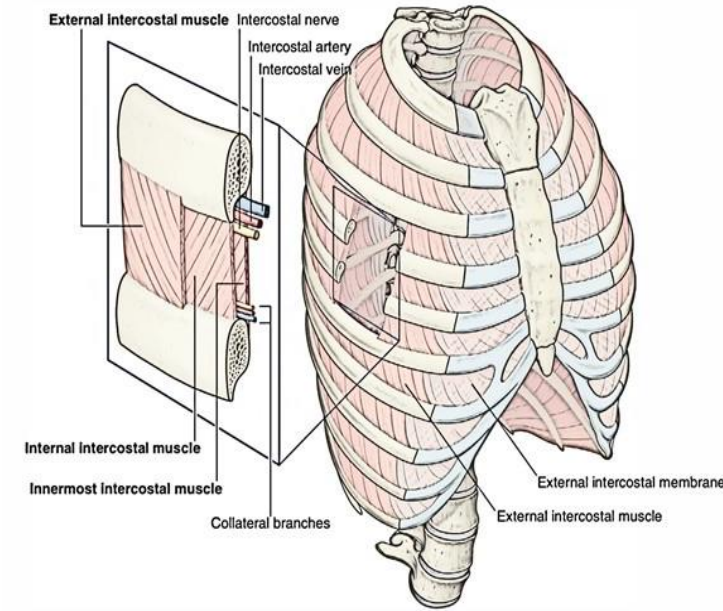


Muscles of chest wall

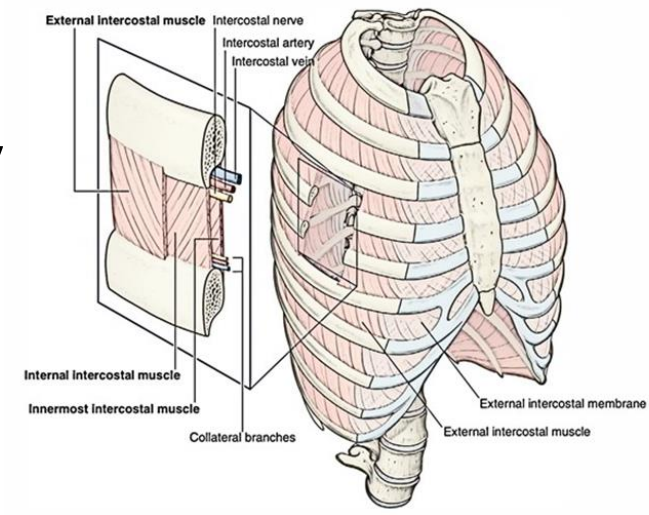
- Typically each space contains three muscles
- Each space has an associated neurovascular bundle

1. External intercostal muscles

- Fibers pass downwards and forwards from the rib above to the rib below
- Extend from the tubercle of rib posteriorly to the costochondral junction anteriorly.
- Replaced anteriorly by the anterior intercostal membrane



- Innervated by **intercostal nerves - T1-T11**
- Mostly active during **inspiration**; Moves the ribs superiorly
- Supports the intercostal spaces



2. Internal intercostal muscles

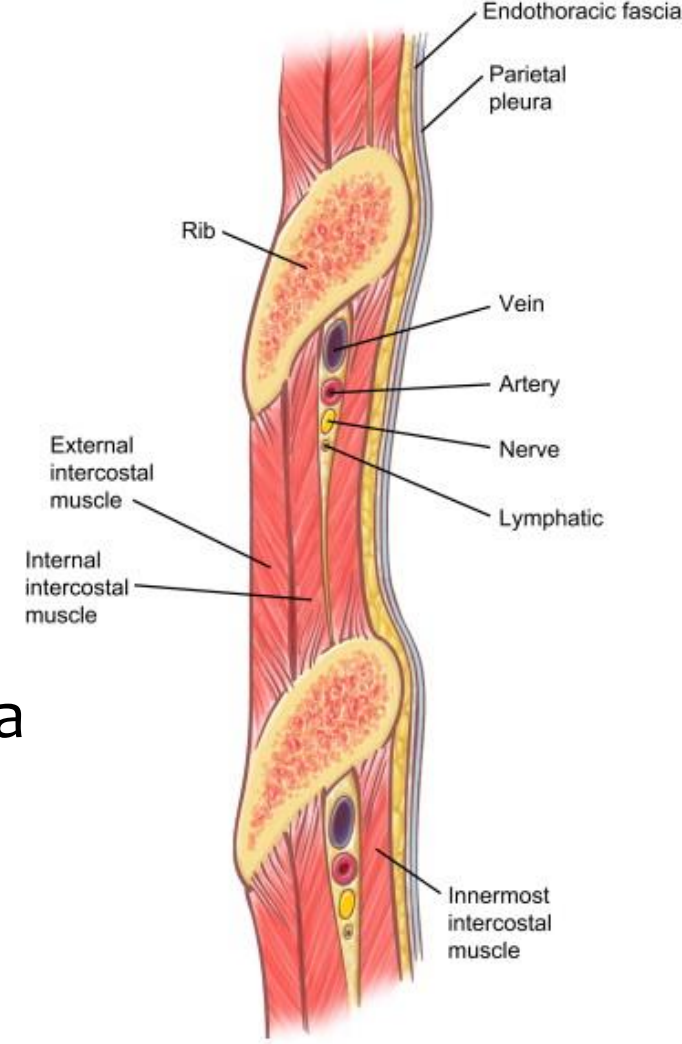
- **Runs downwards and backwards** from the rib above to the rib below
- From the sternum to the angles of the ribs
- Posteriorly it becomes the **posterior intercostal membrane**



- Innervated by intercostal nerves; T1-T11
- Mostly active during **expiration**; moves the ribs inferiorly
- Supports intercostal space

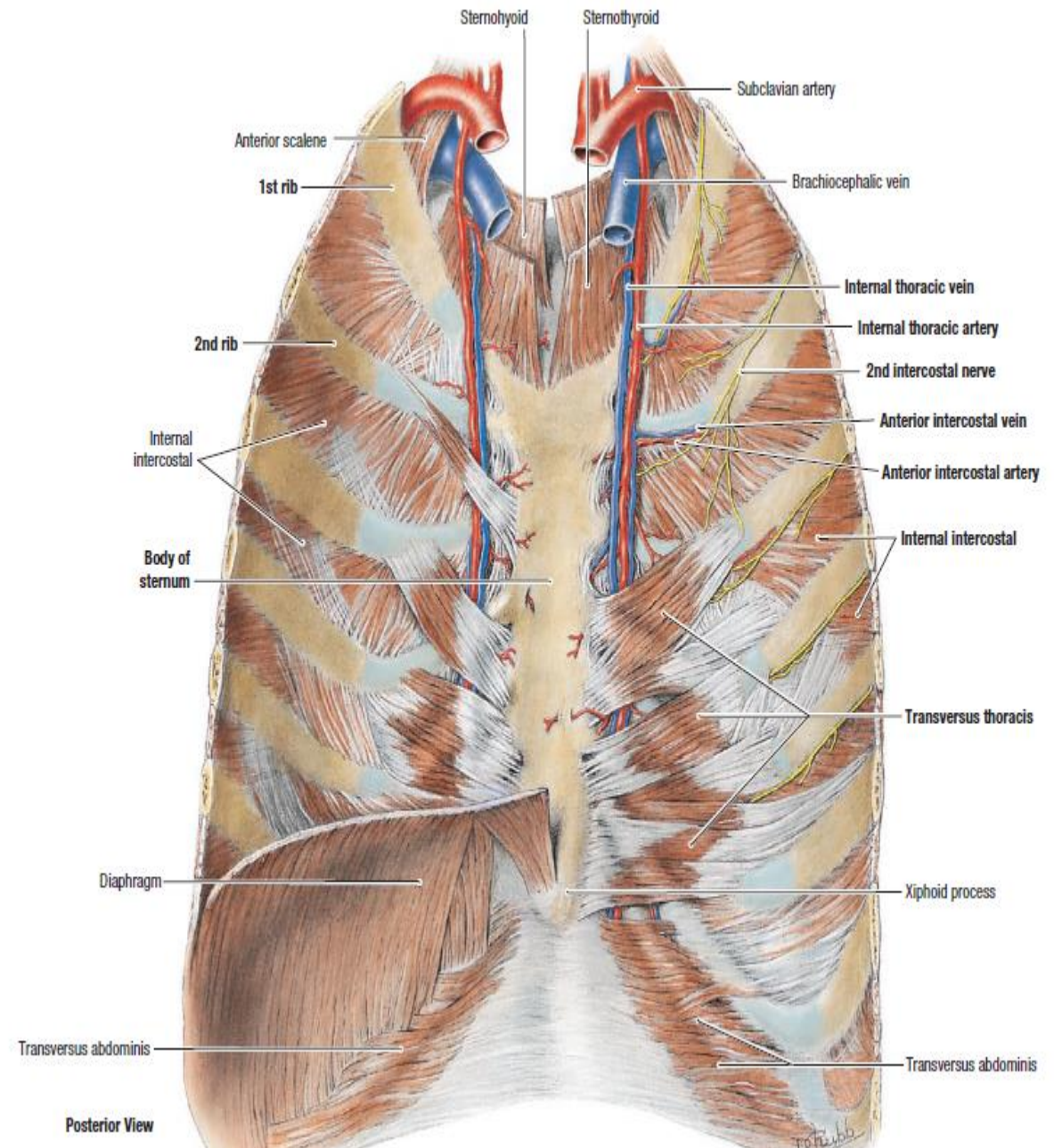
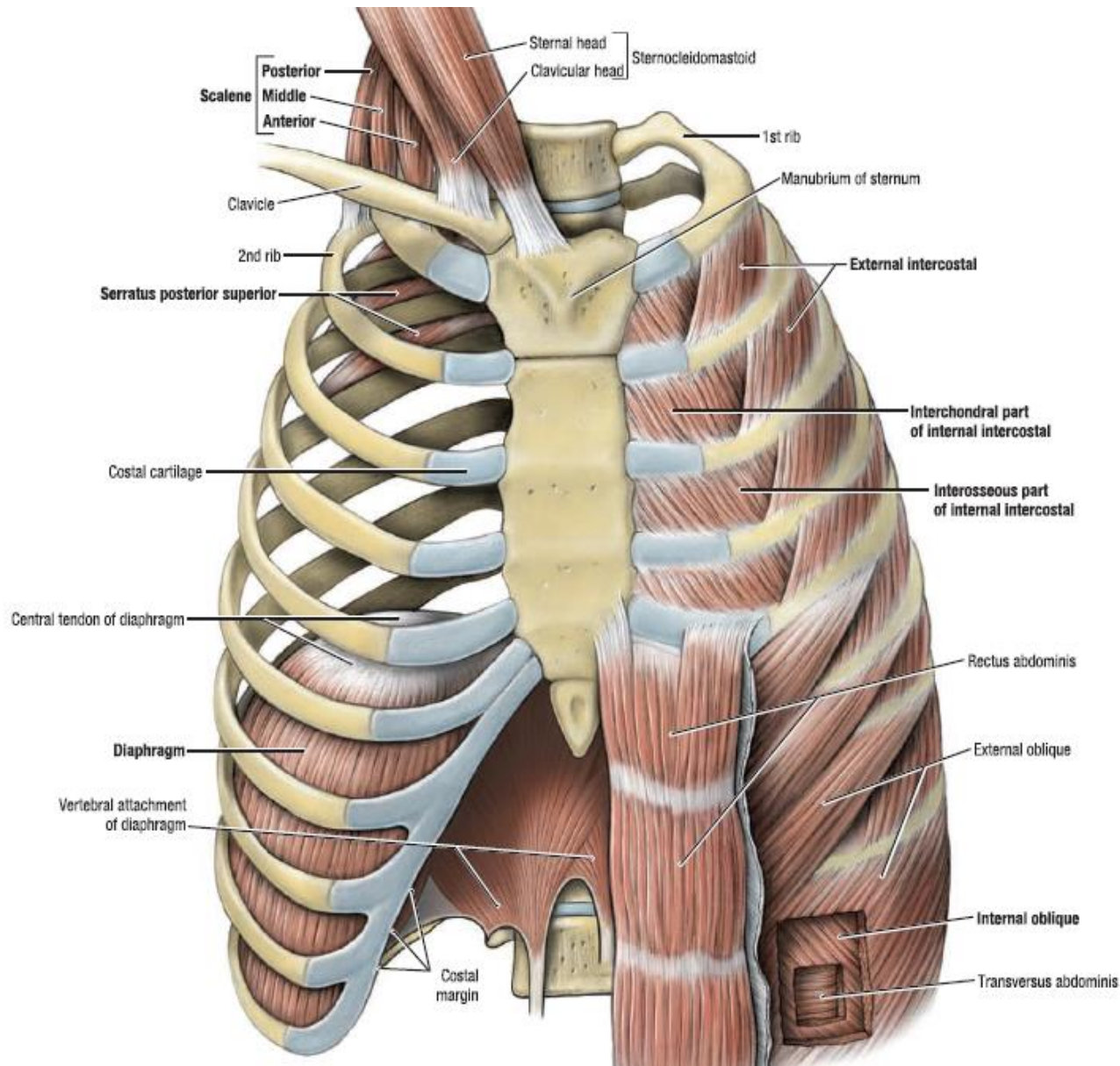
3. Innermost intercostal muscles

- Only incompletely separated from the internal intercostal muscle by the neurovascular bundle
- Fibers **cross** more than one intercostal space
- May be incomplete
- Probably the weakest of the intercostal muscles.

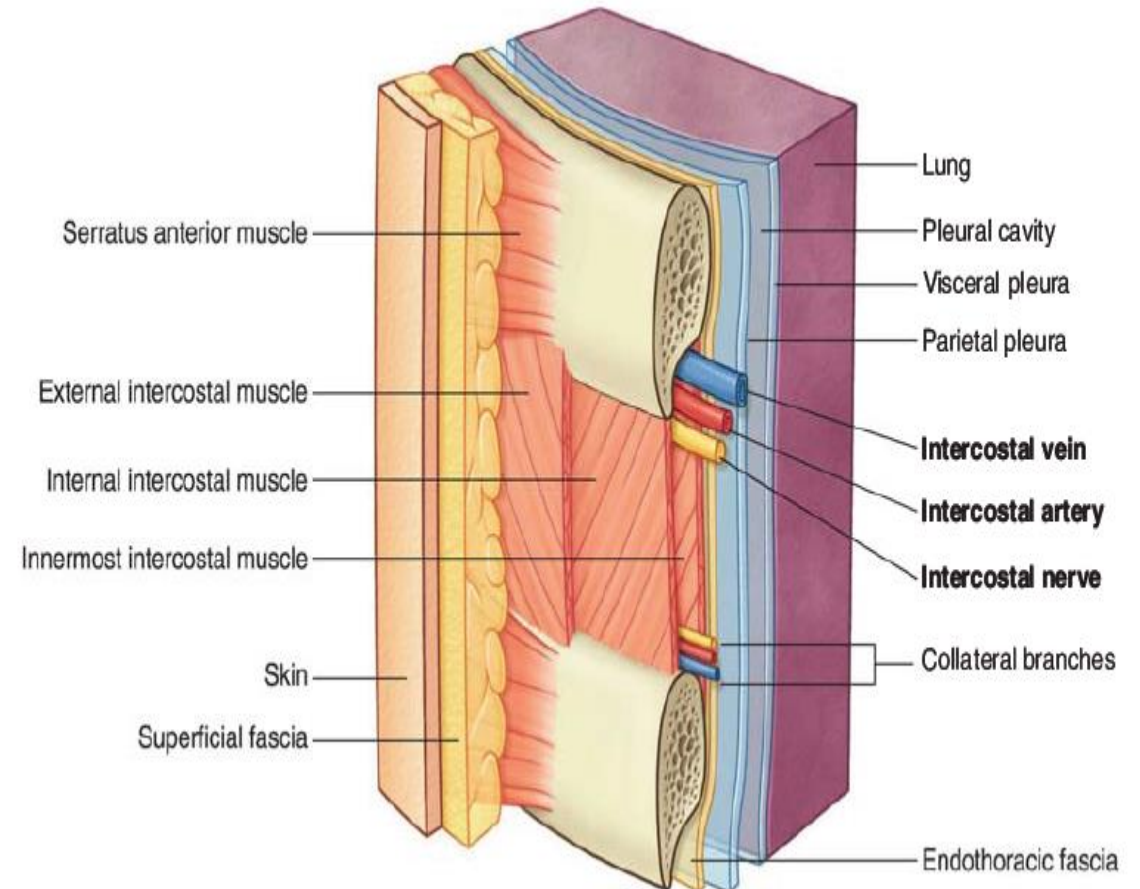
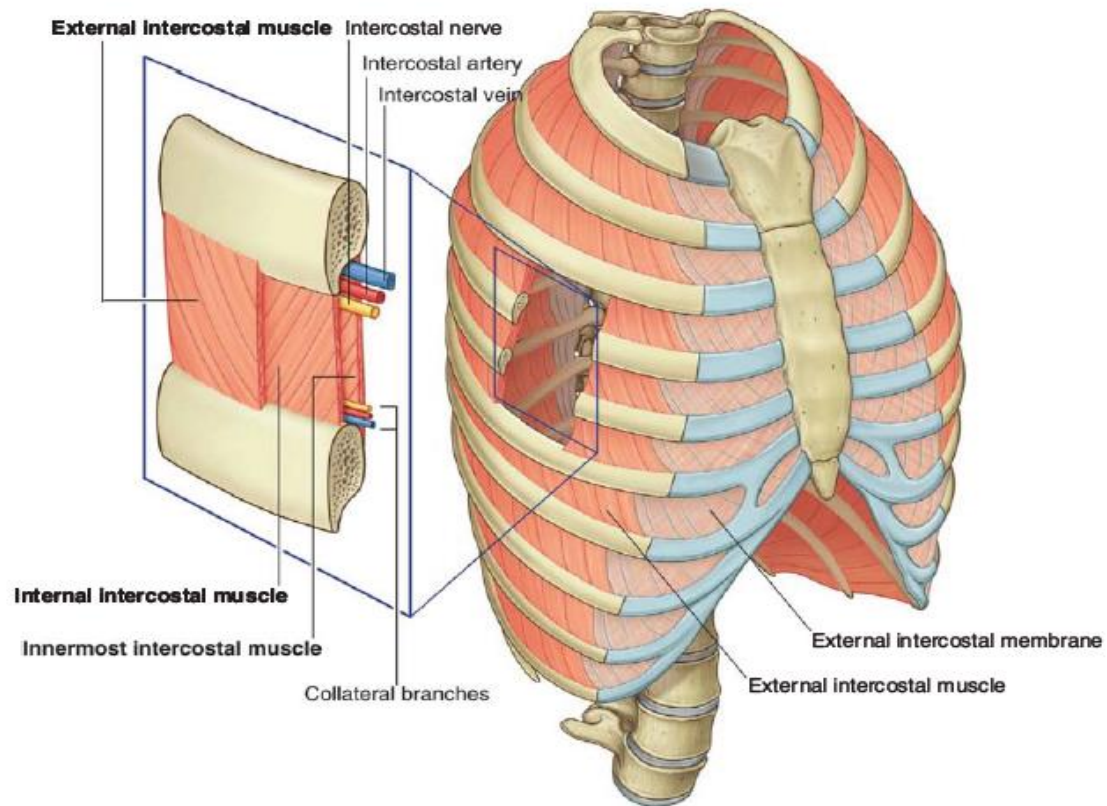


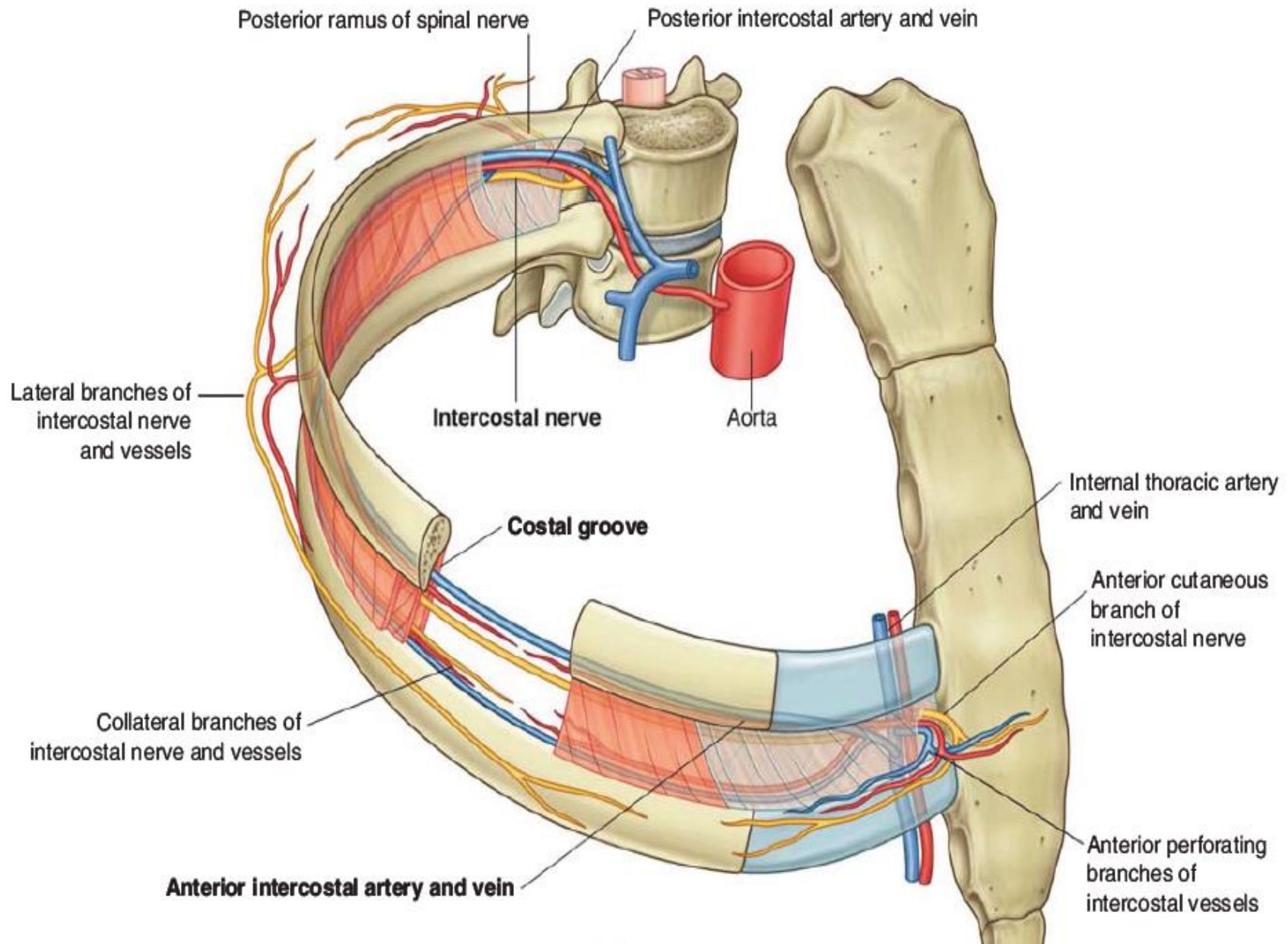
- Spreads **upwards** from the posterior aspect of the lower sternum to insert onto the inner surfaces of the 2nd to the 6th costal cartilages
- Innervated by intercostal nerves - T1-T11
- Contraction causes ,
 - Reduction in volume of the thoracic cavity in the transverse dimension
 - Expelling air from the lungs during inspiration.





- The nerves and vessels of the thoracic wall lie between the middle and innermost layers of muscles.
- From above downwards, of vein, artery and nerve (VAN) the vein lying in a groove on the undersurface of the corresponding rib



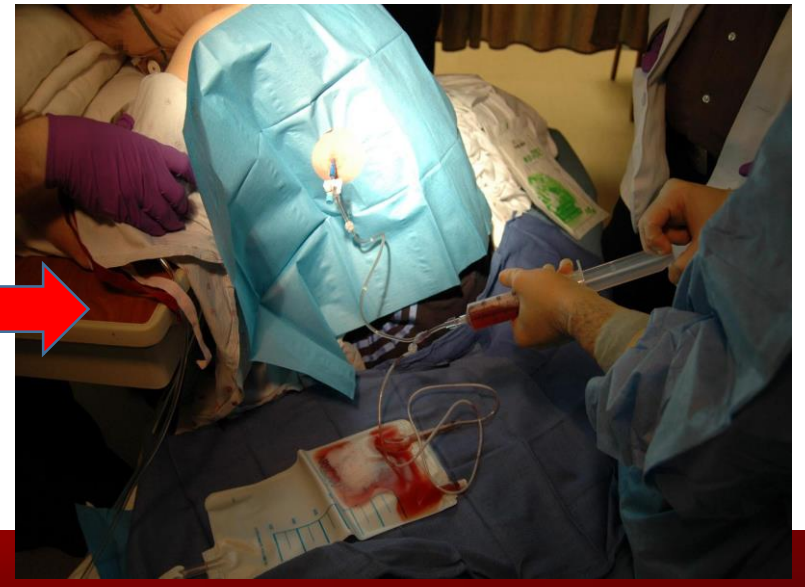
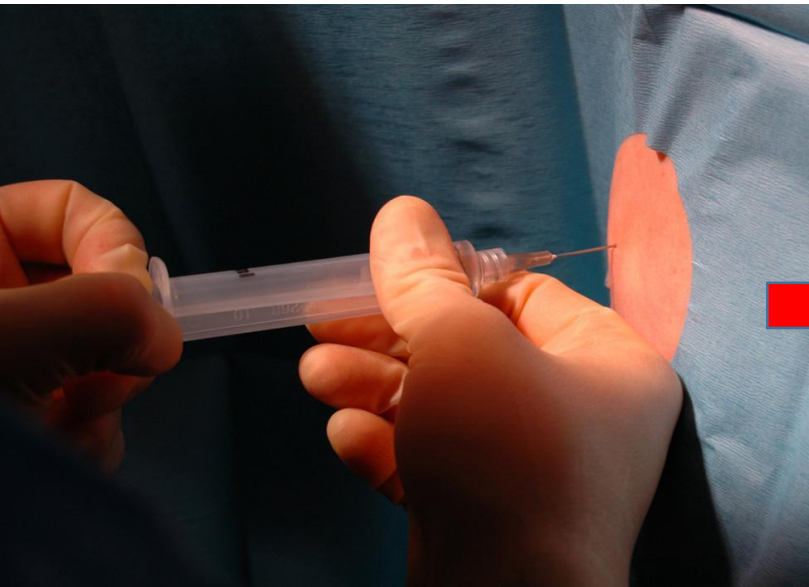
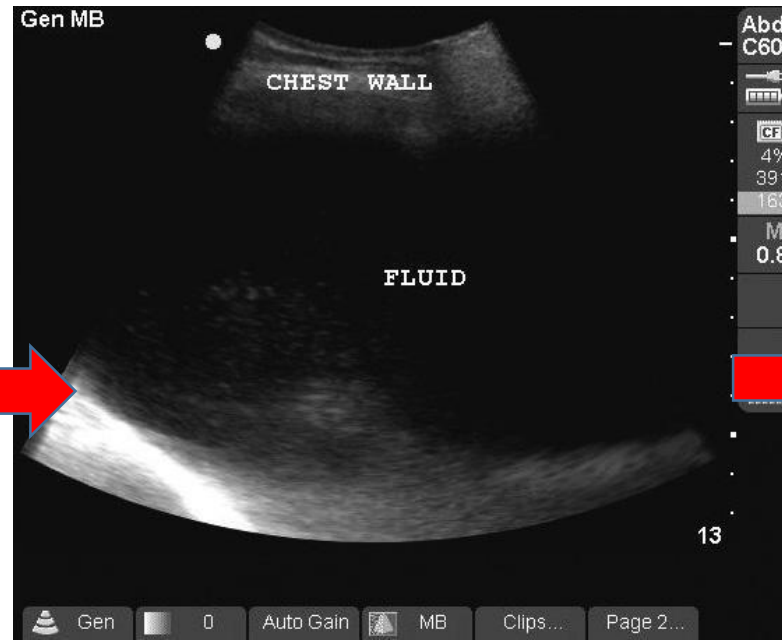
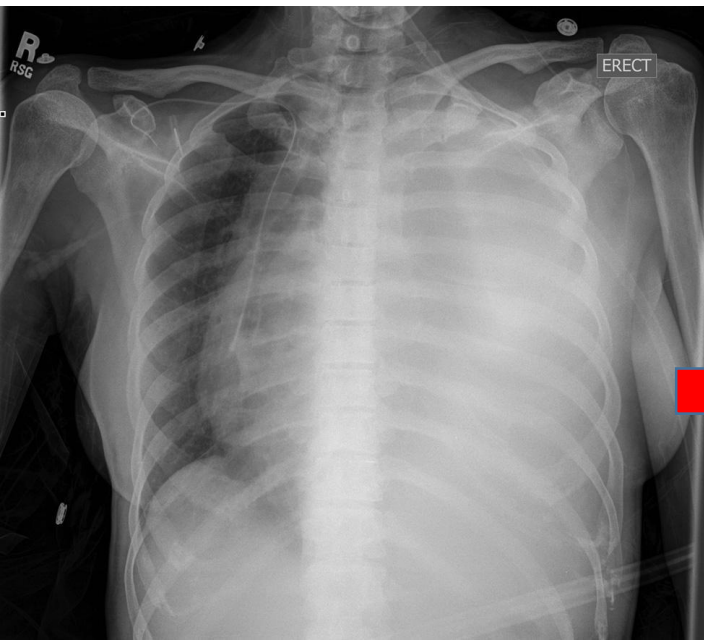


Pleural Aspiration

- Indication : Pleural effusion (For diagnostic or therapeutic),Empyema
- The optimal puncture site may be determined by searching for the largest pocket of fluid
- Between the 7th and 9th rib spaces
- Between the posterior axillary line and the midline



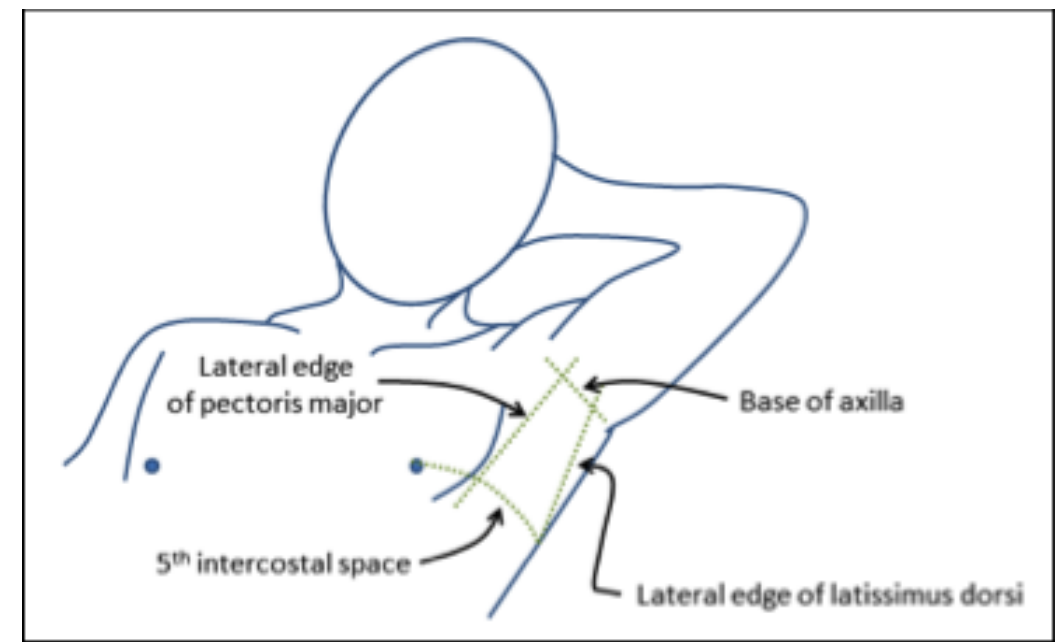
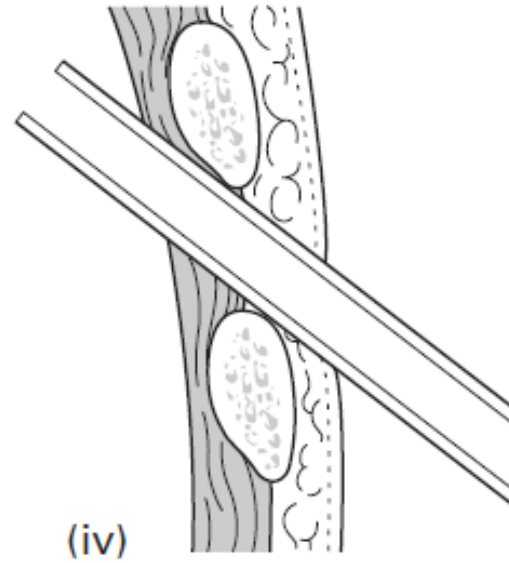
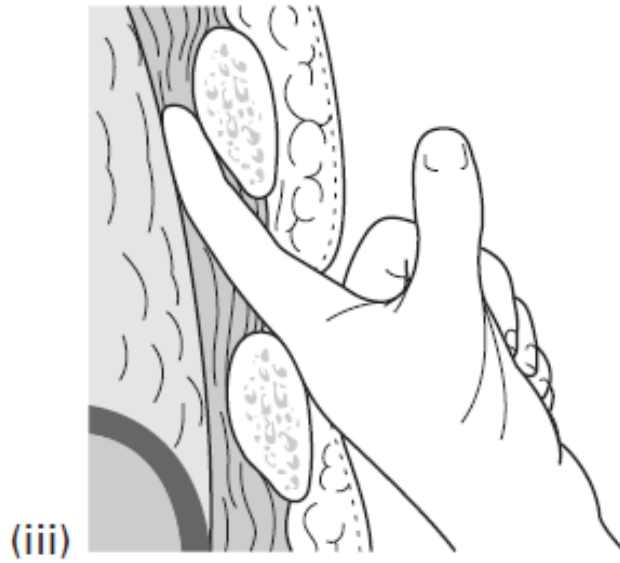
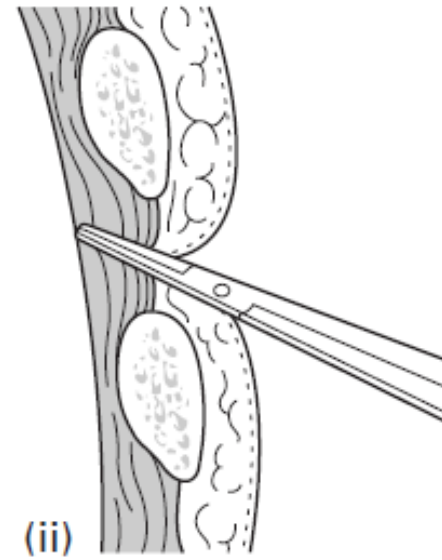
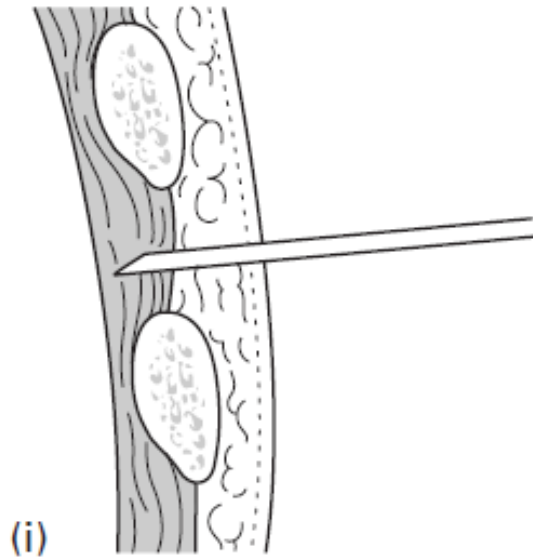
Pleural Aspiration



Insertion of an emergency chest drain

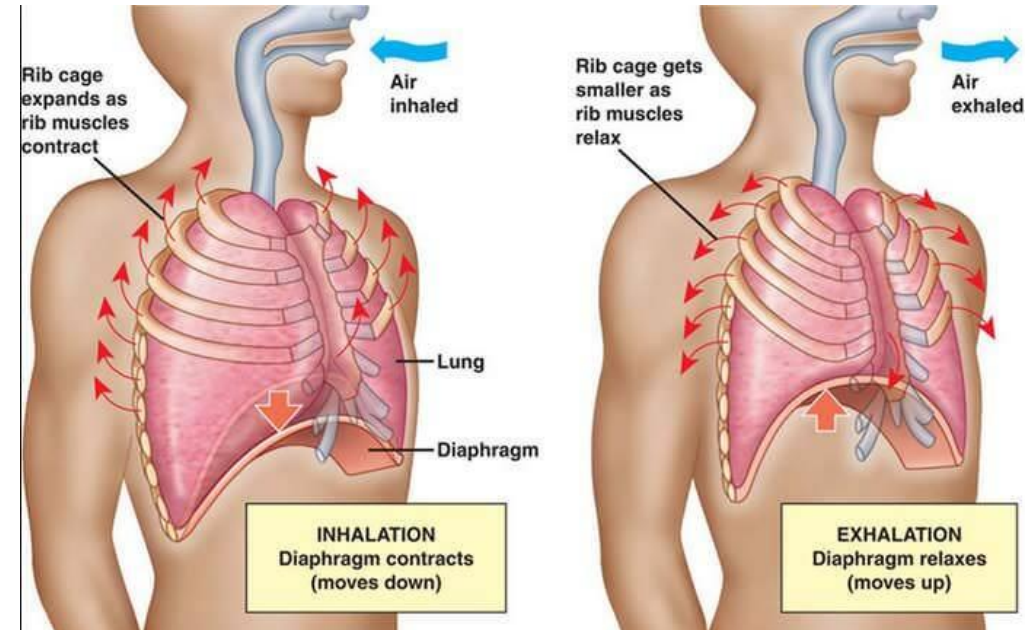
- For emergencies like haemothorax and pneumothorax
- Performed through the 5th intercostal space in the midaxillary line
- Incision is made through the skin and subcutaneous tissue
- Incision is placed closer to the upper edge of the lower rib
- This avoids potential damage to the intercostal neurovascular bundle





Mechanics of ventilation

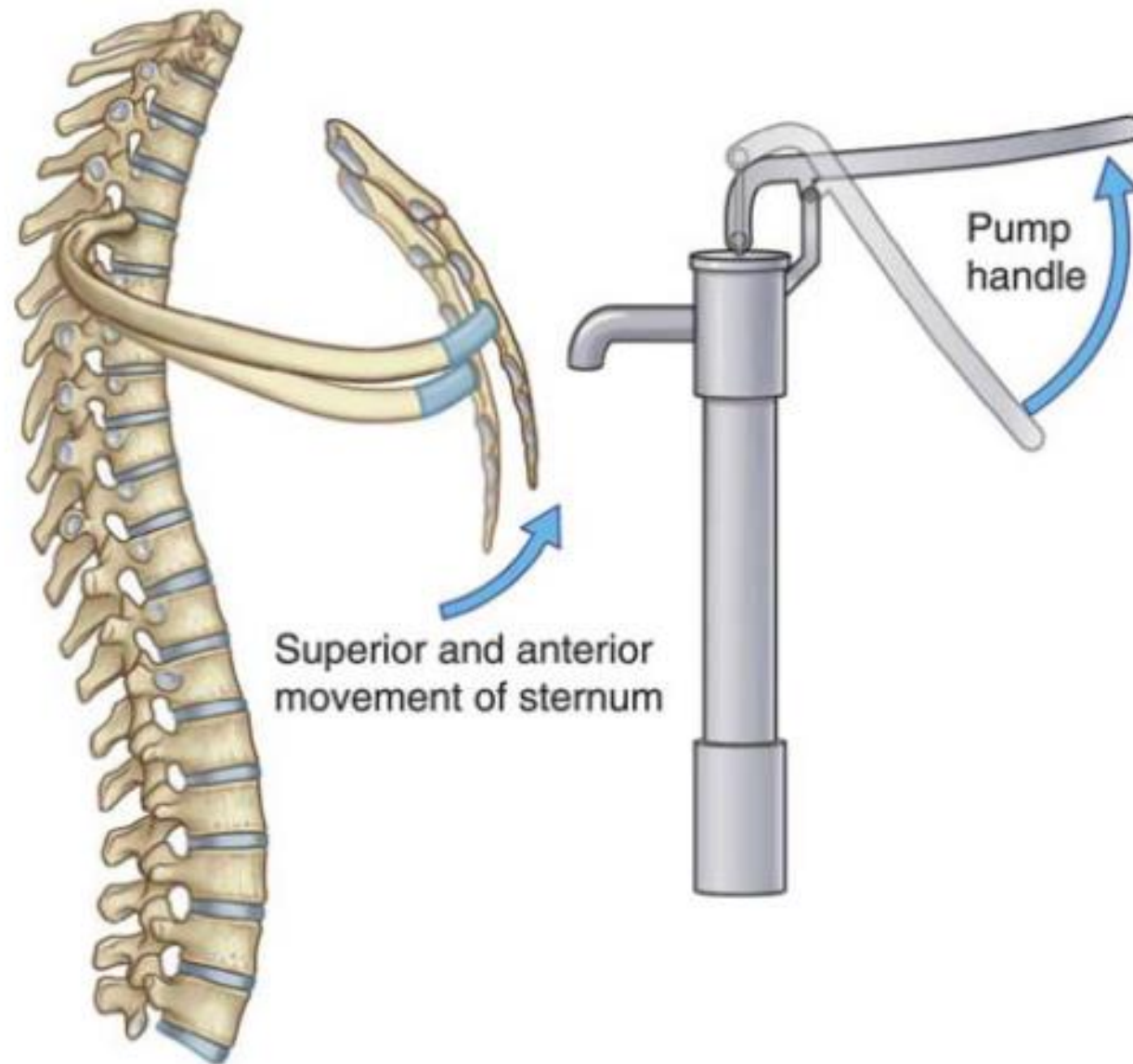
- Contraction of intercostal muscles and diaphragm increases the intra thoracic volume
- The intra thoracic pressure drops than atmospheric pressure
- Air flows in according to pressure gradient
- Reverse happens during expiration



Mechanics of ventilation

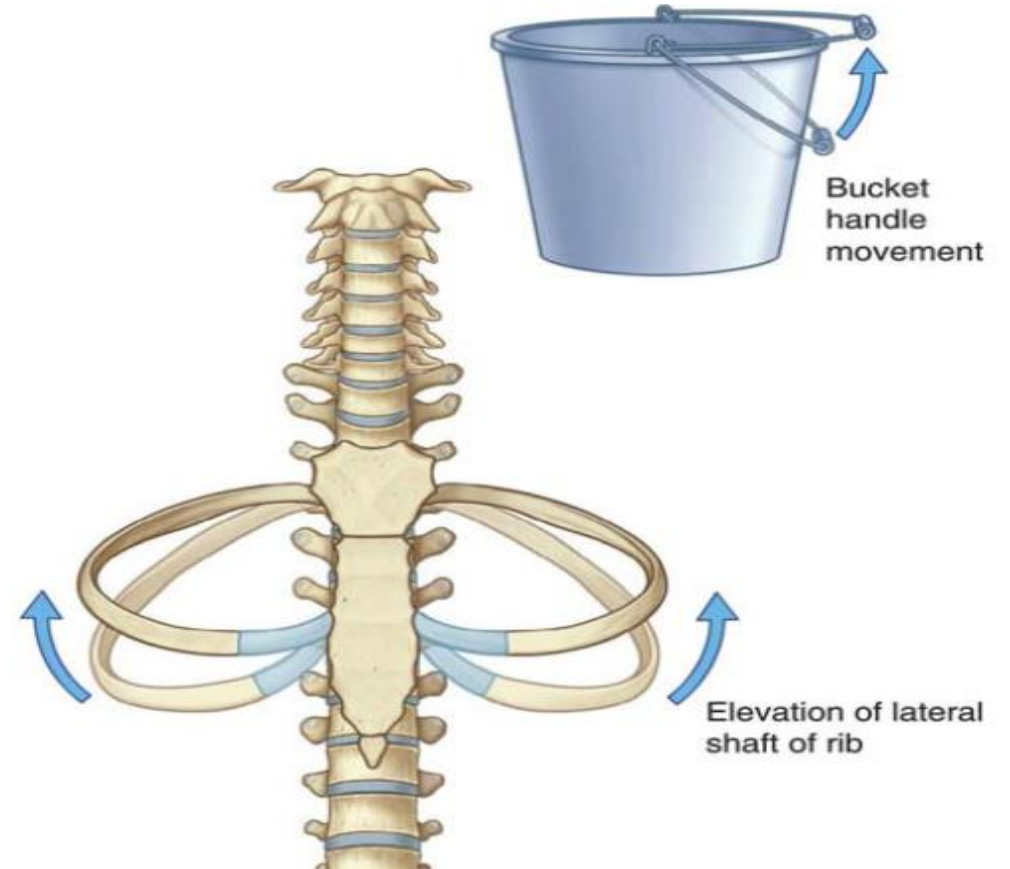
- Anterior ends of ribs are inferior to posterior ends
- When the ribs are elevated, sternum is moved upwards and forwards
- When they depress, sternum moves downwards and backwards
- This movement is called “pump handle” movement
- It changes the antero-posterior dimensions of the thorax





Mechanics of ventilation

- Middle of the shafts of ribs tend to be lower than the two ends
- When the shafts are elevated, the middles of the shafts move laterally
- This is termed “bucket handle” movement
- Increases the lateral dimensions of the thorax



In normal quiet inspiration

External intercostal muscles actively contract



Ribs and sternum move upwards and outwards



Width of chest increases from side to side and depth from front to back increases



Diaphragm contracts, length of chest increases



Pressure between pleural surfaces (already negative) becomes more negative: from -2 to -6 mmHg



Air is sucked into alveoli from atmosphere because of pressure difference



In normal quite expiration

External intercostal muscles relax



Ribs and sternum move downwards and inwards



Width and depth of chest diminishes



Diaphragm relaxes – ascends – length of chest diminishes



Capacity of thorax is decreased.



Pressure between pleural surfaces becomes less negative, from -6 to -2 mmHg



Air is forced out of alveoli to atmosphere



In forced inspiration

Extensors of vertebral column may aid inspiration



Muscles of neck (sternocleidomastoids) contract



Move 1st rib upwards and sternum further upwards and forwards



Further increases the dimensions of the thorax creating more negative pressure



Air is forcefully sucked in



In forced expiration

Internal intercostal may contract



Move ribs downwards more actively.



Abdominal muscles contract



Actively aid ascent of diaphragm



Intra thoracic volume is reduced much more than usual



Negativity of intra thoracic pressure is greatly reduced, positivity is further increased



Air is forced out of lungs



THANK YOU

