

**Al-Mustaqbal University  
College of Medicine  
Department of Anatomy**



**LECTURES IN GROSS AND CLINICAL ANATOMY  
FOR 1<sup>ST</sup> YEAR MEDICAL STUDENTS.**

**BY**

**PROF. DR. NEMAH HASSONE MAHDI**

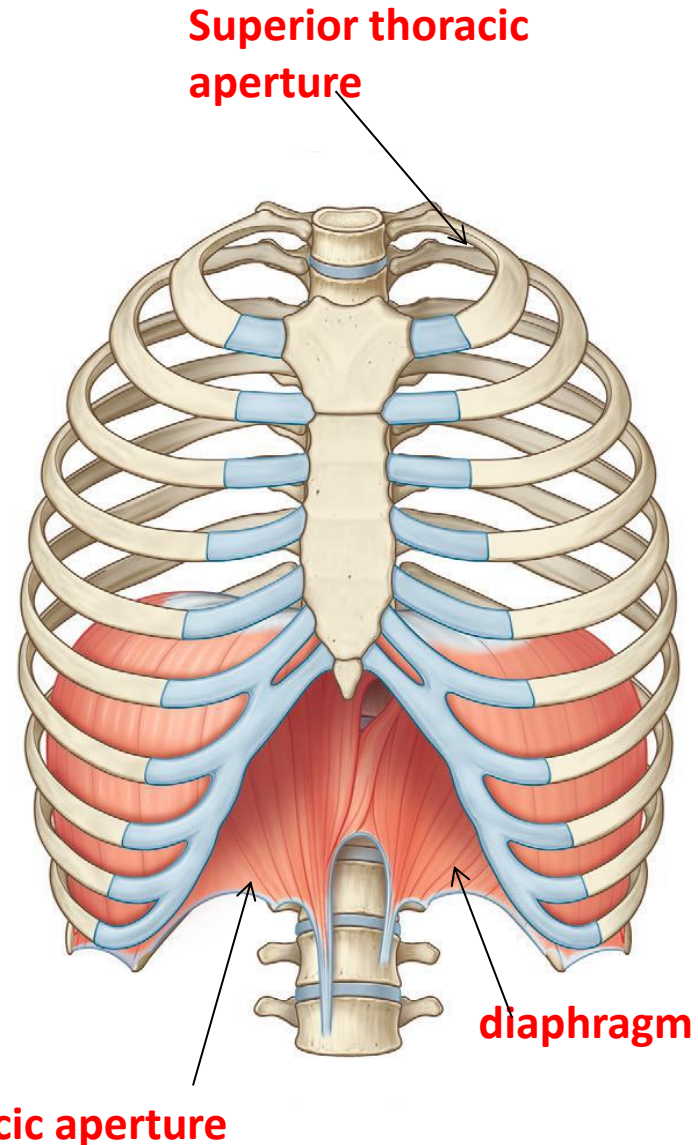
# The Thorax

## 1. The thoracic wall

### Introduction

The chest, or thorax is the region of the body that lies between the neck and the abdomen. It is an irregular shaped cylinder, flattened in front and behind, but rounded at the sides. The Thorax has **two openings: Superior thoracic aperture (thoracic inlet)** and Inferior thoracic aperture (**thoracic outlet**). The thoracic wall is covered exteriorly **by skin and muscles** and interiorly is **lined with parietal pleura**.

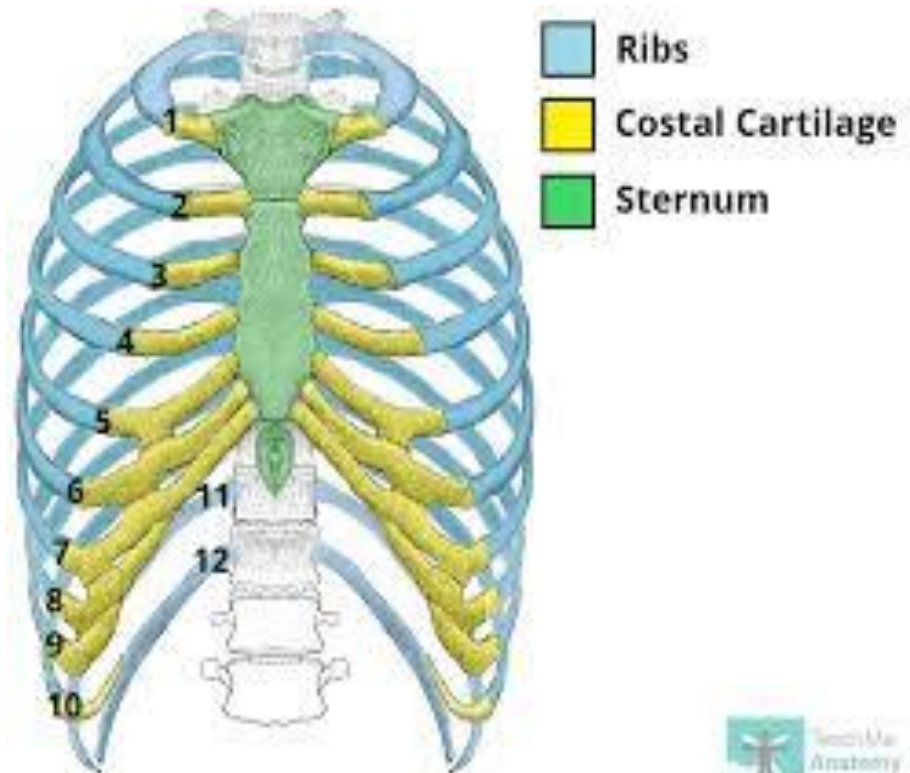
The skeletal framework of the thoracic walls is referred to as the **thoracic cage**.



Inferior thoracic aperture

The bony thoracic wall (**thoracic cage**) is formed; **anteriorly** by the **sternum and costal cartilages**; **posteriorly** by **the Twelve thoracic vertebrae and their intervening intervertebral discs** ; **laterally** by **twelve ribs, and intercostal spaces on each side**; **superiorly** by the **supra pleural membrane**; and **inferiorly** by **the diaphragm**.

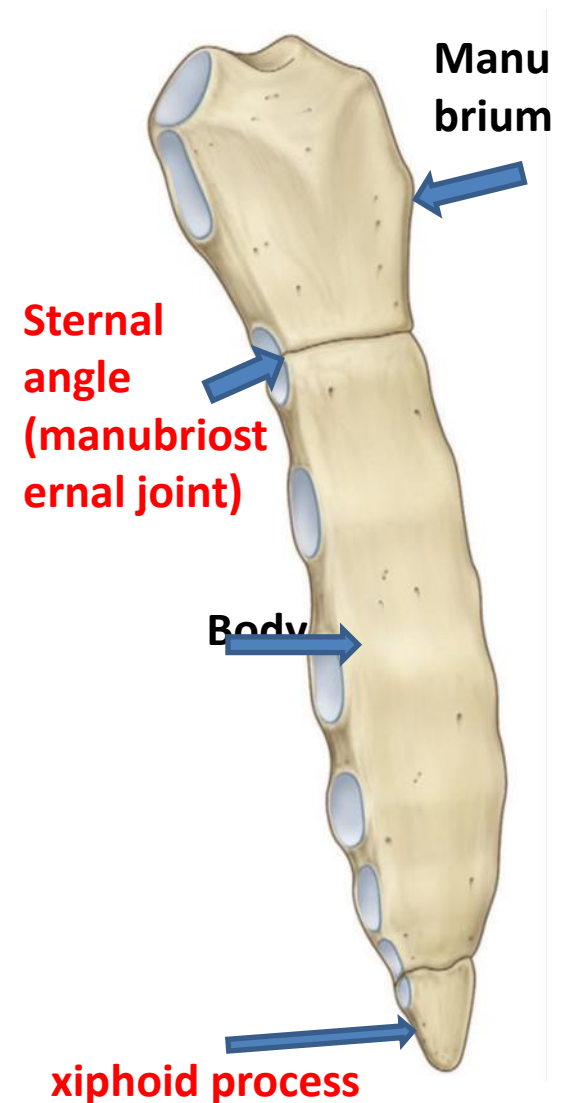
The thoracic cage protects the lungs and heart and provides attachment for the muscles of the thorax, upper extremity, abdomen, and back.



# Sternum

The sternum (*stern-* is Greek for “breast”; “breastbone”) is the elongated, flat bone that lies in the midline of the anterior chest wall. The adult sternum consists of three parts: **manubrium, body, and xiphoid process.**

The **manubrium of the sternum** (*manubri-* is Latin for “handle”) is the upper part of the sternum. It articulates with the body of the sternum at the **manubriosternal joint or sternal angle (angle of Louis)**, and it also **articulates with the clavicles, with the first costal cartilage, and the upper part of the second costal cartilage on each side.**

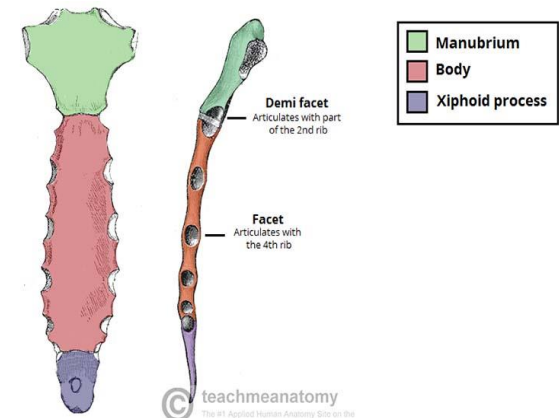
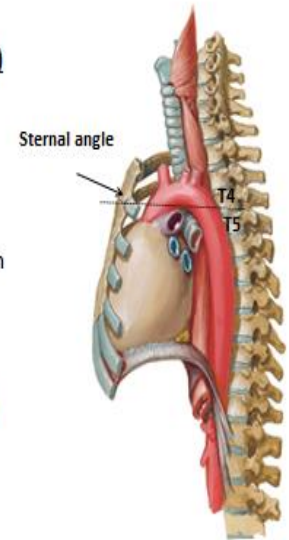


# Clinical and anatomical significance of Sternal angle (angle of Louis)

1. Located opposite the 2nd pair of costal cartilages.
2. Used as a surface landmark in chest examination.
3. Correspond to the level of the **IV disc** between the **T4** and **T5** vertebrae.
4. Located opposite bifurcation of trachea.
5. Used for counting ribs for auscultation and pericardiocentesis.
6. Marking point to know articulation of costal cartilages with the sternum.
7. A horizontal line drawn from it typically projects posteriorly onto the T4 intervertebral disc, and **marks the plane of separation between the superior and inferior mediastina.**

## Sternal angle (Angle of Louis)

- Located opposite the 2nd pair of costal cartilages
- Use as a surface landmark in chest examination
- Correspond to the level of the **IV disc** between the **T4** and **T5** vertebrae



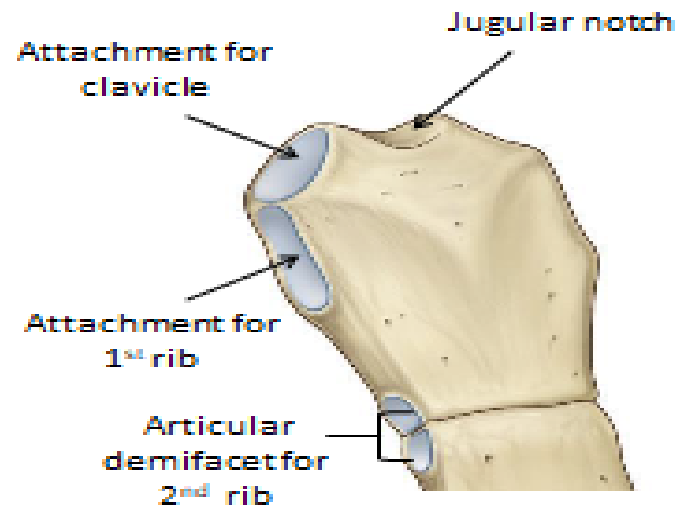
**The suprasternal (jugular) notch** is the easily palpable, concave notch on the superior border of the manubrium.

**The clavicular notch**; each holds the sternal end of a clavicle, is an ovoid articular surface at each superolateral corner of the manubrium, on each side of the jugular notch.

## Manubrium of sternum

### • Depression & facet

- Jugular notch (suprasternal notch)
- Articular site for clavicle (clavicular notch)
- Attachment site (facet) for 1<sup>st</sup> costal cartilage
- Attachment site (demifacet) for upper half of anterior end of 2<sup>nd</sup> costal cartilage



The body of the sternum is the relatively long, transversely ridged, middle part of the sternum. It articulates above with the manubrium at the manubriosternal joint and below with the xiphoid process at the xiphisternal joint

(primary cartilaginous joints). It articulates with the second to the seventh costal cartilages on each side.

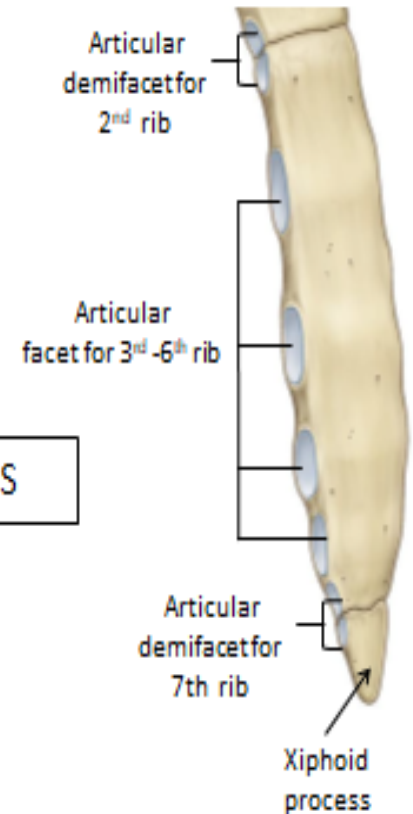
## Important landmarks

### Body of sternum

- At T5 to T9 vertebral level
- Anterior surface-transverse ridges
- Lateral margin:
  - Demifacet for lower half of anterior end of 2<sup>nd</sup> costal cartilage
  - Facet for articulation with 3<sup>rd</sup>-6<sup>th</sup> costal cartilages
  - Demifacet for upper half of anterior end of 7<sup>th</sup> costal cartilage

### Xiphoid process

- At T10 vertebral level
- Smallest, variable shape
- Cartilagenous → ossifies in adult
- Demifacet for lower half of anterior end of 7<sup>th</sup> costal cartilage

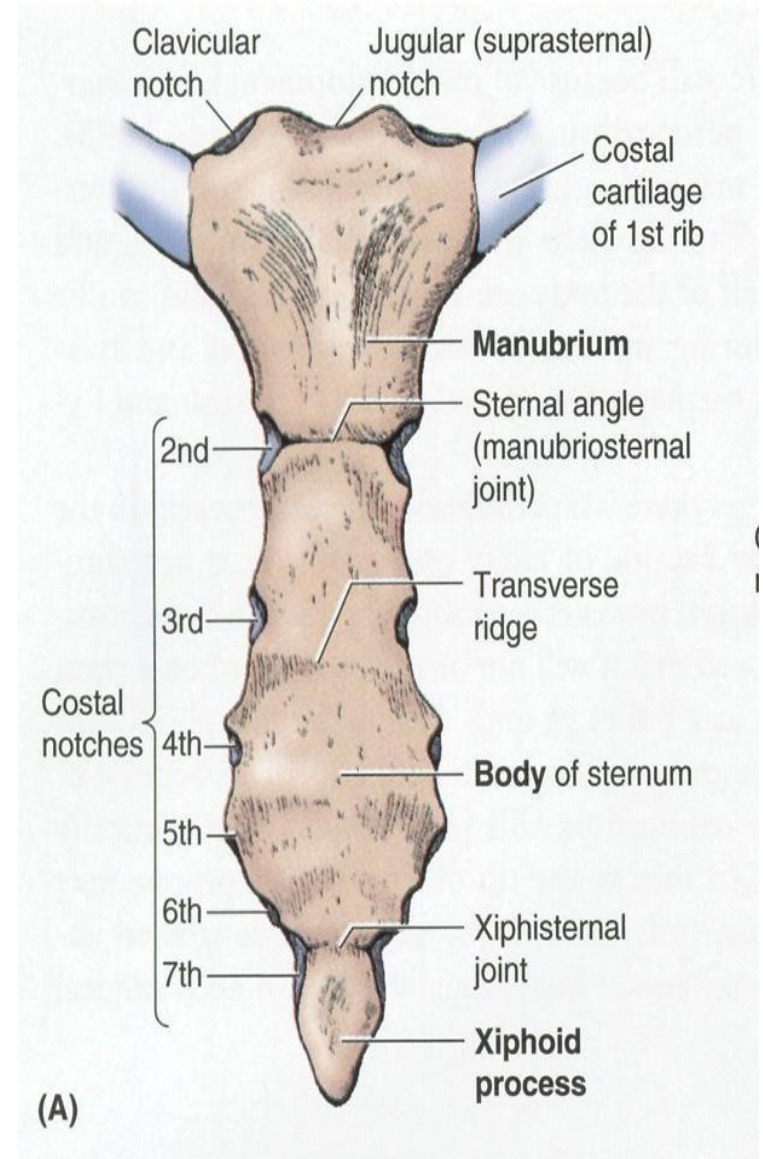




## General features of the sternum

The **xiphoid process** (*xiph-* is Greek for “sword”) is the small, pointed most inferior part of the sternum. It is a **thin plate of cartilage that becomes ossified at its proximal end during adult life**. No ribs or costal cartilages attach to it. However, the seventh costal cartilage may have a shared attachment with the xiphoid process and the body.

The **xiphisternal joint** lies opposite the body of the **ninth thoracic vertebra**. The inferior end of the xiphoid provides attachment for the **linea alba of the abdominal wall**.

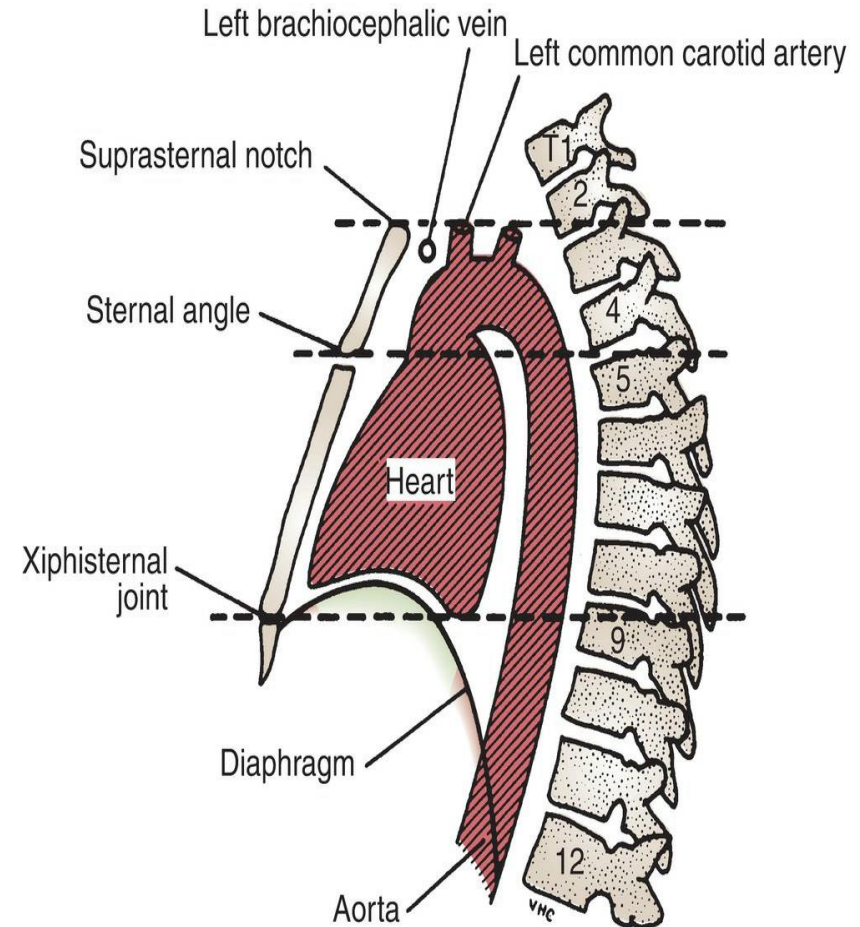




## Clinical Notes

### Sternum and Marrow Biopsy

The sternum is subcutaneous and readily palpable along its entire length. **It possesses red hematopoietic marrow throughout life.** Because of its morphology and shallow depth in the chest, the sternum can be **punctured readily in a needle biopsy procedure** (“sternal puncture”).



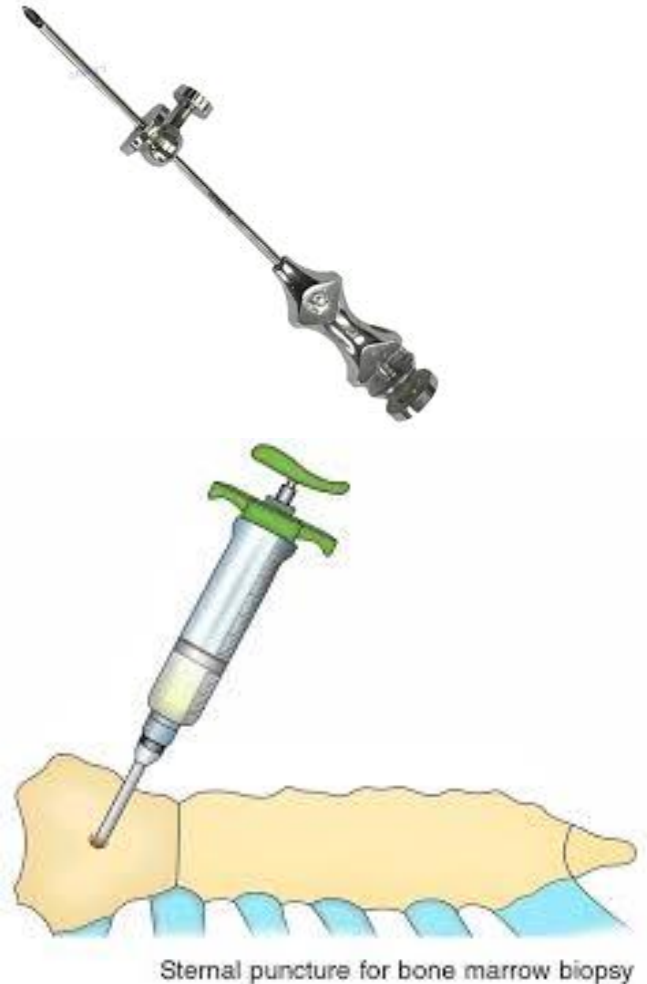
## Sternal Puncture

For aspiration of red marrow, under a local anesthetic, a wide bore needle is inserted into the marrow cavity through the anterior surface of the sternum, and bone marrow is aspirated..

## Sternum Development (embryology)

The adult sternum consists of three parts: **manubrium**, **body**, and **xiphoid process** . Prenatally, it consists of **six** main parts. The first and last parts remain distinguishable as the **manubrium** and **xiphoid process**, respectively. The middle four parts (**sternebrae**) fuse to form the body.

Wide bore needle



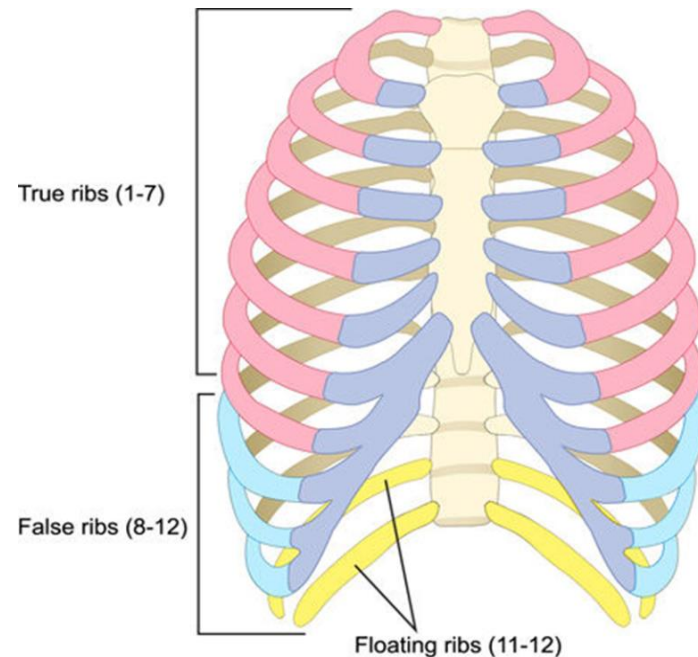
# Ribs

Ribs form a large part of the bony thoracic wall. Normally, both males and females have 12 pairs of ribs. The posterior (dorsal; vertebral) end of each rib articulates with one or two thoracic vertebrae. The anterior (ventral; sternal) ends have variable relations with the sternum that allow the ribs to be categorized as “true” ribs, “false” ribs, and “floating” ribs.

**True (vertebrocostal) ribs** (pairs 1 to 7) are connected directly to the sternum via individual costal cartilages.

**False (vertebrochondral) ribs** (pairs 8 to 10) are connected indirectly to the sternum via individual costal cartilages that join together and attach collectively to the seventh costal cartilages.

**Floating (free) ribs** (pairs 11 to 12) do not attach to the sternum.



## Typical Ribs (3<sup>rd</sup> -9<sup>th</sup> )

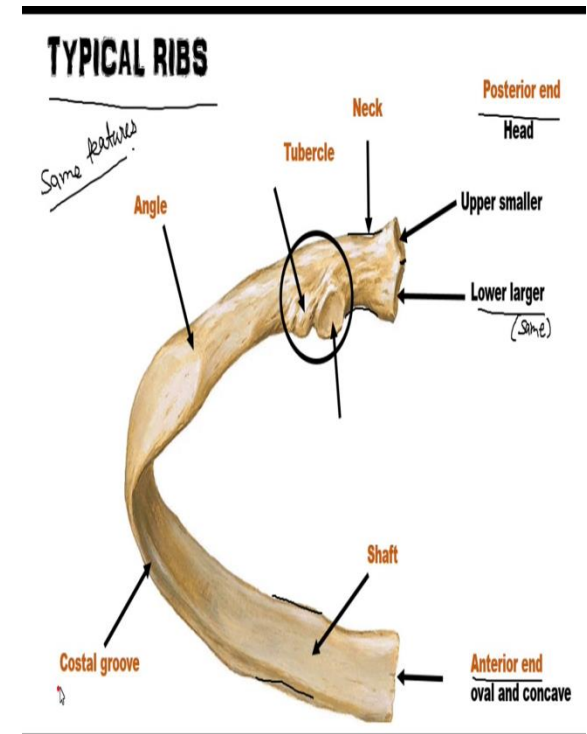
A typical rib is a long, twisted, and flat bone having a rounded, smooth superior border and a sharp, thin inferior border. The anterior end of each rib is attached to the corresponding costal cartilage.

A typical rib has a **head, neck, tubercle, shaft, and angle** .

The **head** is the posterior (vertebral) end of the rib, it is **wedge-shaped and has two facets** for articulation with the **numerically corresponding** vertebral body and that of the vertebra immediately above.

The **neck** is the flattened, slightly constricted portion situated between the head and the tubercle.

The **tubercle** is a prominence on the outer posterior surface of the rib at the junction of the neck with the body. It has a facet for articulation with **the transverse process of the numerically corresponding vertebra**.

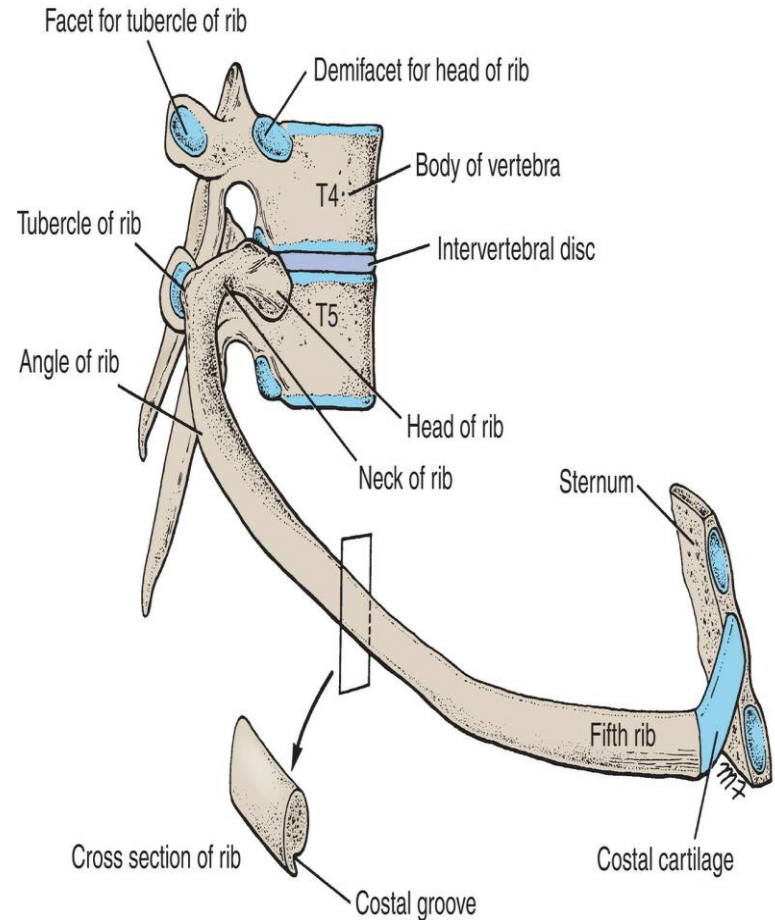


The **body (shaft)** is the long, thin, flattened, and twisted part that extends from the tubercle to the anterior (sternal) end.

The **costal groove** is the elongate depression along the inferior aspect of the internal surface of the shaft of the rib. This holds the intercostal vessels and nerve.

The **angle** is the point (usually slightly distal to the tubercle) at which the body of the rib bends sharply and turns from a lateral to a more anteriorly directed orientation.

The **anterior (sternal) end** of the rib is flat and has a depression for the costal cartilage.

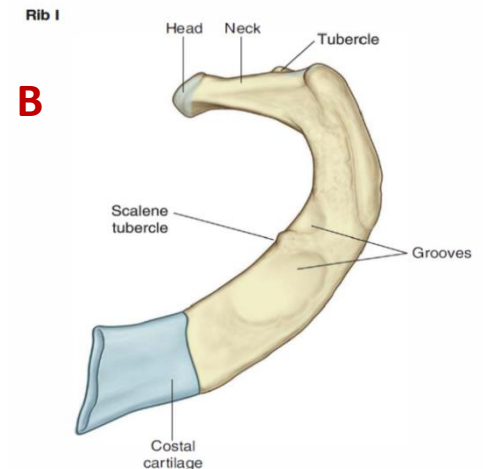
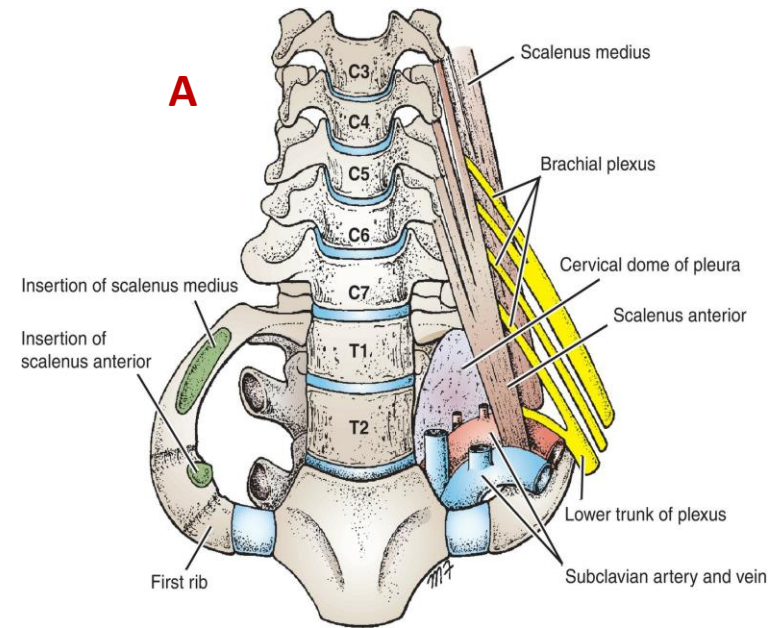




# Atypical Ribs (1<sup>st</sup> ,2<sup>nd</sup> ,10<sup>th</sup> ,11<sup>th</sup> & 12<sup>th</sup> ribs)

**The first rib** is nearly horizontal, **shortest**, and most **sharply curved** of the seven true ribs, it is important clinically because of its close relationship to the lower nerves of the **brachial plexus** and the main vessels to the arm, namely, **the subclavian artery and vein**. **The scalenus anterior muscle** is attached to its upper surface and inner border; figure (A). Anterior to the **scalenus anterior**, the **subclavian vein crosses** the rib; posterior to the muscle, the **subclavian artery** and the **lower trunk of the brachial plexus** cross the rib and lie in contact with the bone.

On the superior surface of the 1<sup>st</sup> rib, there are **two grooves** for the subclavian vessels, they are separated by a tubercle (**scalene tubercle**) for attachment of scalene anterior muscle; figure(B)





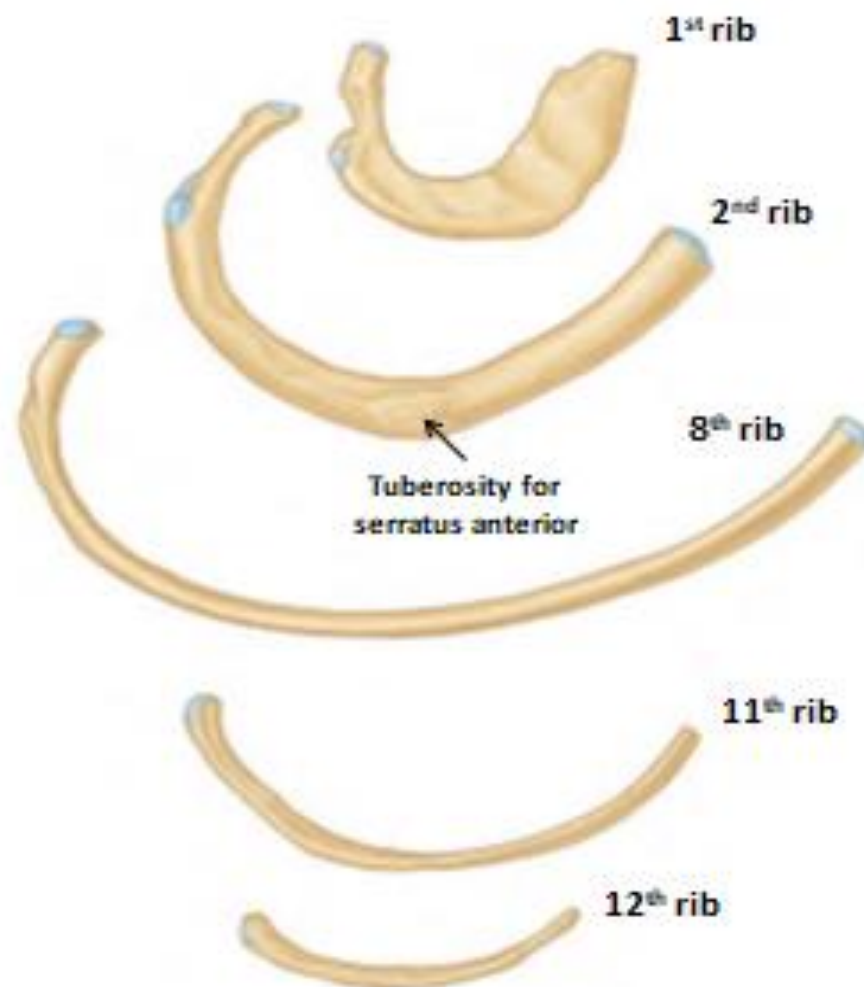
## Atypical Ribs (1<sup>st</sup>, 2<sup>nd</sup>, 10<sup>th</sup>, 11<sup>th</sup> & 12<sup>th</sup> ribs)

### 2<sup>nd</sup> rib

- thinner, less curved, and much longer than the 1<sup>st</sup> rib
- has two facets on its head for articulation with the bodies of the T1 and T2 vertebrae
- rough area on its upper surface → **tuberosity for serratus anterior**

### 10<sup>th</sup>, 11<sup>th</sup> & 12<sup>th</sup> ribs

- Have only one facet on their heads, articulates with single vertebra
- 11<sup>th</sup> & 12<sup>th</sup> ribs → short and have no necks or tubercles



## Costal Cartilages

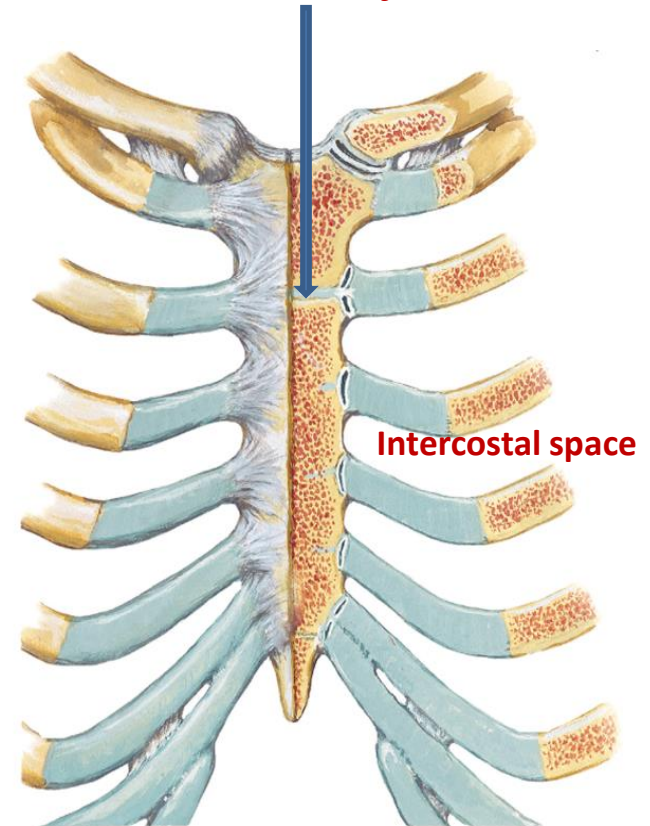
Costal cartilages are bars of **hyaline cartilage connecting the upper seven ribs** to the lateral edge of the sternum, and the **8th, 9th, and 10th** ribs to the cartilage of the rib immediately above. The cartilages of the 11th and 12th ribs end in the abdominal muscles.

The costal cartilages prolong the ribs anteriorly and contribute significantly to the **elasticity and mobility** of the thoracic walls. In old age, the costal cartilages tend to lose some of their flexibility as the result of superficial calcification.

**Intercostal spaces** separate the ribs and their costal cartilages from one another.

The **spaces and neurovascular structures** are named **according to the rib** forming the superior border of the space that is, there are **11 intercostal spaces** and **11 intercostal nerves**.

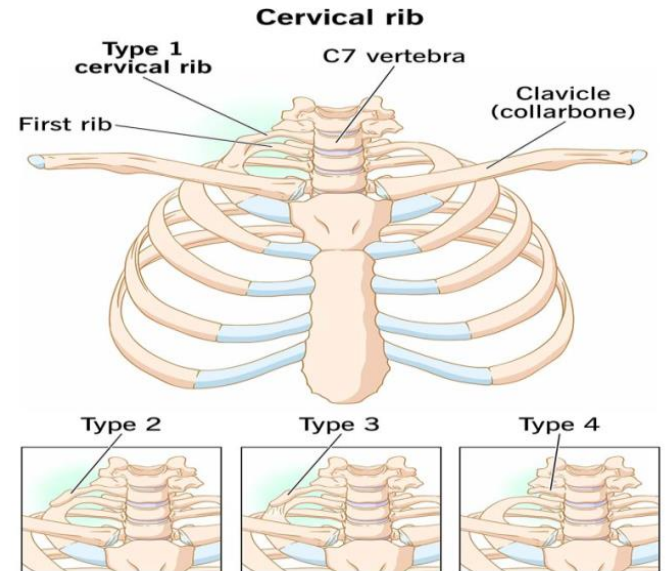
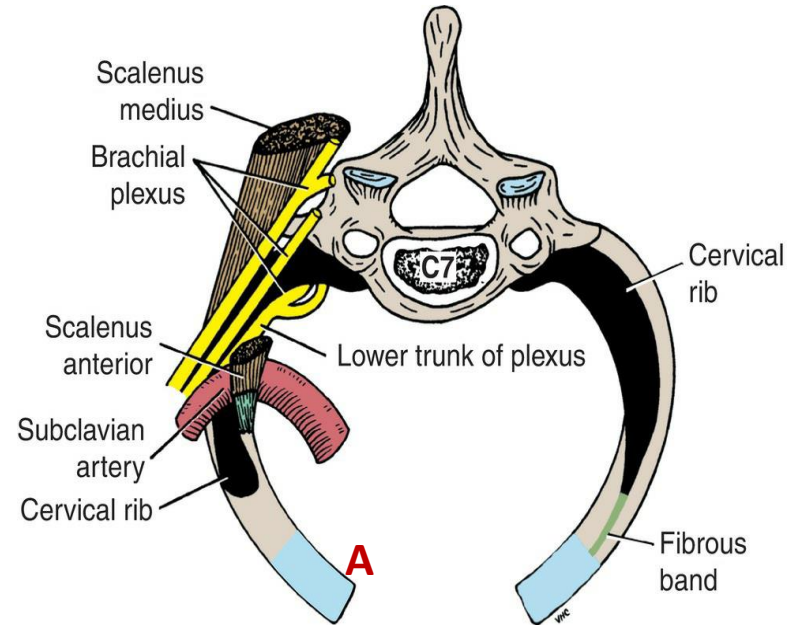
Manubriosternal joint



# Clinical Notes

**Cervical Rib.** A cervical rib (i.e., a rib arising from the anterior tubercle of the transverse process of the seventh cervical vertebra) occurs in about 0.5% of humans. The importance of a cervical rib is that it may cause **pressure on the lower trunk of the brachial plexus**, causing pain down the medial side of the forearm and hand and wasting of the small muscles of the hand (**ulnar nerve**). It can also exert pressure on the overlying subclavian artery and interfere with the circulation of the upper limb.

*Picture (A) shows thoracic outlet as seen from above. Note the presence of the cervical ribs (black) on both sides. On the right side of the thorax, the rib is almost complete and articulates anteriorly with the first rib. On the left side of the thorax, the rib is rudimentary but is continued forward as a fibrous band that is attached to the first costal cartilage. Note that the cervical rib may exert pressure on the lower trunk of the brachial plexus and may kink the subclavian artery.*



# The thoracic vertebrae

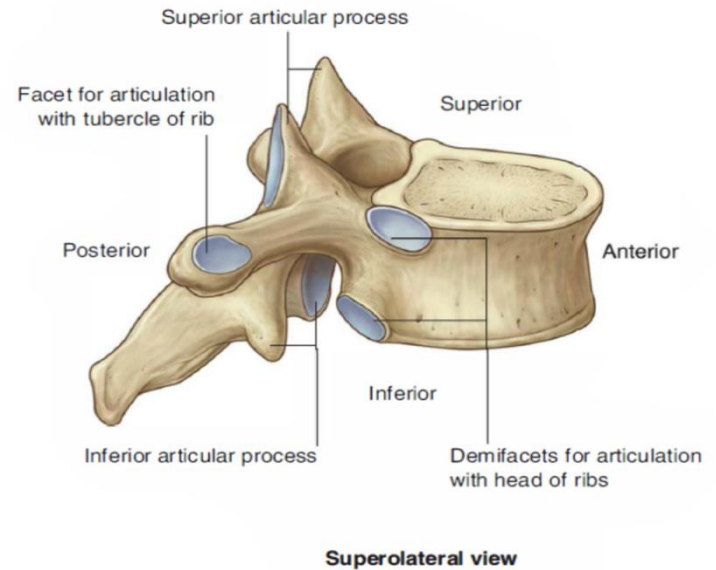
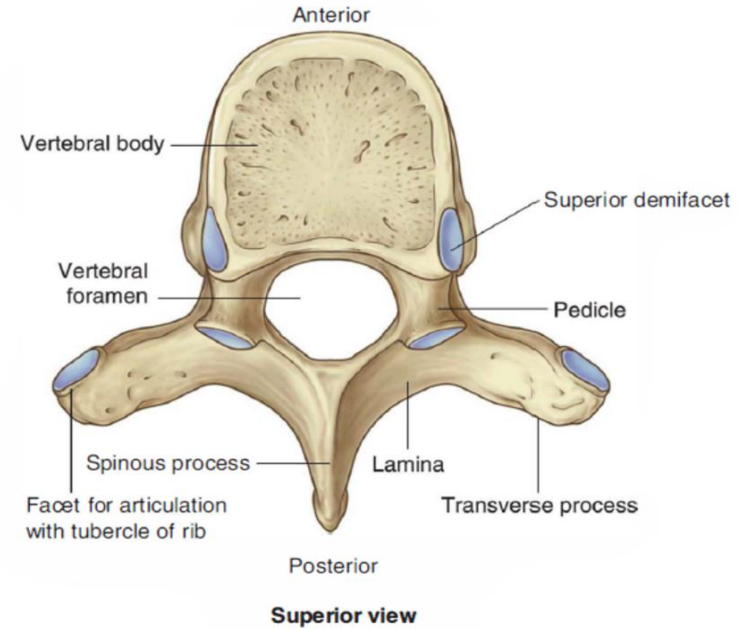
## Characteristics:

### Typical thoracic vertebra.

Heart-shaped **vertebral body**, Long **spinous process**, The **vertebral foramen** is generally circular, **The laminae** are broad and overlap with those of the vertebra below, The **transverse processes** are club shaped and project postero-laterally. The **superior articular processes** are flat, with their articular surfaces facing almost posteriorly. The **inferior articular processes** project from the laminae and their articular facets face anteriorly.

Normally, only the **thoracic vertebrae carry ribs**, and these vertebrae have unique structures for that purpose.

**Costal facets** are small articular surfaces at the posterolateral aspect of the body, at the junction of the body and the pedicle. Typical thoracic vertebrae (2 to 8) have two on each side. One is located superiorly (**superior costal facet**). One is located inferiorly (**inferior costal facet**). These facets are the sites where the heads of the ribs articulate with the body.

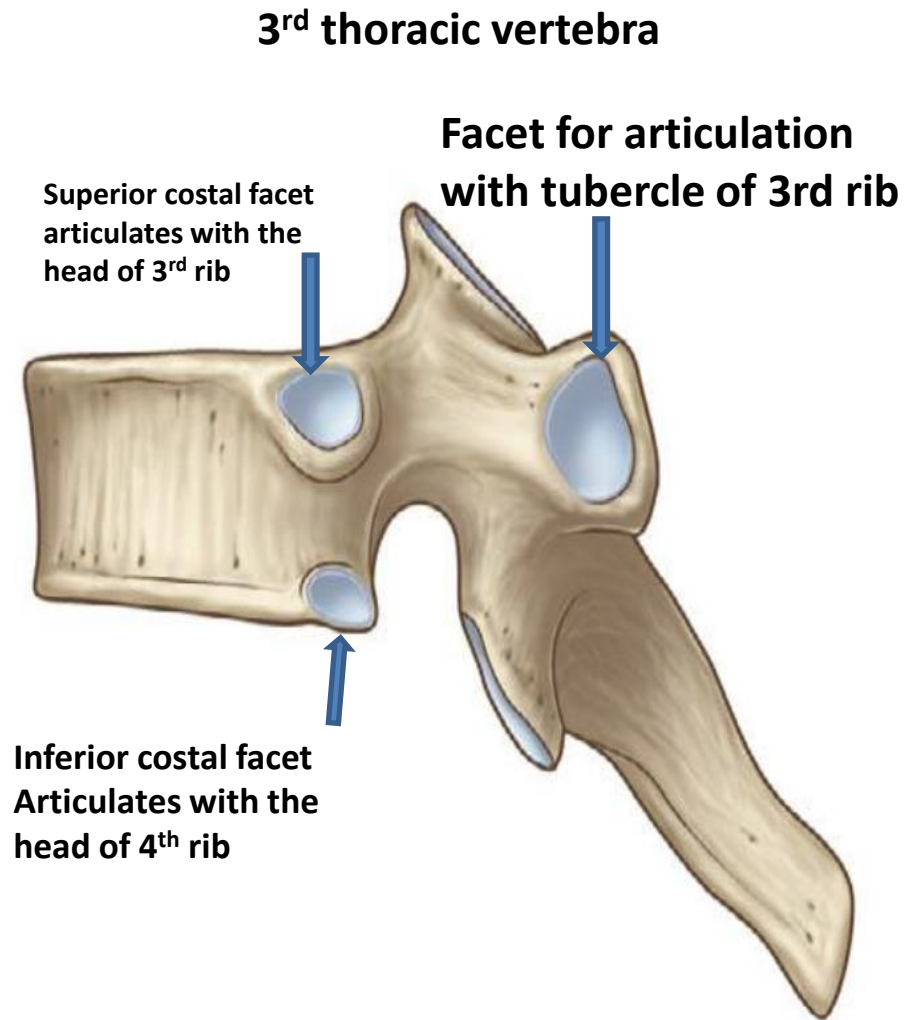




- **Articulation with ribs (typical thoracic vertebrae)**

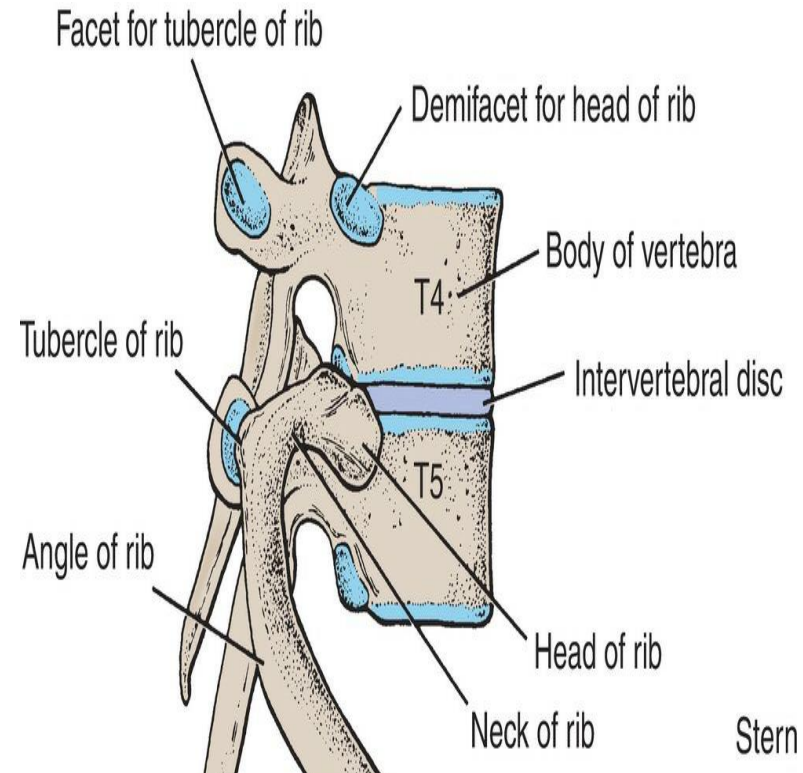
Typical thoracic vertebra has three sites on each side for articulation with ribs:

1. Two demifacets are located on the superior and inferior aspects of the body of the vertebra.
  - The **superior costal facet** articulates with part of the head of its own rib.
  - the **inferior costal facet** articulates with part of the head of the rib below.
2. An **oval facet (transverse costal facet)** at the end of the **transverse process** articulates with **the facet of the tubercle of its own rib**



The T1 vertebra **has a full superior costal facet (instead of a superior demifacet)** for the head of the first rib, plus an **inferior demifacet for the superior half of the head of the second rib.**

The T11 and T12 vertebrae each have **full costal facets** (located mainly on the pedicles) instead of demifacets because the heads of ribs 11 and 12 articulate only with their own individual vertebrae. **Transverse costal facets are not present on the T11 and T12 vertebrae** because ribs 11 and 12 do not articulate with the **transverse processes.**





## Joints of the thoracic wall

Joint	Type of joint	Articulation
Intervertebral	Symphysis (secondary cartilaginous)	Adjacent vertebral bodies with intervertebral disc in between
Costochondral	Primary cartilaginous	Articulation of lateral end of costal cartilage with sternal end of rib
Interchondral	Synovial plane	Articulation between costal cartilages of 6 <sup>th</sup> and 7 <sup>th</sup> , 7 <sup>th</sup> and 8 <sup>th</sup> and 8 <sup>th</sup> and 9 <sup>th</sup> ribs
Sternocostal	1 <sup>st</sup> : primary cartilaginous (synchondrosis) 2 <sup>nd</sup> -7 <sup>th</sup> : synovial plane	1 <sup>st</sup> costal cartilage with manubrium 2 <sup>nd</sup> -7 <sup>th</sup> pairs of costal cartilages with body of sternum
Sternoclavicular	Saddle type of synovial joint	Sternal end of clavicle with manubrium & 1 <sup>st</sup> costal cartilage
Xiphisternal	Primary cartilaginous (synchondrosis) (bones unites by hyaline cartilage)	Articulation between xiphoid process and body of sternum
Manubriosternal	2ry cartilaginous joint (symphysis)	Articulation between manubrium and body of sternum

## Clinical Notes

**Thoracic Cage Distortion.** The shape of the thorax can be distorted by congenital anomalies of the vertebral column or by the ribs.

**Destructive disease of the vertebral column that produces lateral flexion or scoliosis** results in marked distortion of the thoracic cage.

### Traumatic Injury to Thorax

Traumatic injury to the thorax is common, especially as a result of automobile accidents.

**Sternum Fracture** The sternum is a resilient structure that is held in position by relatively pliable costal cartilages and bendable ribs. For these reasons, **fracture of the sternum is not common**; however, it does occur in high-speed motor vehicle accidents. **Remember that the heart lies posterior to the sternum and may be severely contused by the sternum on impact.**



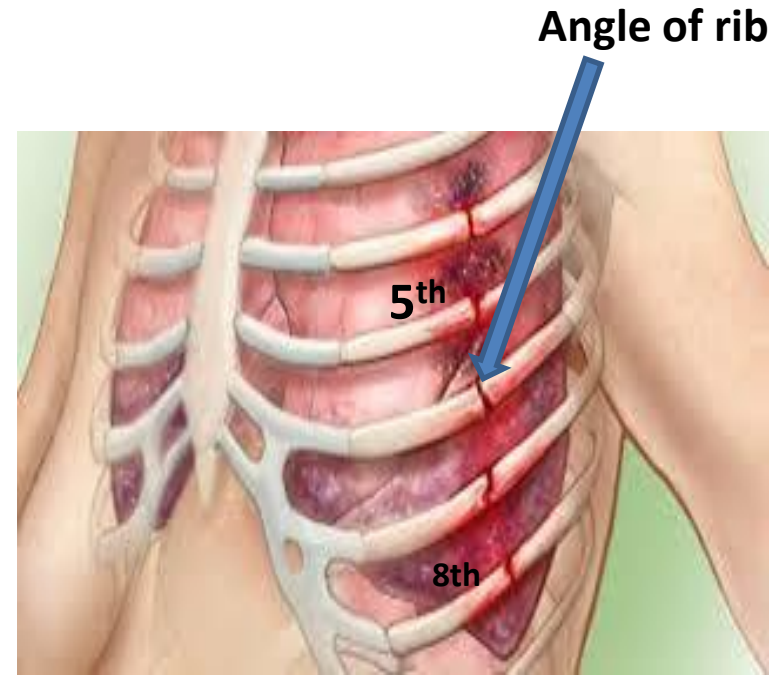
**Fracture of sternum**

# Rib Fractures

Fractures of the ribs are common chest injuries. The ribs tend to break at **their angles**. The ribs that are most commonly fractured are 5<sup>th</sup> through 10<sup>th</sup> are the most commonly fractured ribs. The clavicle and pectoral muscles protect the first four ribs anteriorly and the scapula and its associated muscles do so posteriorly. The 11th and 12th ribs float and move with the force of impact.

Because the rib is sandwiched between the skin externally and the delicate pleura internally, the jagged ends of a fractured rib may penetrate the lungs and present as a **pneumothorax**.

**Severe localized pain is usually the most important symptom of a fractured rib.** The intercostal nerves above and below the rib innervate the periosteum of each rib. To encourage the patient to breathe adequately, performing an intercostal nerve block may be necessary to relieve the pain.



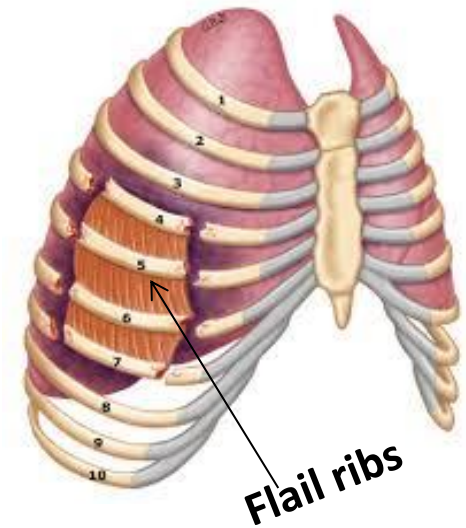
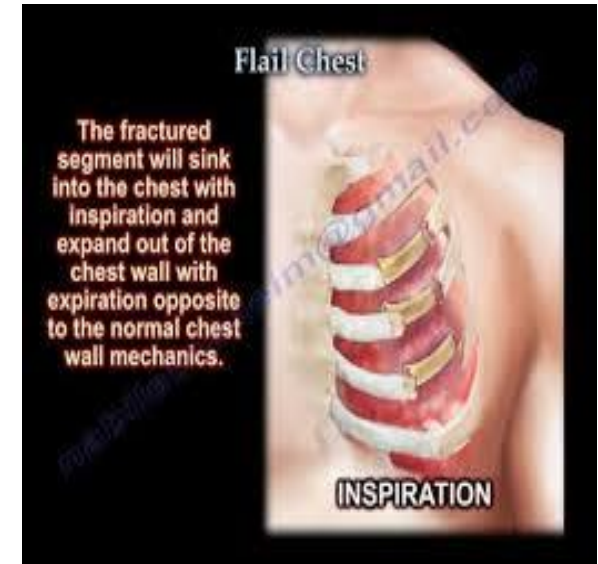
X- ray PA view

## Flail Chest

In severe crush injuries, a number of ribs may break. If limited to one side, the fractures may occur **near the rib angles and anteriorly near the costochondral junctions**. This causes **flail chest**, in which a section of the chest wall is disconnected from the rest of the thoracic wall. If the fractures occur on either side of the sternum, **the sternum may be flail**. In either case, **the stability of the chest wall is lost**, and the flail segment is sucked in during inspiration and driven out during expiration, producing paradoxical and ineffective respiratory movements.

## Traumatic Injury to Abdominal Viscera and Chest

The upper abdominal organs—namely, the **liver, stomach, and spleen**—may be injured by trauma to the rib cage. In fact, any injury to the chest **below the level of the nipple line** may involve abdominal organs as well as thoracic organs.



# Thoracic openings

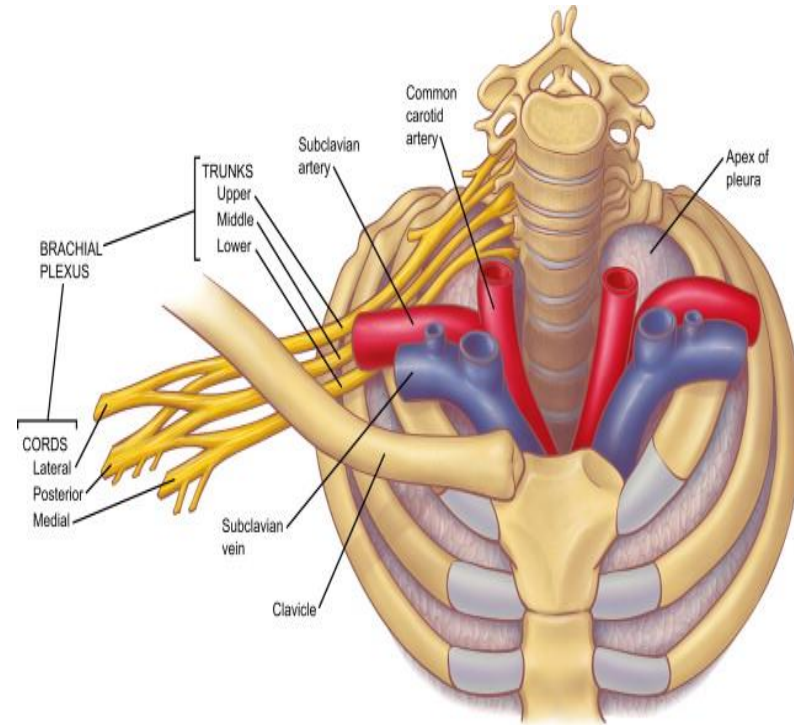
## Thoracic outlet

The chest cavity communicates with the root of the neck through a narrow opening called the **superior thoracic aperture**, or **thoracic outlet**. This is called an outlet because important vessels and nerves emerge from the thorax here to enter the neck and upper limbs.

### Boundaries of thoracic outlet

1. Posteriorly, the body of the first thoracic vertebra .
2. Laterally the medial edges of the first ribs and their costal cartilages.
3. Anteriorly the superior margin of the manubrium sterni.

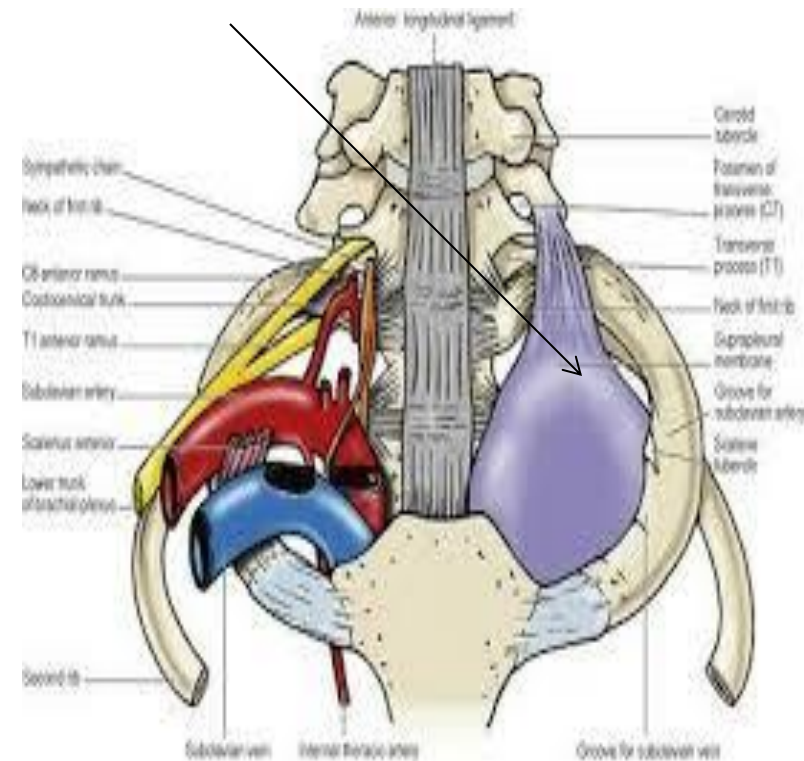
The outlet **conveys the esophagus, trachea, and several vessels and nerves**. The apices of the lungs and pleurae project upward into the neck.





The thoracic outlet is closed by a dense fibrous layer called the **suprapleural membrane** on either side of structures passing through it. This fibrous sheet attaches **laterally** to the **medial border of the first rib and costal cartilage**; **medially** to the **fascia investing the structures passing from the thorax into the neck**; and, **and superiorly** to the tip of the transverse process of the seventh cervical vertebra. It protects the underlying cervical pleura and resists the changes in intrathoracic pressure occurring during respiratory movements.

## Suprapleural membran





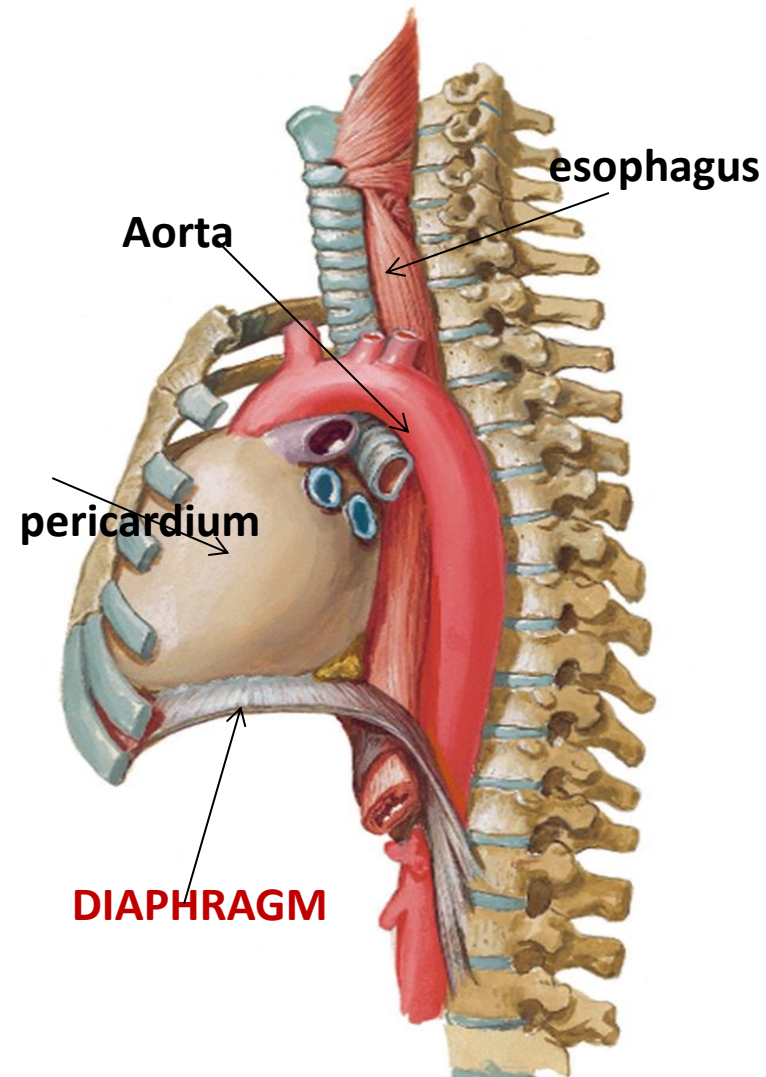
# Inferior thoracic aperture

## The DIAPHRAGM

The chest cavity communicate with abdominal cavity through the inferior thoracic aperture which is closed by **musculotendinous sheet called the diaphragm**. The body of the 12th thoracic vertebra forms the posterior boundary of this opening, the costal margin marks its lateral boundaries, and the xiphisternal joint forms the anterior border.

## THE DIAPHRAGM

The diaphragm is a thin muscular and tendinous septum that separates the chest cavity above from the abdominal cavity below. Structures that pass between the thoracic and abdominal cavities (e.g., esophagus, aorta) must either pierce the diaphragm or go around the diaphragm. The diaphragm is the most important muscle of respiration. It consists of two parts; peripheral muscular and central tendinous.



**The muscular part of the diaphragm** :The origin of the muscular part of diaphragm can be divided into three parts:

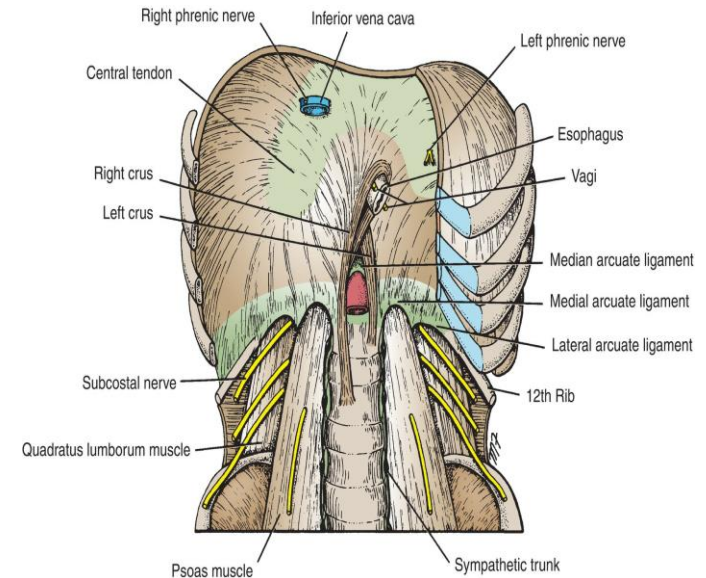
**1. sternal part** arising from the posterior surface of the xiphoid process,

**2. costal part** arising from the deep surfaces of the lower six ribs and their costal cartilages, and

**3. vertebral part** arising by vertical columns (crura) and from the arcuate ligaments.

The **right crus** arises from **the sides of the bodies of the first three lumbar vertebrae** and the **intervertebral discs**. The **left crus** arises from **the sides of the bodies of the first two lumbar vertebrae** and the **intervertebral disc**. Lateral to the crura, the diaphragm arises from the **medial and lateral arcuate ligaments**.

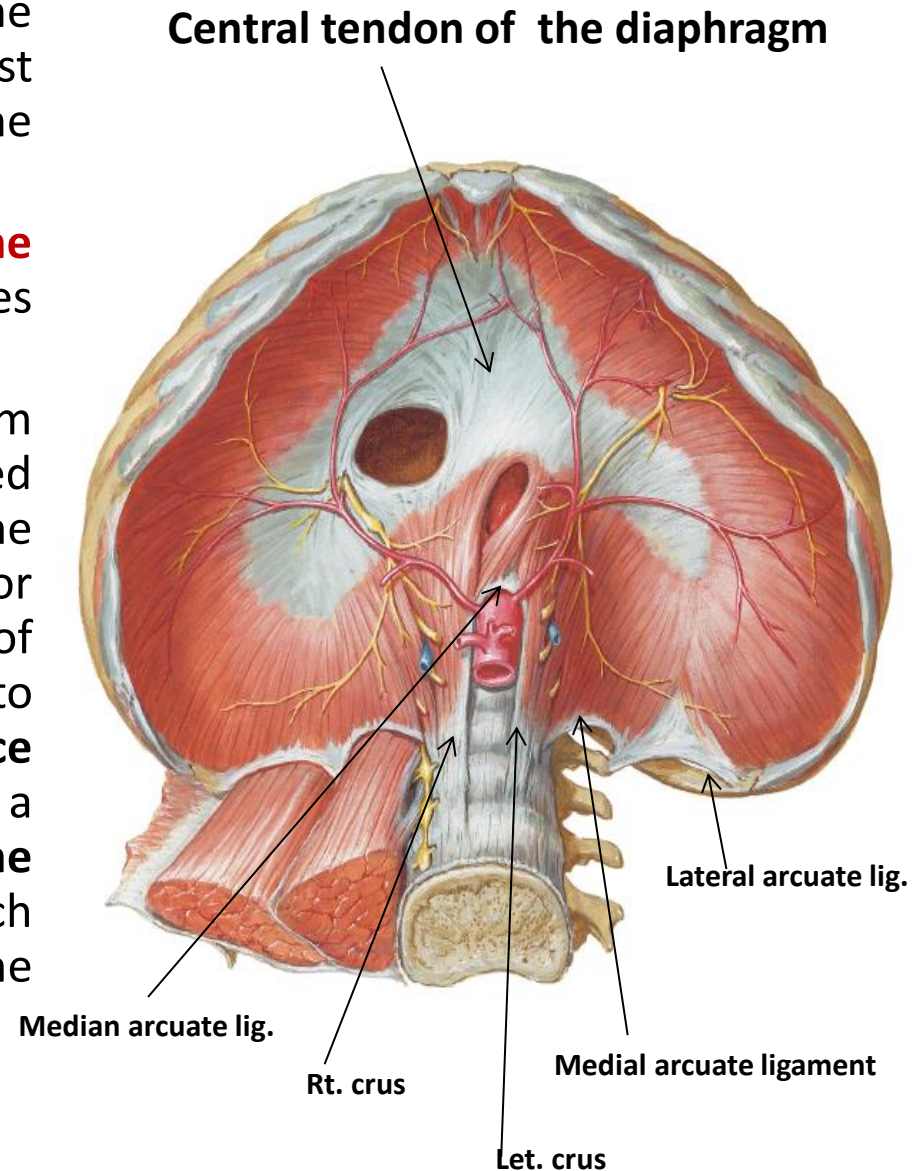
**The medial arcuate** ligament extends from the side of the body of the second lumbar vertebra to the tip of the transverse process of the first lumbar vertebra.



**The lateral arcuate ligament** extends from the tip of the transverse process of the first lumbar vertebra to the lower border of the 12th rib.

**The median arcuate ligament connects the medial borders of the two crura** and crosses over the **anterior surface of the aorta**.

The three parts of the muscular diaphragm insert into a **central tendon**, which is shaped **like three leaves**. The superior surface of the tendon is partially fused with the inferior surface of the fibrous **pericardium**. Some of the muscle fibers of the right crus pass up to the left and **surround the esophageal orifice in a sling-like loop**. These fibers act as a **sphincter** and **possibly assist in the prevention of regurgitation** of the stomach contents into the thoracic part of the esophagus.

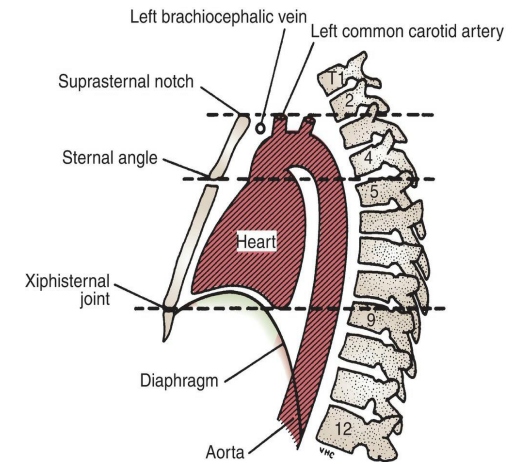
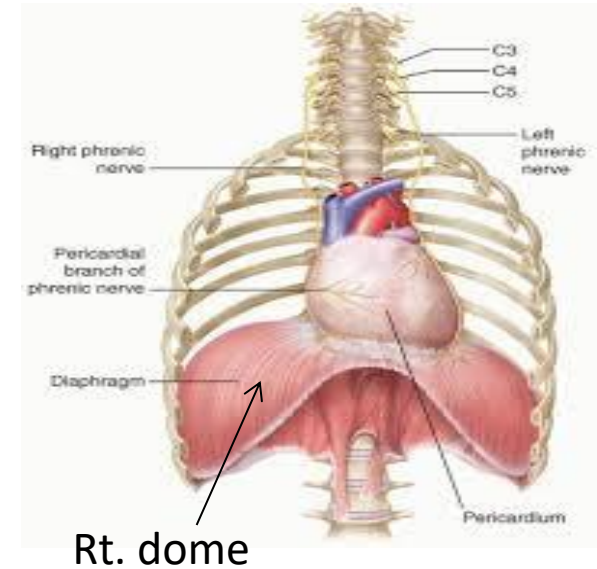


The diaphragm curves up into **right** and **left domes (cupulae)**. The right dome reaches as high as the **upper border of the fifth rib**, and the left dome may reach the **lower border of the fifth rib**. The right dome lies at a higher level because of the large size of the right lobe of the liver.

**The central tendon lies at the level of the xiphisternal joint.** The domes support the right and left lungs, whereas the central tendon supports the heart.

The diaphragm is lower when a person is sitting or standing; it is higher in the supine position and after a large meal.

When seen from the side, the diaphragm has the **appearance of an inverted “J,”** with the long limb extending up from the vertebral column and the short limb extending forward to the xiphoid process.





## Nerve Supply of Diaphragm

**Motor nerve supply** comes from the **right and left phrenic nerves (C3, 4, 5)**.

Each phrenic nerve supplies approximately half of the diaphragm. Thus, functionally, the diaphragm operates as two hemidiaphragms.

**Sensory nerve supply**, the phrenic nerves supply **the parietal pleura and peritoneum covering the central surfaces of the diaphragm**. The **lower six intercostal nerves** supply sensory nerve to the periphery of the diaphragm.

## Nerve Supply of the Diaphragm

**Motor nerve supply:**

**Right and Left phrenic nerves (C3, 4, 5)**

**Sensory nerve supply:**

**Central surfaces of diaphragm:**

**Right and Left phrenic nerves (C3, 4, 5)**

**Periphery of diaphragm:**

**Lower six intercostal nerves.**

**Action and functions of the Diaphragm**

On contraction, diaphragm pulls down its central tendon and increases vertical diameter of thorax.

Therefore, functions of the diaphragm are:

1. Muscle of inspiration.
2. Muscle of abdominal straining.
3. Weight-lifting muscle.
4. Thoracoabdominal pump for blood & lymph.

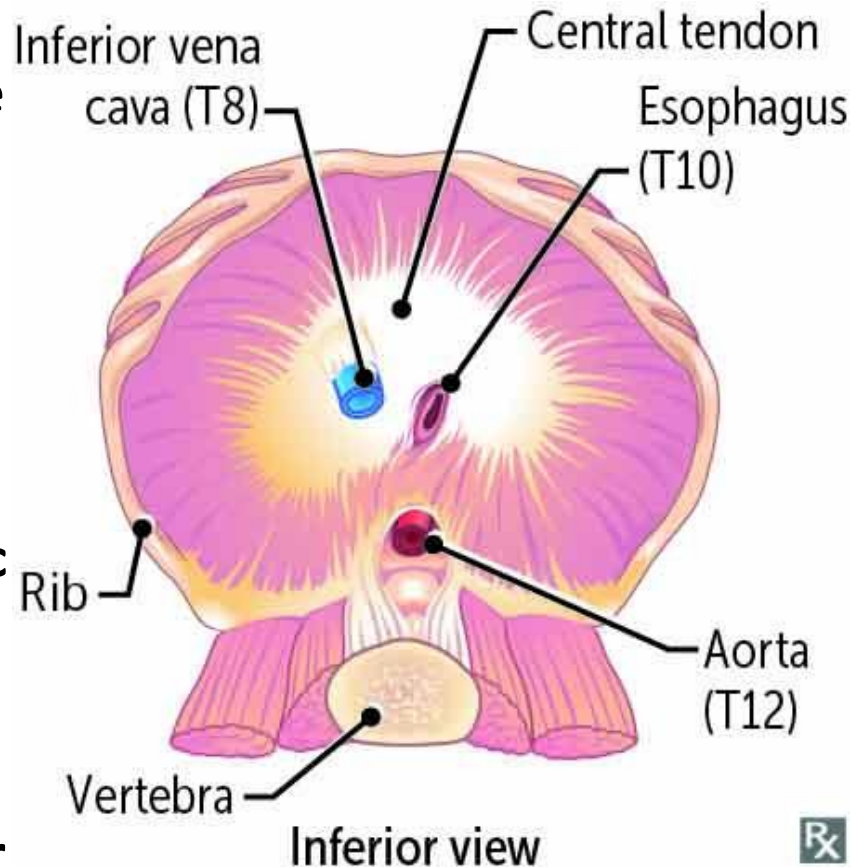


The diaphragm has three main openings :

**1. The aortic opening** lies anterior to the body of the **12th thoracic** vertebra and between the crura. It transmits the **aorta, the thoracic duct, and the azygos vein.**

**2. The esophageal opening** lies at the level of the **10th thoracic** vertebra in a sling of muscle fibers derived from the right crus. It transmits the **esophagus, the right and left vagus nerves, the esophageal branches of the left gastric vessels, and the lymphatics from the lower third of the esophagus.**

**3. The caval opening** lies at the level of the **eighth thoracic vertebra**, in the central tendon. It transmits the **inferior vena cava and terminal branches of the right phrenic nerve.**





## CLINICAL NOTES

**Penetrating Injuries to Diaphragm.** Penetrating injuries to the diaphragm can result from stab or bullet wounds to the chest or abdomen. Any penetrating wound to the chest below the level of the nipples should be suspected of causing damage to the diaphragm until proved otherwise. The arching domes of the diaphragm can reach the level of the fifth rib (the right dome can reach a higher level).

### Embryology of the diaphragm

The diaphragm is formed from the following structures: (a) the **septum transversum**, which forms the muscle and central tendon; (b) the two **pleuroperitoneal membranes**, which are largely responsible for the peripheral areas of the diaphragmatic pleura and peritoneum that cover its upper and lower surfaces, respectively; and (c) the **dorsal mesentery of the esophagus**, in which the crura develop.

**The septum transversum is a mass of mesoderm that is formed in the neck by the fusion of the myotomes of the third, fourth, and fifth cervical segments.** With the descent of the heart from the neck to the thorax, the septum is pushed caudally, pulling its nerve supply with it. Thus, cervical nerves C3 to 5 form the phrenic nerve, which supplies the diaphragm.

**The pleuroperitoneal membranes grow medially from the body wall** on each side until they fuse with the septum transversum anterior to the esophagus and with the dorsal mesentery posterior to the esophagus. The motor nerve supply to the entire muscle of the diaphragm is the phrenic nerve. The sensory innervation of the peripheral parts of the pleura and peritoneum covering the peripheral areas of the upper and lower surfaces of the diaphragm is from the lower six thoracic nerves.

## Diaphragmatic Herniae

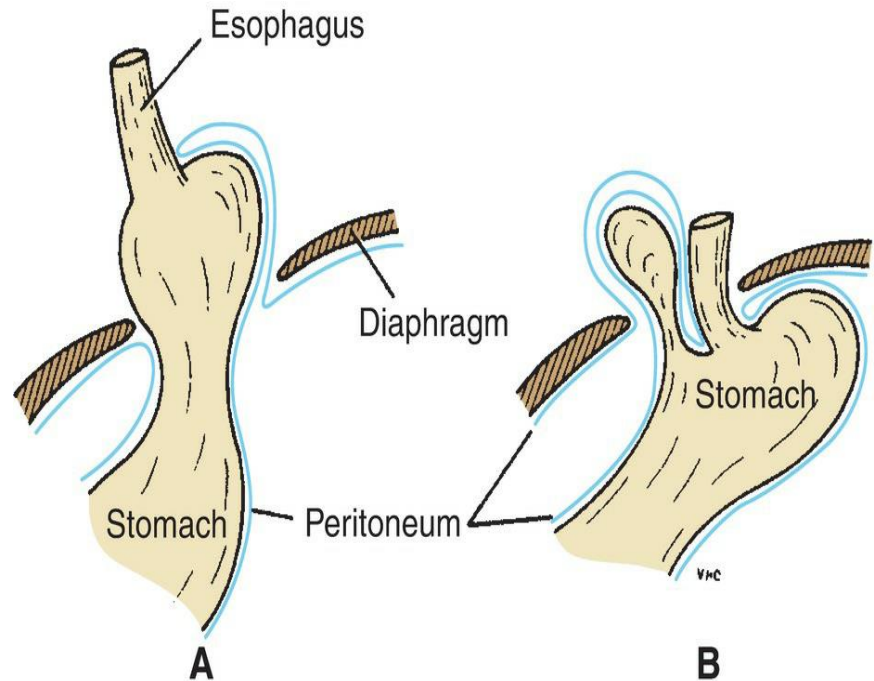
**Congenital herniae** occur as the result of incomplete fusion of the septum transversum, the dorsal mesentery, and the pleuroperitoneal membranes from the body wall. The herniae occur at the following sites:

**(a) the pleuroperitoneal canal** (more common on the left side; caused by failure of fusion of the septum transversum with the pleuroperitoneal membrane),

**(b) the opening between the xiphoid and costal origins** of the diaphragm, and

**(c) the esophageal hiatus.**

**Acquired herniae** may occur in middle-aged people with weak musculature around the esophageal opening in the diaphragm. These herniae may be either sliding (hiatal) or paraesophageal.



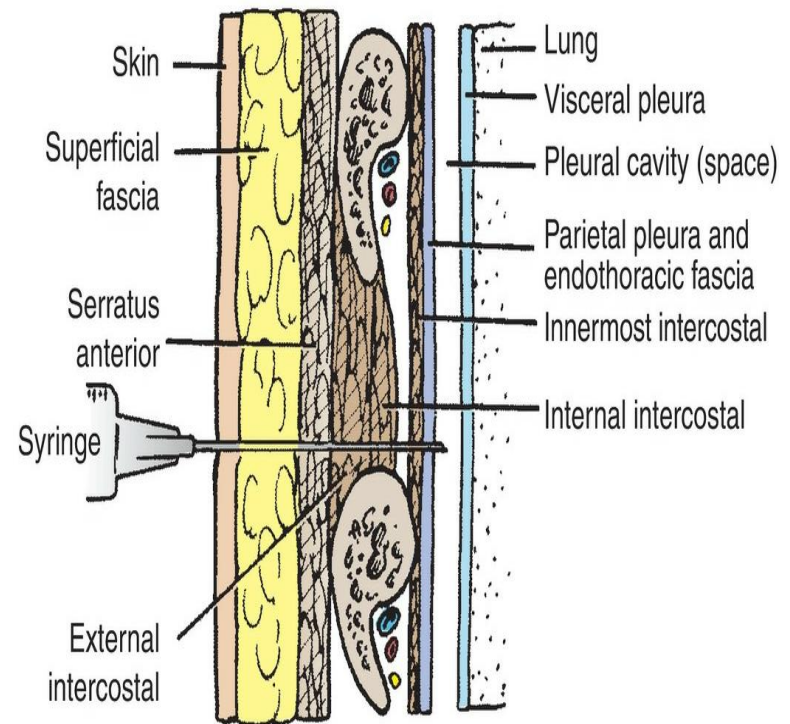
A. Sliding esophageal hernia.  
B. Paraesophageal hernia.

# Intercostal Spaces

Intercostal spaces are the gaps between adjacent ribs. A needle passing through the entire depth of an intercostal space must penetrate seven structural layers. These are most pronounced in the lateral aspect of the thoracic wall. In superficial to deep sequence, the layers are the following:

- 1. Skin**
- 2. Superficial fascia**
- 3. Deep fascia**
- 4. Intercostal muscles**
- 5. Endothoracic fatty layer**
- 6. Extrapleural fatty layer**
- 7. Parietal pleura**

An additional layer of muscle, the serratus anterior, may cover the intercostal muscle layer. The three intercostal muscles are the external intercostal, the internal intercostal, and the innermost intercostal muscles. The innermost intercostal muscle is lined internally by the endothoracic fascia, which is lined internally by a highly variable extrapleural fatty layer and then the parietal pleura. The intercostal nerves and blood vessels run between the intermediate and deepest layers of muscles.

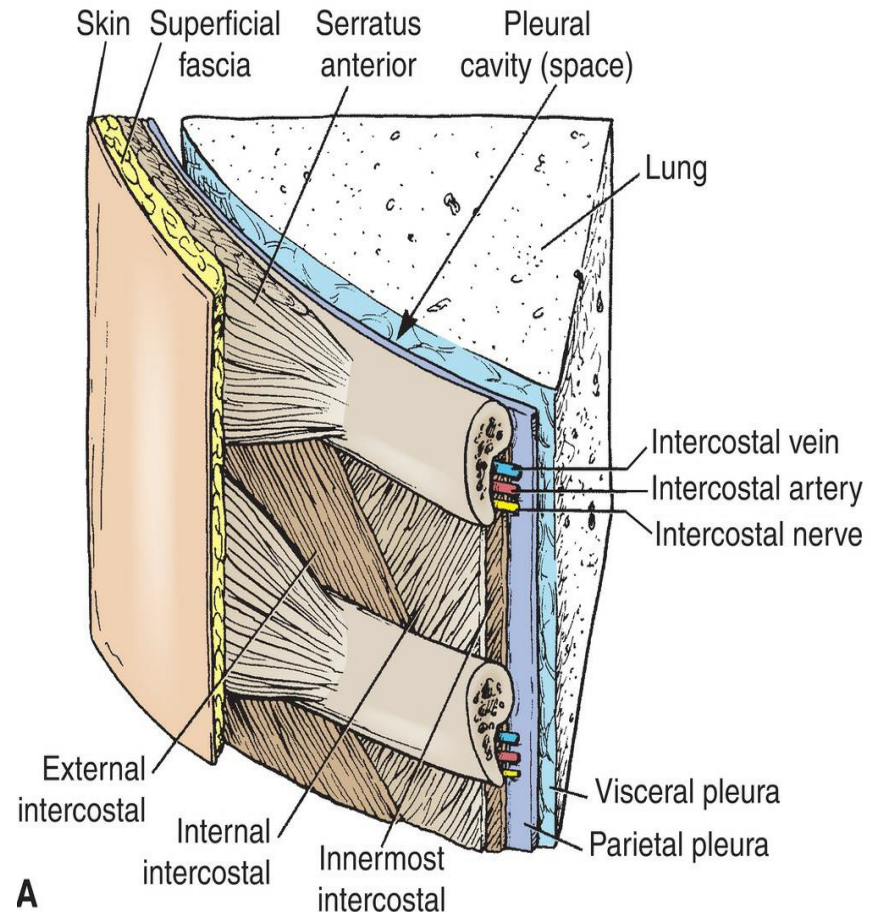


# INTERCOSTAL MUSCLES

There are three intercostal muscles in the thoracic wall that fill the intercostal spaces: these are :

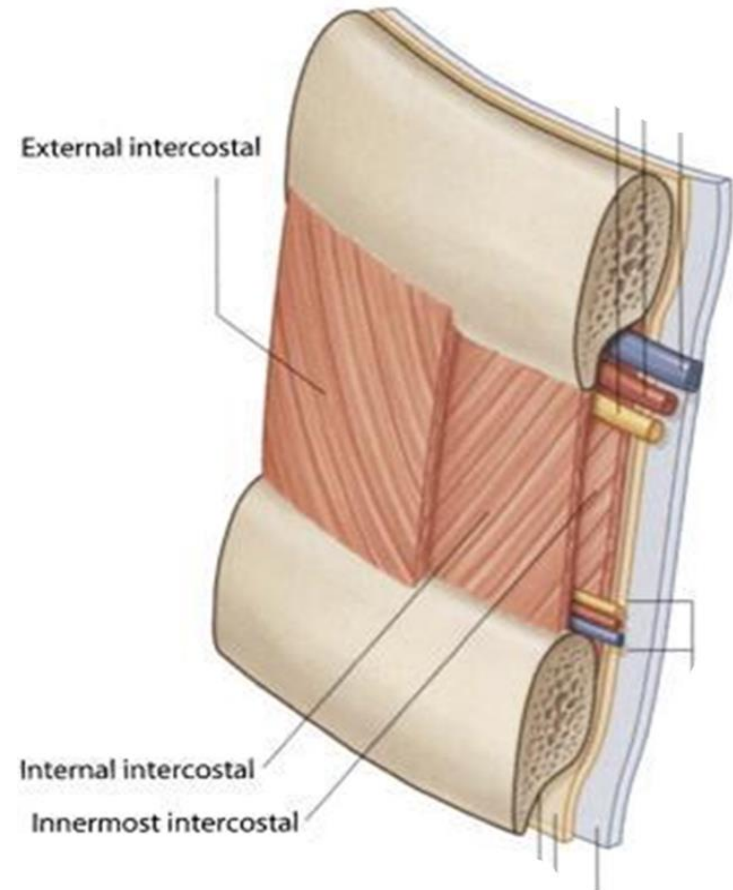
- 1) External intercostal,
- 2) Internal intercostal, and
- 3) Innermost intercostal.

The **external intercostal muscle** is the most superficial. Its fibers are **directed downward and forward** from the **inferior border of the rib above to the superior border of the rib below**. The muscle extends forward from distal part of the rib to the costal cartilage **where it is replaced by an aponeurosis**, called the **anterior intercostal membrane**.



The **internal intercostal muscle** forms the intermediate layer. Its fibers are directed **downward and backward from the subcostal groove of the rib above to the upper border of the rib below**. The muscle extends backward from the sternum in front to the angles of the ribs behind, where the muscle is replaced by an aponeurosis, the **posterior (internal) intercostal membrane**.

The **innermost intercostal muscle** forms the deepest layer and corresponds to the transversus abdominis muscle in the anterior abdominal wall. The innermost intercostal muscle can be divided into three portions, which are more or less separate from one another. The anterior portion is named the **transversus thoracis** muscle, the lateral portion is the **innermost intercostal** muscle, and the posterior portion is the **subcostalis** muscle.





## Muscles of the thoracic wall

NAME OF MUSCLE	ORIGIN	INSERTION	NERVE SUPPLY	ACTION
External intercostal muscle (11) (fibers pass downward and forward)	Inferior border of rib	Superior border of rib below	Intercostal nerves	Stabilize the rib cage: With first rib fixed, they raise ribs during inspiration and thus increase anteroposterior and transverse diameters of thorax
Internal intercostal muscle (11) (fibers pass downward and backward)	Inferior border of rib	Superior border of rib below	Intercostal nerves	Stabilize the rib cage: With last rib fixed by abdominal muscles, they lower ribs during expiration
Innermost intercostal muscle (incomplete layer)	Adjacent ribs	Adjacent ribs	Intercostal nerves	Assists external and internal intercostal muscles
Diaphragm	Xiphoid process; lower six costal cartilages, first three lumbar vertebrae	Central tendon	Phrenic nerve	Most important muscle of inspiration; increases vertical diameter of thorax by pulling central tendon downward; assists in raising lower ribs; also used in abdominal straining and weight lifting
Levatores costarum (12)	Tip of transverse process of C7 and T1–11 vertebrae	Rib below	Posterior rami of thoracic spinal nerves	Elevates ribs; possibly proprioception
Serratus posterior superior	Lower cervical and upper thoracic spines	Upper ribs	Intercostal nerves	Proprioception; possibly raises ribs and therefore an inspiratory muscle
Serratus posterior inferior	Upper lumbar and lower thoracic spines	Lower ribs	Intercostal nerves	Proprioception; possibly depresses ribs and therefore an expiratory muscle

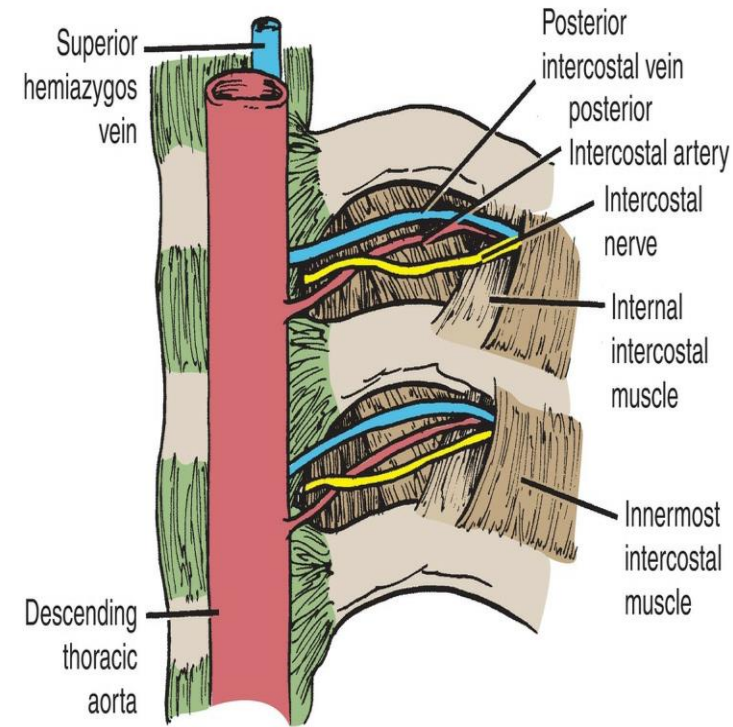
# NERVES of the thorax

The **intercostal nerves** supply the entire thoracic wall. These nerves are the **anterior rami of the first 11 thoracic spinal nerves**.

The anterior ramus of the 12th thoracic nerve lies in the abdomen and runs forward in the abdominal wall as the **subcostal nerve**.

Each intercostal nerve enters an intercostal space between the **parietal pleura and the posterior intercostal membrane**. It then runs forward inferior to the intercostal vessels in the subcostal groove of the corresponding rib, between the **innermost intercostal and internal intercostal muscle**.

**The first six nerves are distributed within their intercostal spaces. The seventh to ninth intercostal nerves** leave the anterior ends of their intercostal spaces by passing deep to the costal cartilages, to **enter the anterior abdominal wall**. The **10<sup>th</sup> and 11<sup>th</sup> nerves** pass directly into the abdominal wall.



## Branches of intercostal nerve.

1. **Rami communicants** connect the intercostal nerve to a ganglion of the sympathetic trunk . The gray and white rami are adjacent to one another.

2. **The collateral branch** runs forward inferiorly to the main nerve on the upper border of the rib below.

3. **The lateral cutaneous branch** reaches the skin on the side of the chest. It divides into an anterior and a posterior branch.

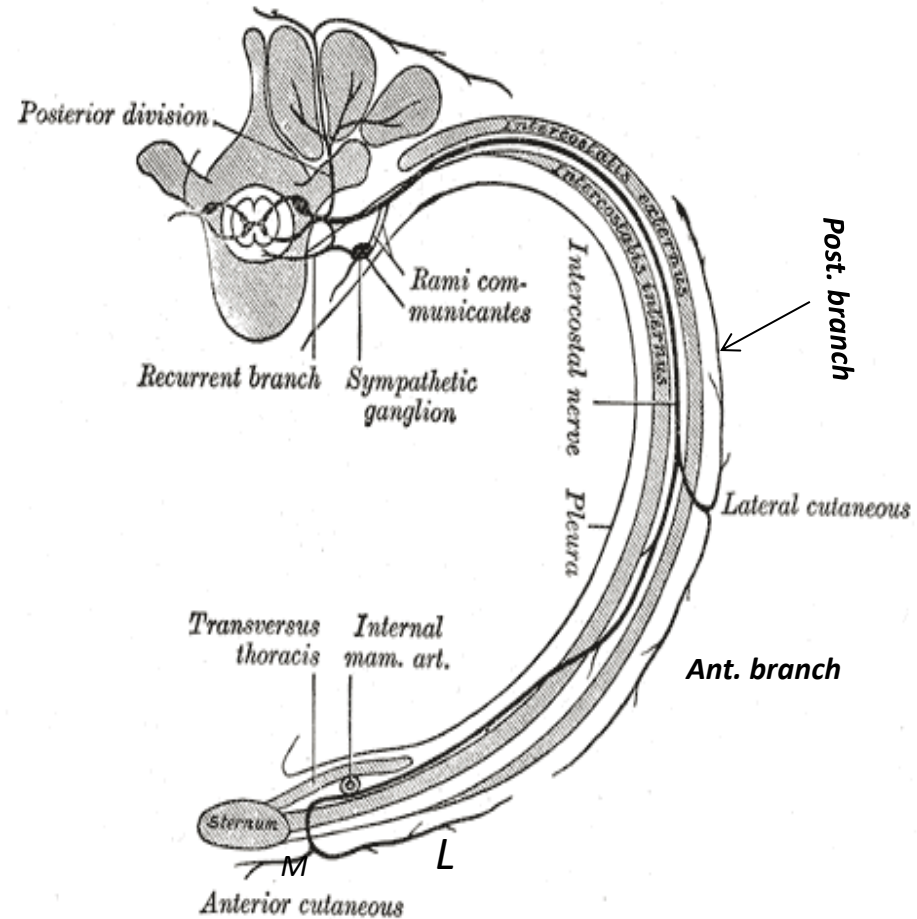
4. **The anterior cutaneous branch**, which is the terminal portion of the main trunk, reaches the skin near the midline. It divides into a medial and a lateral branch.

5. **Muscular branches** run to the intercostal muscles.

6. **Pleural sensory branches** go to the parietal pleura.

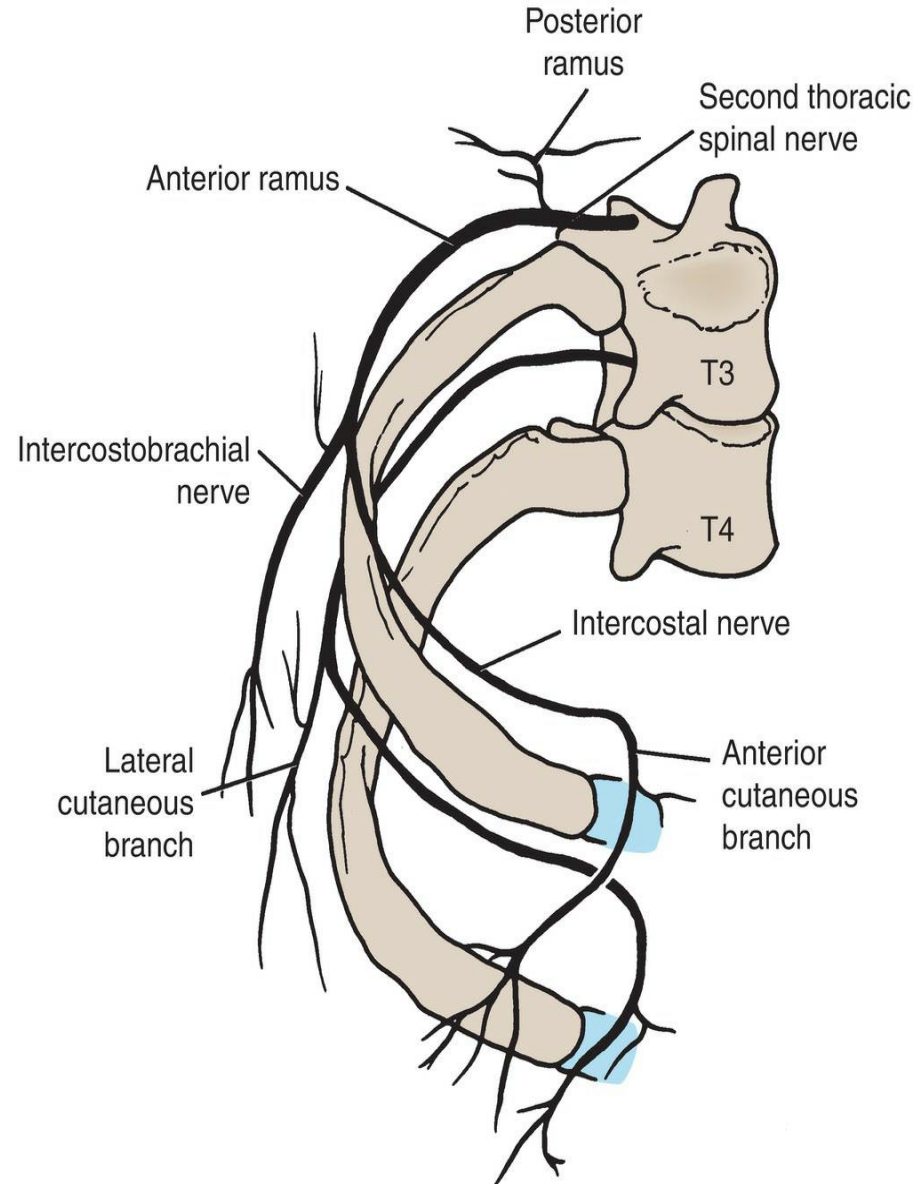
7. **Peritoneal sensory branches** (7th to 11th intercostal nerves only) run to the parietal peritoneum.

The **first intercostal nerve** joins the brachial plexus by a large branch; **Intercostobrachial nerve**. The remainder of the first intercostal nerve is small.



The **second intercostal nerve** joins the medial cutaneous nerve of the arm by a large branch named the **Intercostobrachial nerve**. Therefore, the second intercostal nerve supplies the skin of the armpit and the **upper medial side of the arm**.

The first six intercostal nerves supply the **1.skin and the parietal pleura** of each intercostal space, **2. the intercostal muscles** of each intercostal space; **3. the levatores costarum**; **4. serratus posterior muscles**; **5. the 7th to 11th intercostal nerves supply the skin and the parietal peritoneum** covering the outer and inner surfaces of the abdominal wall, **6.the anterolateral abdominal wall muscles** (which include the external oblique, internal oblique, transversus abdominis, and rectus abdominis muscles).

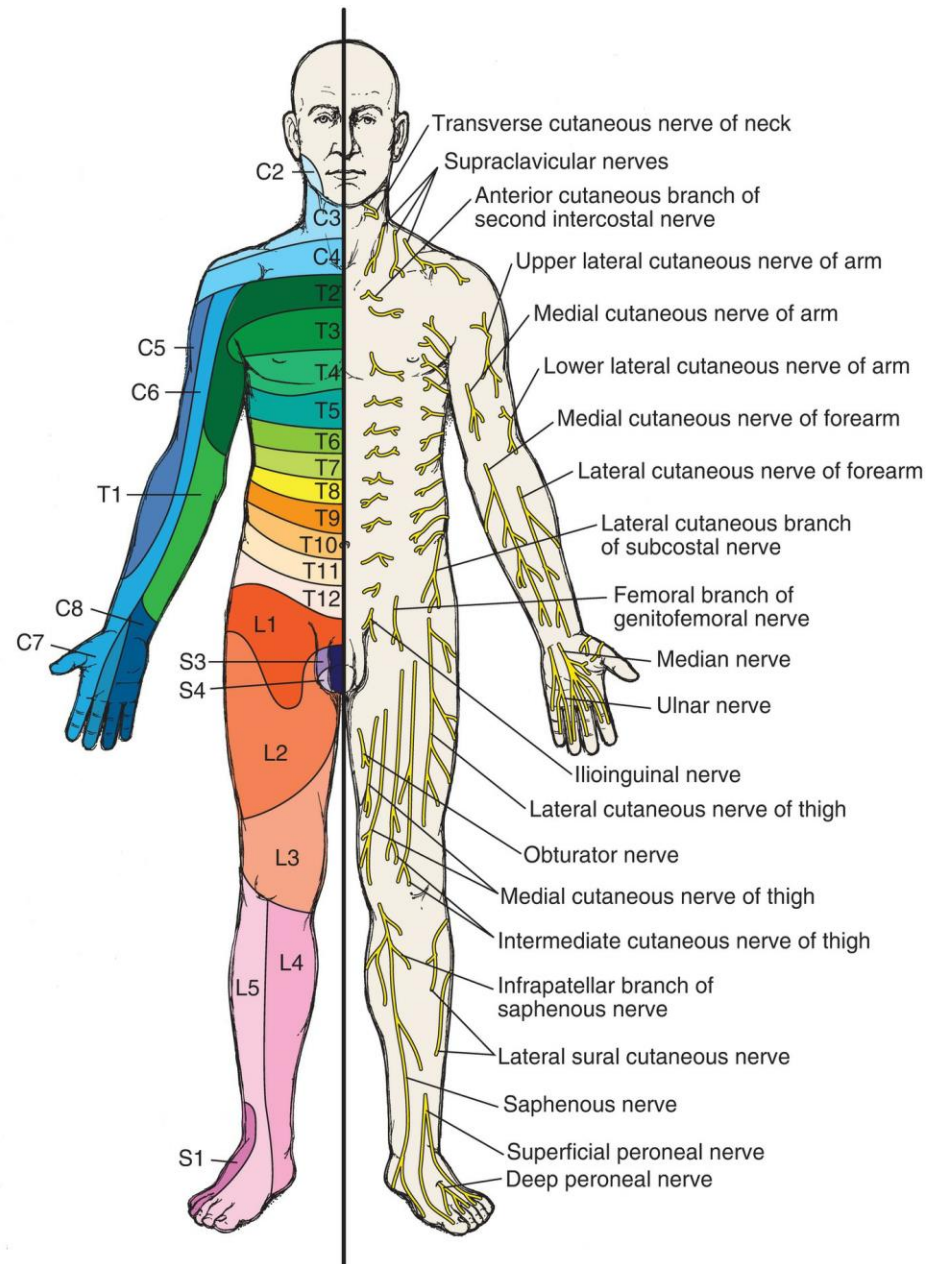




# CLINICAL NOTES

## Referred pain.

The **supraclavicular nerves (C3 and 4)** provide the cutaneous innervation of the anterior chest wall **above the level of the sternal angle**. Below this level, the anterior and lateral cutaneous branches of the intercostal nerves supply oblique bands of skin in regular sequence; **these bands of skin are called dermatomes**. The 7<sup>th</sup> to 11th intercostal nerves supply dermatomes on the anterior abdominal wall, muscles of the anterior abdominal wall, and parietal peritoneum. This latter fact is of great clinical importance because it means that **disease in the thoracic wall may be revealed as pain in the anterior abdominal wall**. For example, a pulmonary pneumonia with pleurisy involving the parietal pleura could give rise to **abdominal pain and tenderness and rigidity of the abdominal musculature**. The abdominal pain in these instances is called **referred pain**.





# Herpes Zoster

Herpes zoster, or **shingles**, is a relatively common condition caused by the reactivation of the latent varicella-zoster virus in a patient who has previously had chickenpox. **The lesion is seen as an inflammation and degeneration of the sensory neurons in a cranial or spinal nerve** with the formation of **vesicles and inflammation of the skin**. In the thorax, the first symptom is a **band of dermatomal pain** in the distribution of the sensory neurons in a thoracic spinal nerve, followed in a few days by a skin eruption. **The condition occurs most frequently in patients older than 50 years.**



Herpes zoster lesions

# BLOOD SUPPLY OF THE THORACIC WALL.

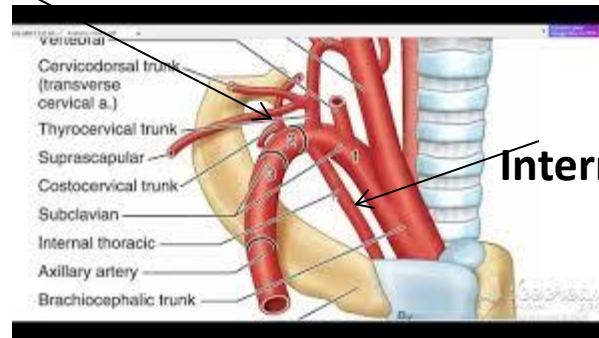
The blood supply of the thoracic wall comes from three sources

1. **Subclavian artery**, it provides blood through its **superior intercostal and internal thoracic branches.**

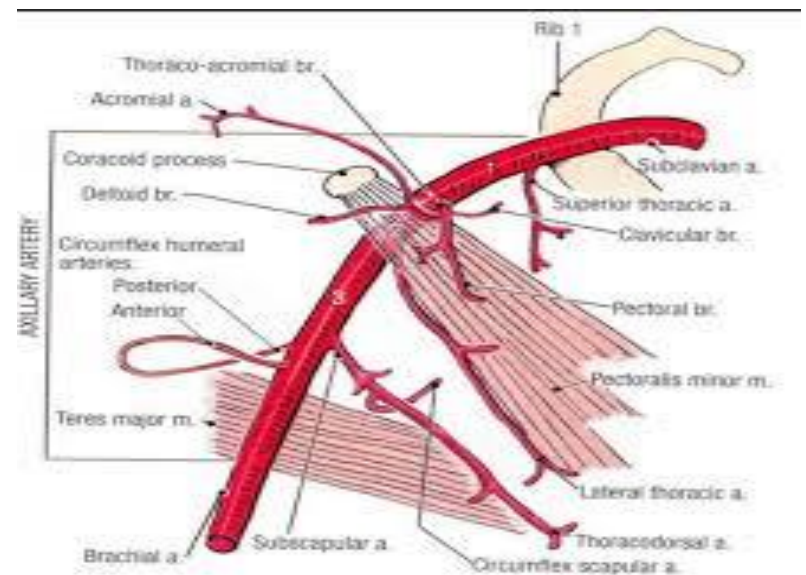
2. **Axillary artery**, it supplies via its **superior thoracic and lateral thoracic** branches.

3. **Thoracic aorta**, it gives off **posterior intercostal and subcostal** branches.

Superior intercostal art.



Internal thoracic artery

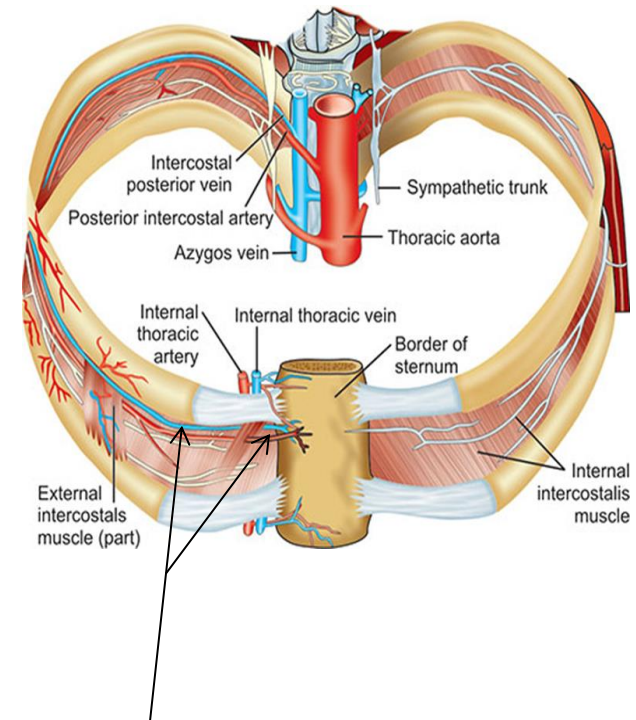


## Internal Thoracic Artery

**course** The internal thoracic artery supplies the anterior wall of the body from the clavicle to the umbilicus. It is a branch of the first part of the subclavian artery in the neck. It descends vertically on the pleura behind the costal cartilages, lateral to the sternum, and ends in the sixth intercostal space by dividing into the superior epigastric and musculophrenic arteries.

### Branches:

1. Two anterior intercostal arteries supplying the upper six intercostal spaces
2. Perforating arteries.
3. The pericardiophrenic artery accompanies the phrenic nerve and supplies the pericardium.
4. Mediastinal arteries supply the contents of the anterior mediastinum (e.g., the thymus).
5. The superior epigastric artery enters the rectus sheath of the anterior abdominal wall and supplies the rectus muscle as far as the umbilicus.
6. The musculophrenic artery runs around the costal margin of the diaphragm and supplies the lower intercostal spaces and the diaphragm.



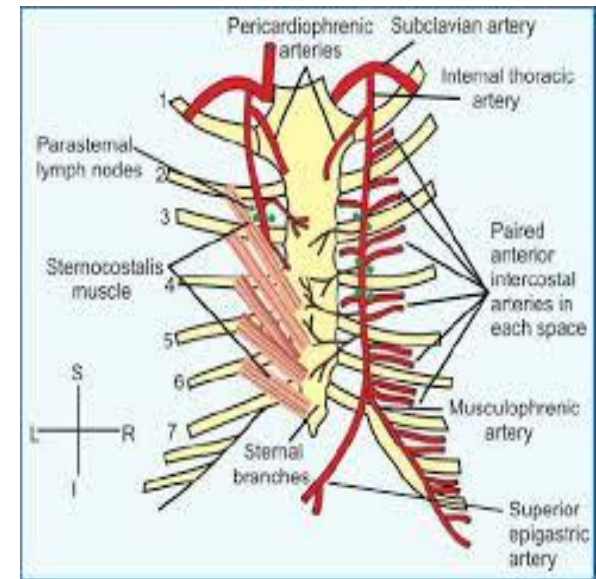
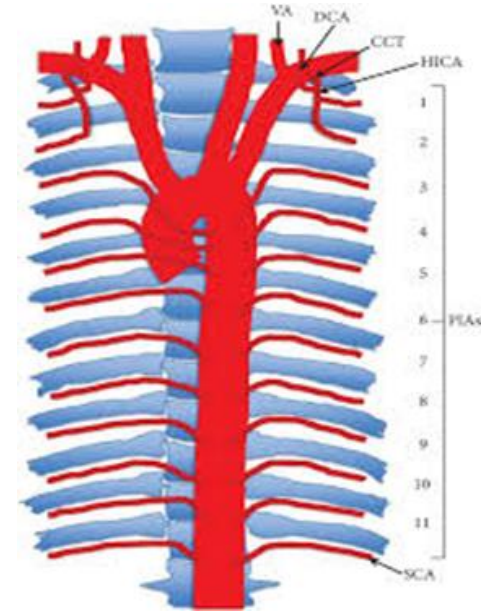
**Anterior intercostal arteries**

# Intercostal Arteries

Each intercostal space contains a large single **posterior intercostal artery** that arise from thoracic aorta and two small **anterior intercostal arteries** that arise from the internal thoracic artery.

The **posterior intercostal arteries** of the first two spaces are branches from the **superior intercostal artery** which is a branch of the **costocervical trunk of the subclavian artery**. The posterior intercostal arteries of the lower nine spaces are branches of the **descending thoracic aorta**.

The **anterior intercostal arteries** of the first six spaces are branches of the internal thoracic artery, The anterior intercostal arteries of the lower spaces are branches of the **musculophrenic artery**, a terminal branches of the internal thoracic artery.

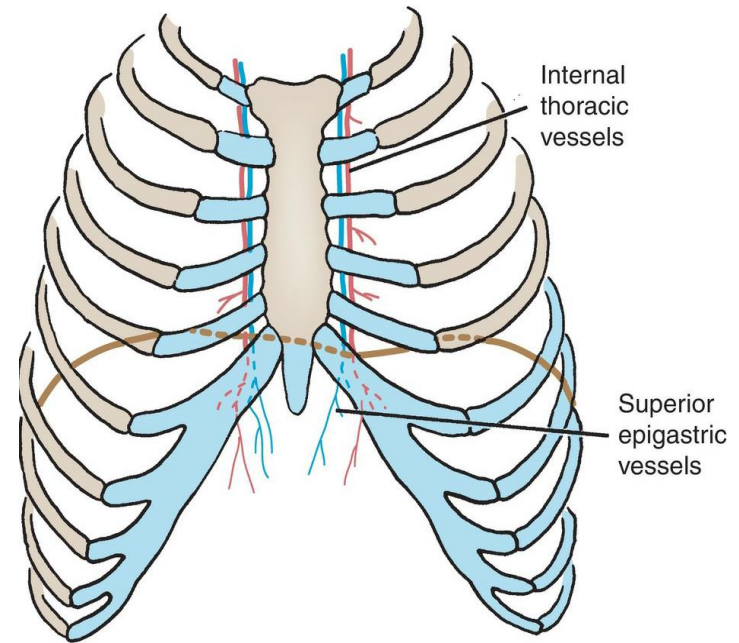




Each intercostal artery gives off branches to the muscles, skin, and parietal pleura. The branches to **the superficial structures are particularly large in the breast region in females.** The anterior and posterior intercostal arteries **typically anastomose with one another at approximately the costochondral junctions.**

### **Venous drainage of thoracic wall**

The corresponding **posterior intercostal veins** drain posteriorly into the **azygos** or **hemiazygos** veins. The **anterior intercostal veins** drain anteriorly into the **internal thoracic and musculophrenic veins.**

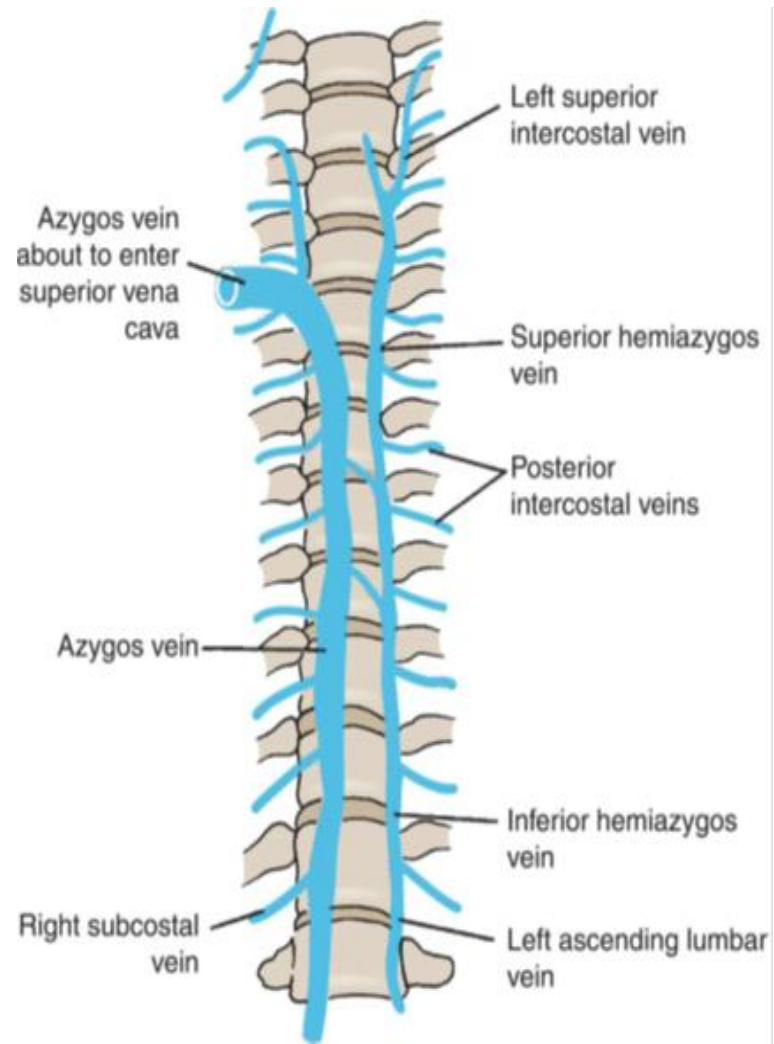




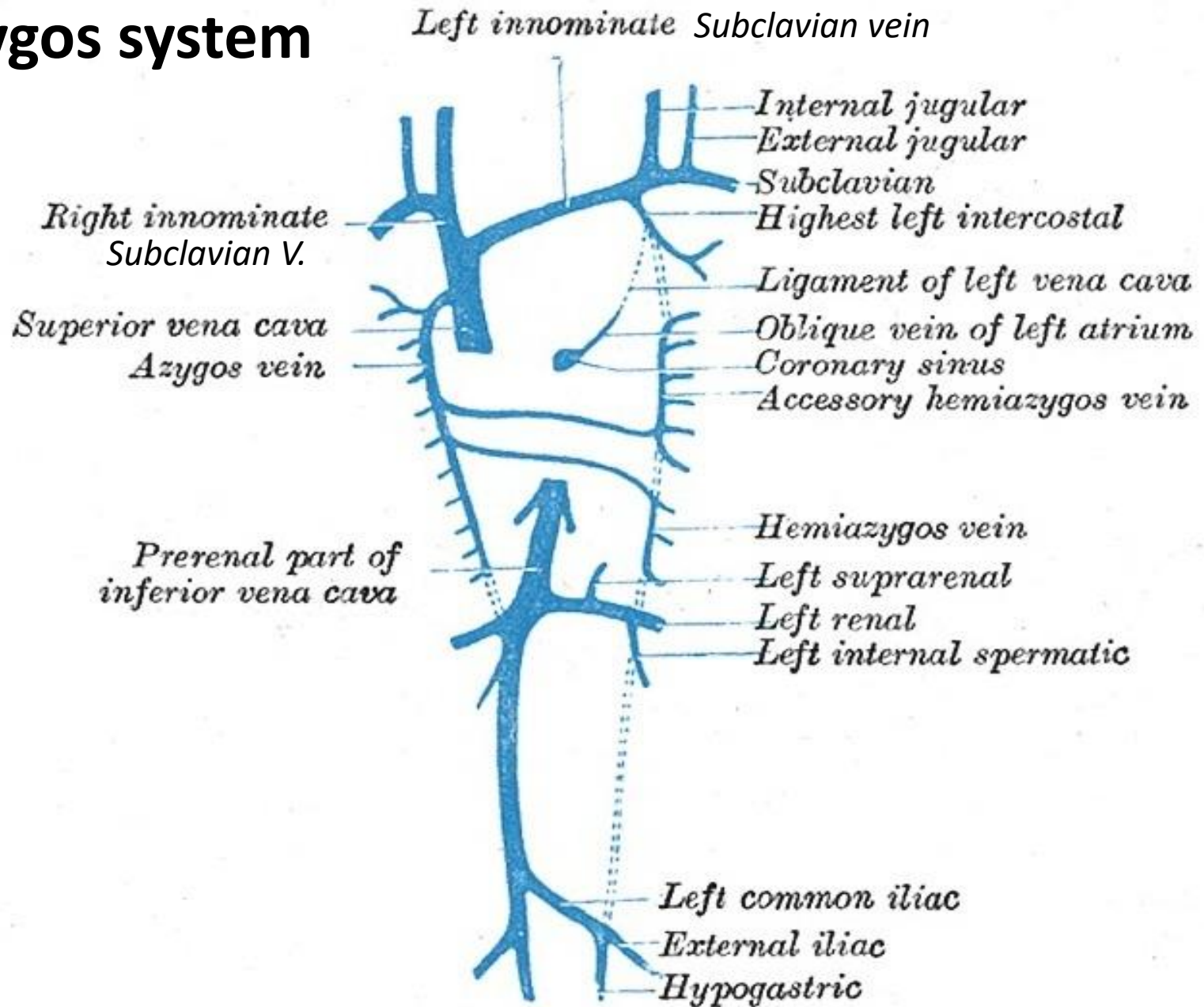
## The azygos venous system

is located on either side of the [vertebral column](#) and drains the viscera within the [mediastinum](#), as well as the [back](#) and thoracoabdominal walls. This system consists of the **azygos vein** and its two main tributaries: the [hemiazygos vein](#) and the accessory [hemiazygos vein](#).

**The azygos vein** usually arises either from the lumbar azygos vein or from the posterior side of [inferior vena cava](#) around the level of [renal veins](#). It passes through the [diaphragm](#), reaches the mediastinum and finally drains into the [superior vena cava](#). The azygos venous system has many anastomoses with inferior vena cava and vertebral venous plexuses. This makes it an important connection between the two venae cavae which allows alternate drainage route in case of inferior vena cava obstruction,

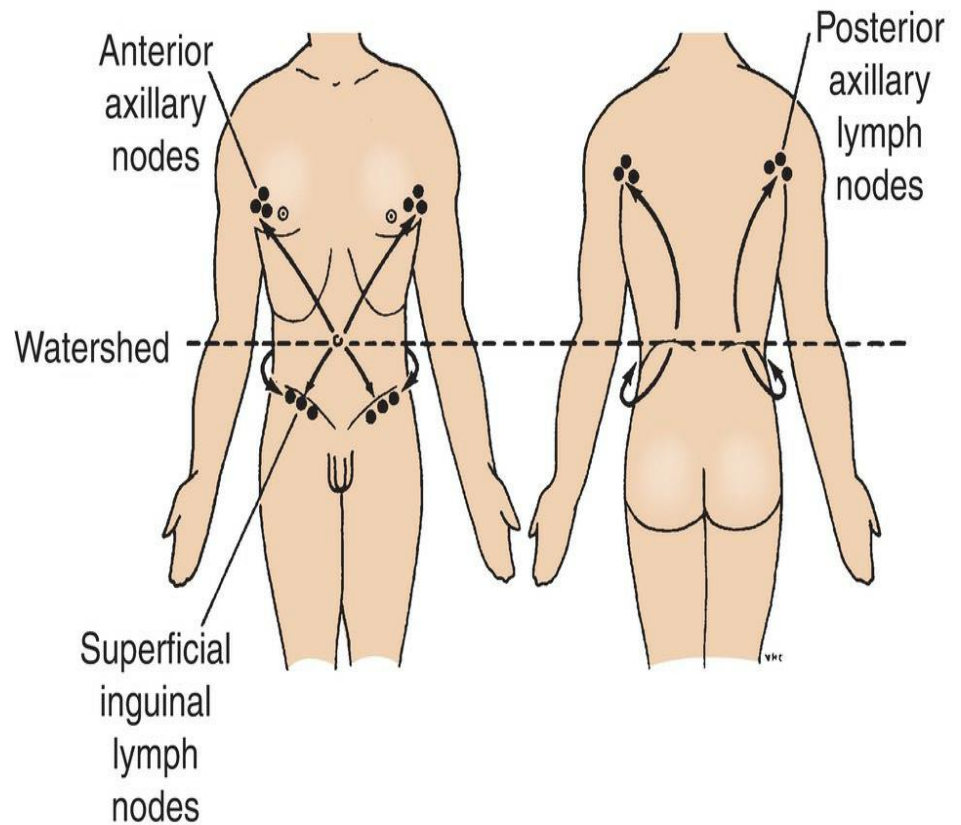


# Azygos system



## Thoracic Wall Lymph Drainage

The lymph drainage of the skin of the anterior chest wall passes to the **anterior axillary lymph nodes**; from the posterior chest wall passes to the **posterior axillary nodes**. The lymph drainage of the intercostal spaces passes forward to the **internal thoracic nodes**, situated along the internal thoracic artery, and posteriorly to the **posterior intercostal nodes** and the **para-aortic nodes** in the posterior mediastinum.



- **Movements of thoracic wall during respiration**

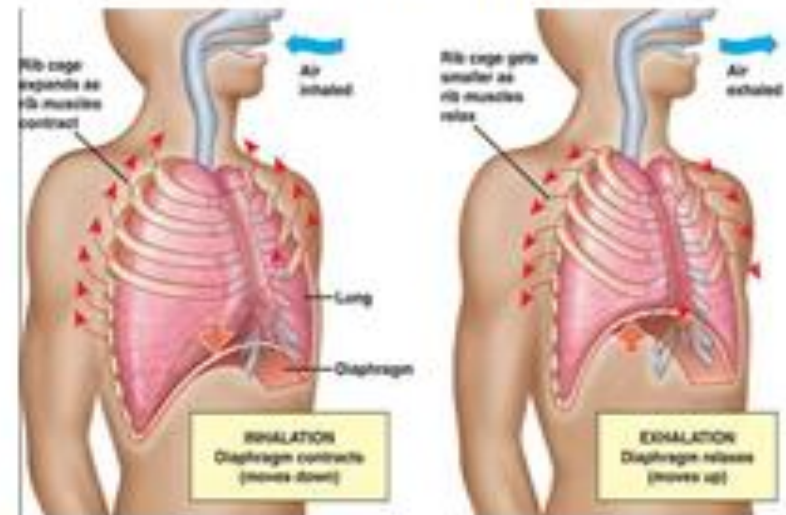
- During breathing, the dimension of thorax change in 3 directions:

- Vertical → contraction & relaxation of diaphragm

- Lateral
  - Anteroposterior

} Elevation & depression of the ribs

Vertical dimension



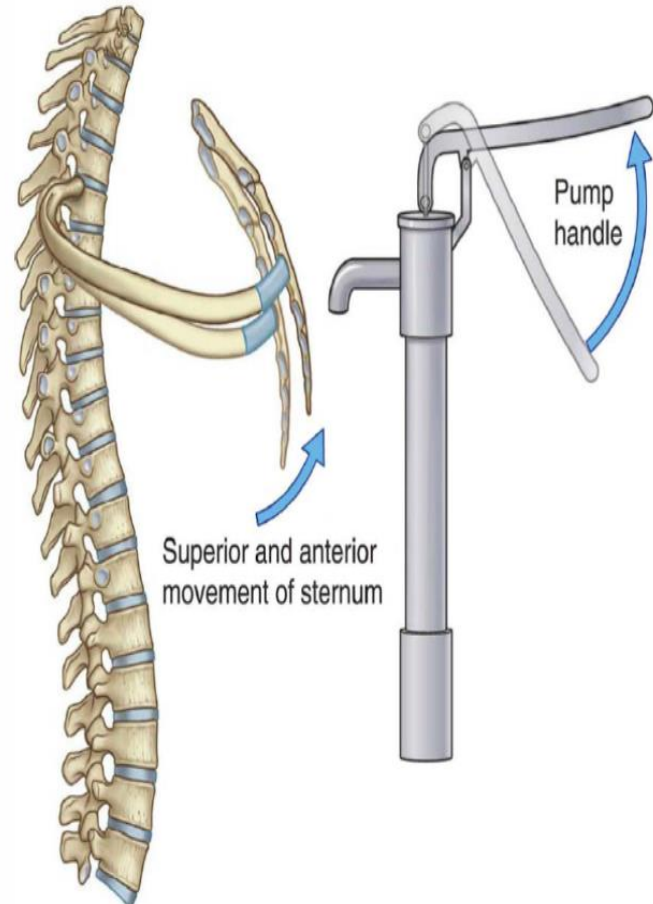
AP dimension





## "Pump handle" movement (anteroposterior direction)

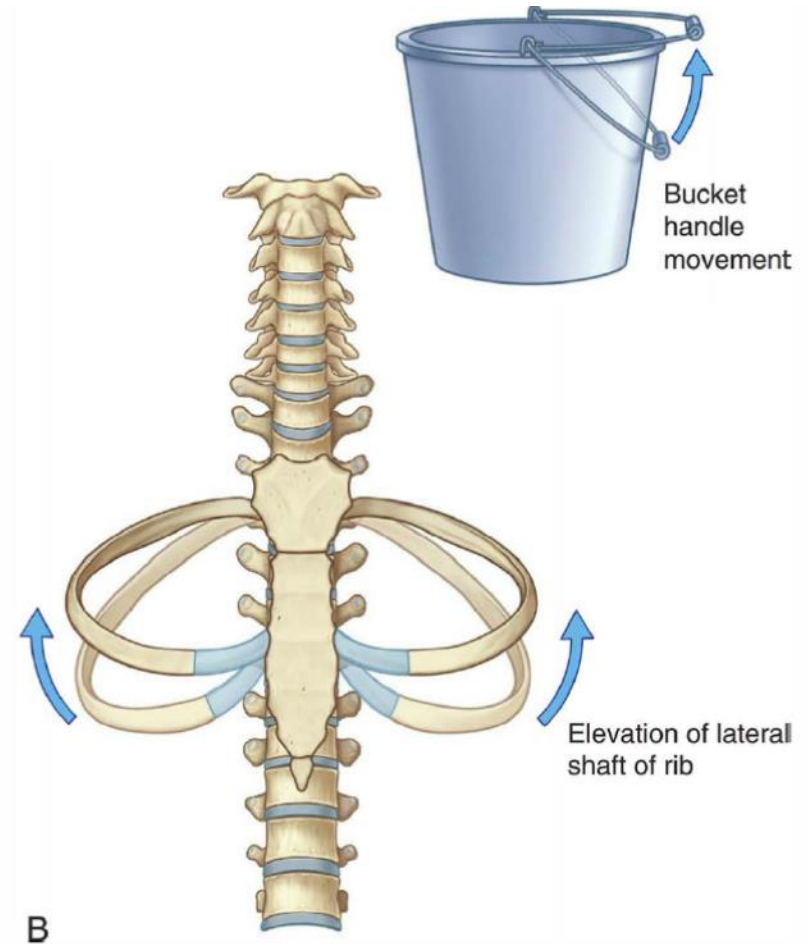
Anterior ends of the ribs are inferior to the posterior ends, **When the ribs are elevated, they move the sternum upward and forward.** The angle between the body of the sternum and the manubrium may become slightly increased. **When the ribs are depressed, the sternum moves downward and backward.** This will alter the dimensions of the thorax in the **anteroposterior** direction





## "Bucket handle" movement (lateral diection)

Anterior ends of the ribs being lower than the posterior ends, the middles of the shafts tend to be lower than the two ends. When the shafts are elevated, the middles of the shafts move laterally. This increases the **lateral dimensions (transverse diameter)** of the thorax



# CLINICAL NOTES

## Needle and tube thoracostomy

Needle thoracostomy is THE PROCEDURE OF creating and maintaining an opening into the thoracic cavity by using a **needle**. This may be necessary in patients with **tension pneumothorax** (air in the pleural cavity under pressure) or to **drain fluid** (blood or pus) away from the pleural cavity to allow the lung to reexpand. It may also be necessary to withdraw a sample of pleural fluid for microbiologic examination.

### Anterior Approach

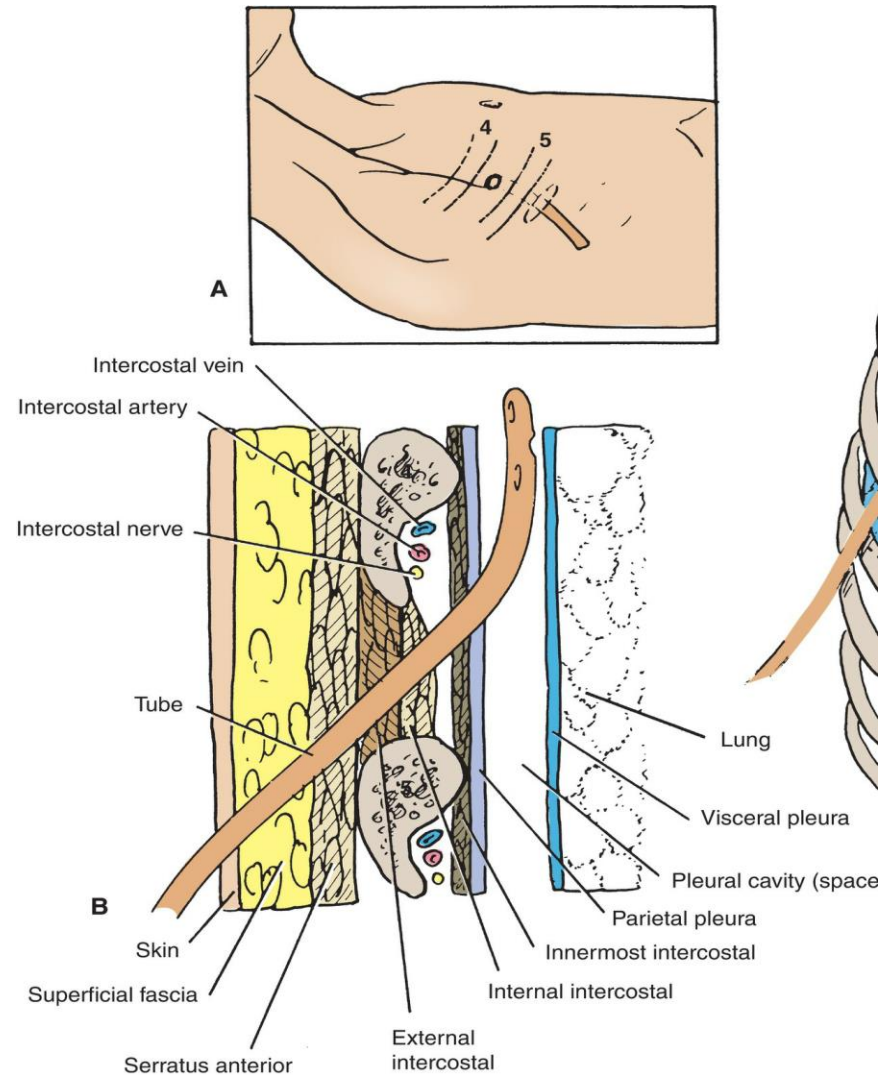
For the anterior approach, the patient is in the supine position. The sternal angle is identified, and then, the second costal cartilage, the second rib, and the second intercostal space are found in the midclavicular line.

### Lateral Approach

For the lateral approach, the patient is lying on the lateral side. The second intercostal space is identified and the anterior axillary line is used. The skin is prepared in the usual way, and a local anesthetic is introduced along the course of the needle above the upper border of the third rib.

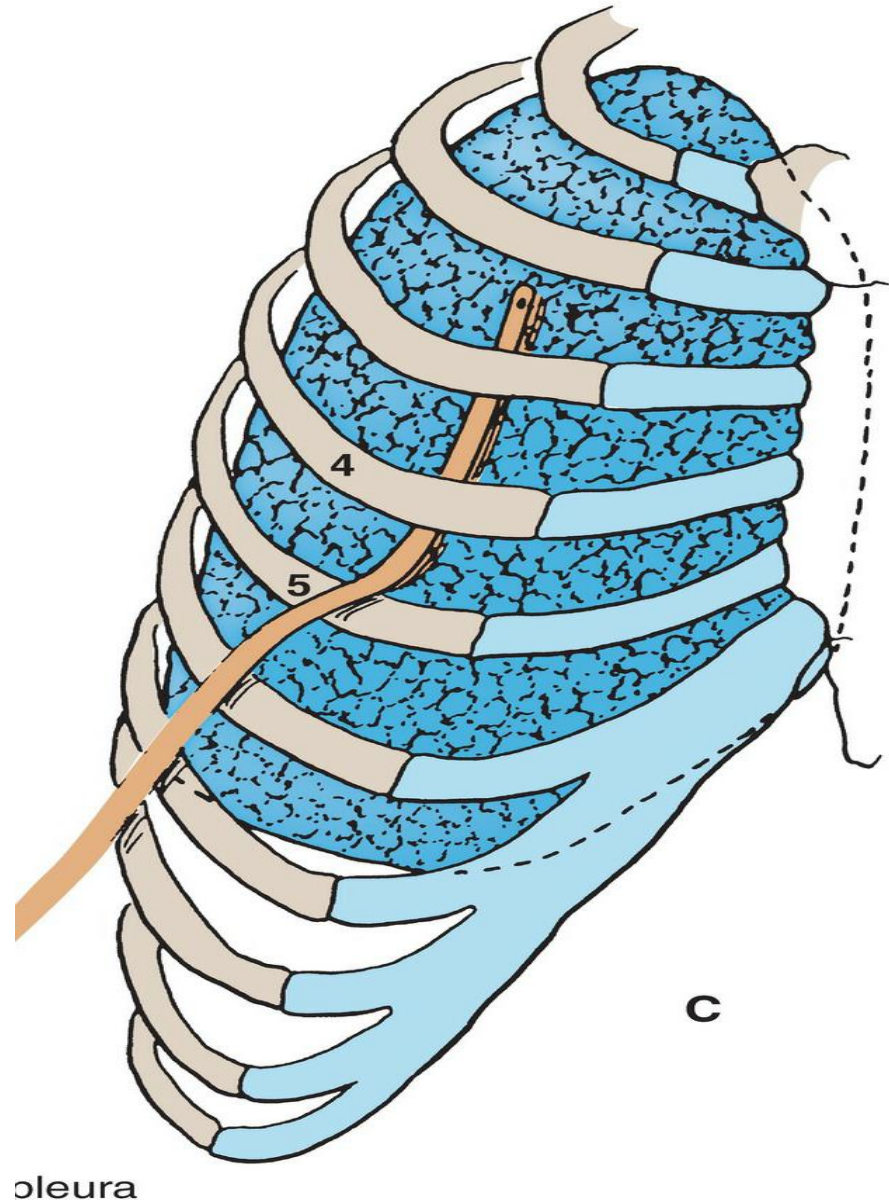
## Tube Thoracostomy

The preferred insertion site for a tube thoracostomy is the **fourth or fifth intercostal space at the anterior axillary line**. The tube is introduced through a small incision. The site for insertion of the tube at the anterior axillary line. The skin incision is usually made over the intercostal space one below the space to be pierced. The various layers of tissue penetrated by the scalpel and later the tube as they pass through the chest wall to enter the pleural cavity (space). The incision through the intercostal space is kept close to the upper border of the rib to avoid injuring the intercostal vessels and nerve. The tube advancing superiorly and posteriorly in the pleural space.



## Tube Thoracostomy

The preferred insertion site for a tube thoracostomy is the **fourth or fifth intercostal space at the anterior axillary line**. The tube is introduced through a small incision. The neurovascular bundle changes its relationship to the ribs as it passes forward in the intercostal space. As the bundle passes forward to the rib angle, it becomes closely related to the costal groove on the lower border of the rib above and maintains that position as it courses forward. The tube advancing superiorly and posteriorly in the pleural space.

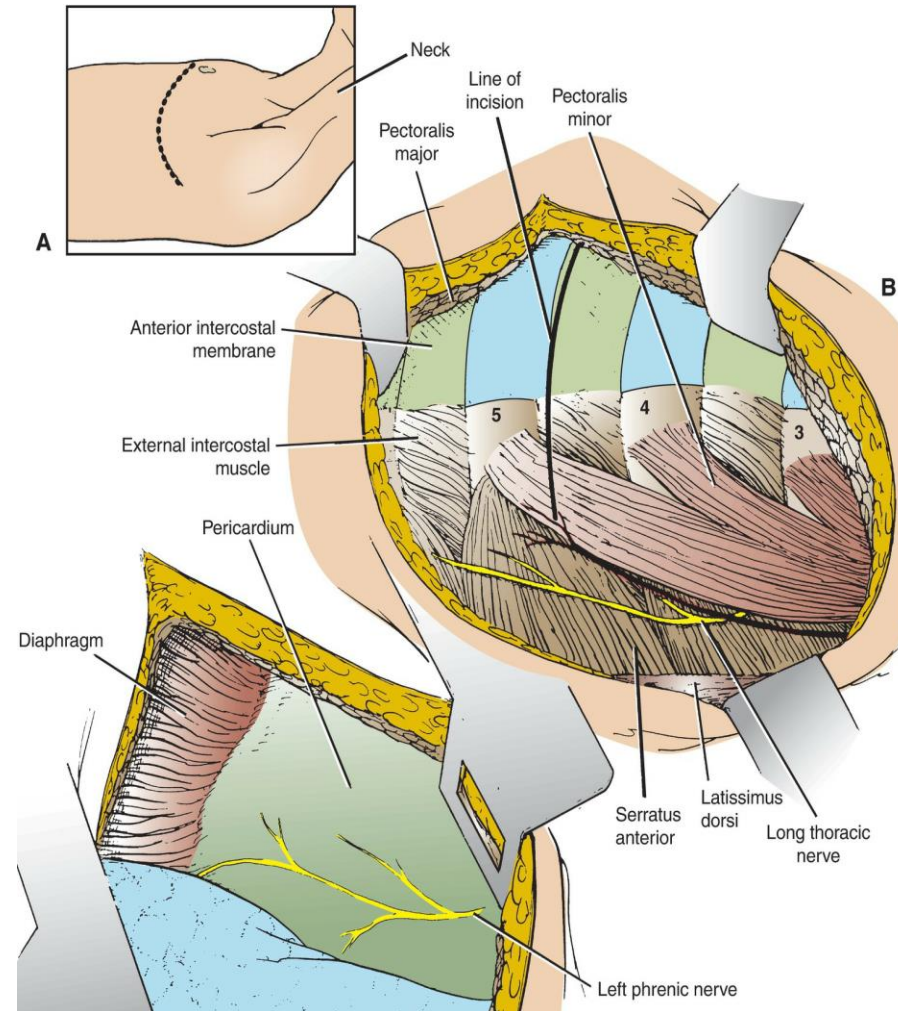




# Thoracotomy

Thoracotomy is making an incision through the thoracic wall into the pleural space. This may be a lifesaving procedure in patients with penetrating chest wounds with uncontrolled intrathoracic hemorrhage.

After preparing the skin in the usual way, the physician makes an incision over the **fourth or fifth intercostal space**, extending from the **lateral margin of the sternum to the anterior axillary line**. The following tissues will be incised: (a) skin, (b) subcutaneous tissue, (c) serratus anterior and pectoral muscles, (d) external intercostal muscle and anterior intercostal membrane, (e) internal intercostal muscle, (f) innermost intercostal muscle, (g) endothoracic fascia, and (h) parietal pleura. Avoid the internal thoracic artery, which runs vertically downward behind the costal cartilages about a fingerbreadth lateral to the margin of the sternum, and the intercostal vessels and nerve, which extend forward in the subcostal groove in the upper part of the intercostal space.





*Thank You*