

# The Thoracic wall including the diaphragm

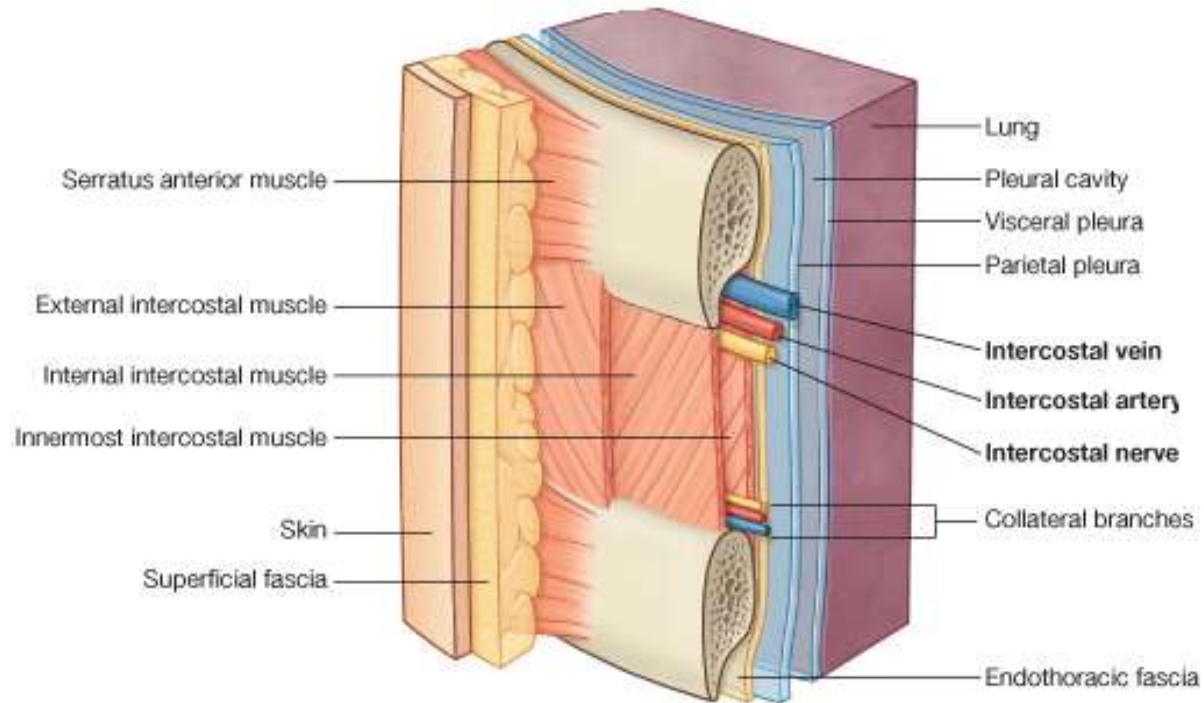
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# Components of the thoracic wall

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- ▶ Skin
- ▶ Superficial fascia
- ▶ Chest wall muscles (see upper limb slides)
- ▶ Skeletal framework
- ▶ Intercostal spaces containing intercostal muscles, vessels and nerves
- ▶ Parietal pleural



# Intercostal spaces

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- ▶ Each intercostal space separates the one rib and its costal cartilage from the other
- ▶ The spaces are named according to the vertebra above
- ▶ There are 11 intercostal spaces
- ▶ The last (12<sup>th</sup>) space is called the subcostal space
- ▶ The spaces are occupied by intercostal nerves, vessels, muscles and membranes
- ▶ The name assigned to these structures is the number of the space in which they are found
- ▶ The spaces widen with inspiration and narrow with expiration
- ▶ They are widest anterolaterally



# Intercostal Muscles

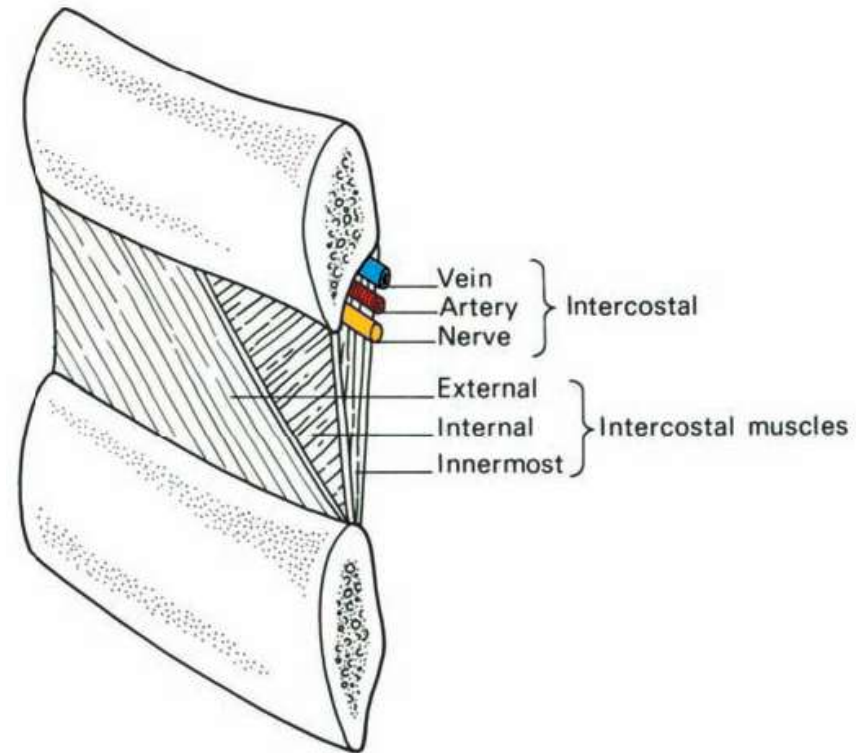
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▶ Each space has three muscles (Comparable to the three muscular layers of the abdomen). These are:

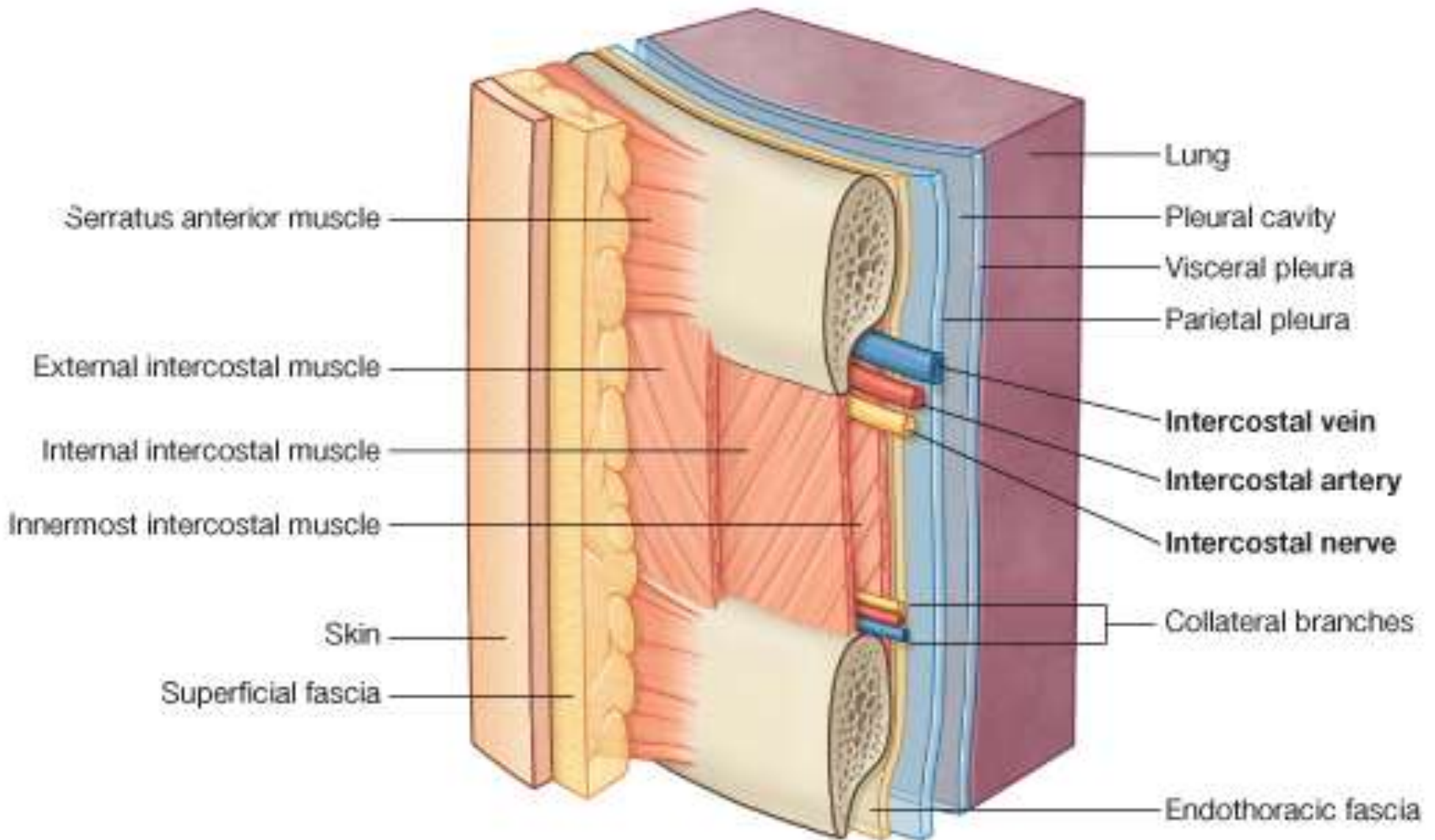
- i. External Intercostal
- ii. Internal Intercostal
- iii. Innermost Intercostal

All are supplied by Intercostal nerves T1-T11

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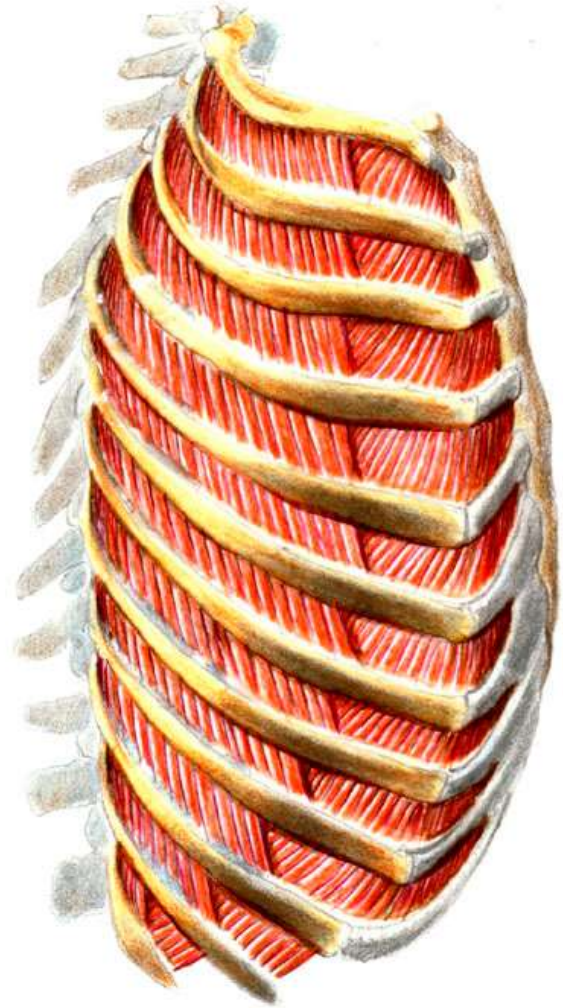
# Intercostal Muscles



# External Intercostal Muscle

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- ▶ There are eleven pairs
- ▶ The fibers of pass downwards and forwards from the rib above to the rib below
- ▶ Extends from the vertebrae to the costochondral junction where muscle is replaced by the anterior intercostal membrane
- ▶ Continuous inferiorly with the external oblique muscles in the abdominal wall
- ▶ Are most active during inspiration



# Internal Intercostal Muscle

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- ▶ Originates from the lateral (outer) edge of costal groove of the rib above
- ▶ Inserts in the superior surface of the rib below, deep to the attachment of the related external intercostals
- ▶ Runs downwards and backwards from the sternum to the angles of the ribs where it becomes the posterior intercostal membrane
- ▶ Continuous with the internal oblique muscles in the anterolateral abdominal wall
- ▶ Most active during expiration



# Innermost Intercostal Muscle

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- ▶ The fibers have the same orientation as the Internal intercostal muscle
  - ▶ Originates from the medial (inner) edge of costal groove of the rib above
  - ▶ Inserts into the internal aspect of the superior surface of the rib below
  - ▶ The neurovascular bundle of each ICS lies in the costal groove between the innermost and the internal intercostal muscles
  - ▶ The muscles are more prominent on the lateral aspect of the thoracic wall, but are less so anteriorly and posteriorly:
    - Anteriorly, they are replaced by the Transversus thoracis muscle
    - Posteriorly they are reinforced by the Subcostalis muscle
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# Transversus Thoracis Muscle

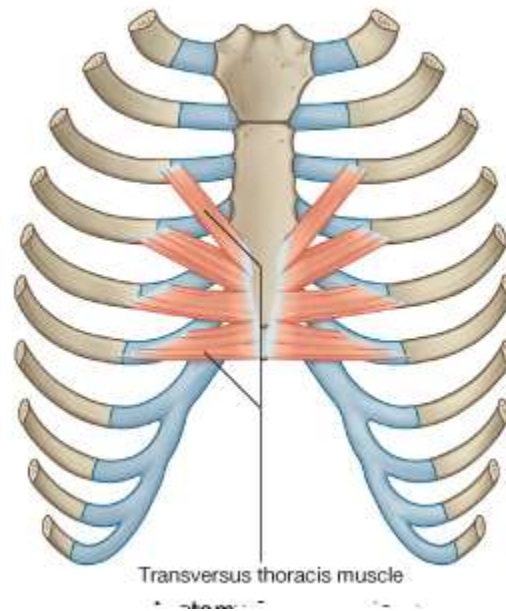
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- ▶ Found in the deep surface of the anterior thoracic wall
- ▶ Occupies the same plane as the innermost intercostal muscle
- ▶ Originate from the posterior aspect of the xiphoid process, the inferior part of the body of the sternum, and the adjacent costal cartilages.
- ▶ Spreads fanlike superiorly to be inserted into the inner surfaces of the 2<sup>nd</sup> to the 6<sup>th</sup> ribs
- ▶ They are deep to the internal thoracic vessels and help in securing these vessels to the wall



# Transversus Thoracis Muscle

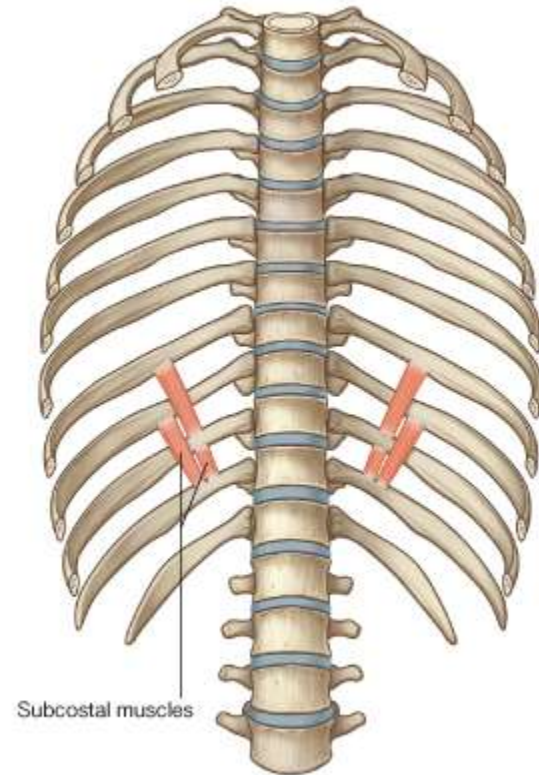
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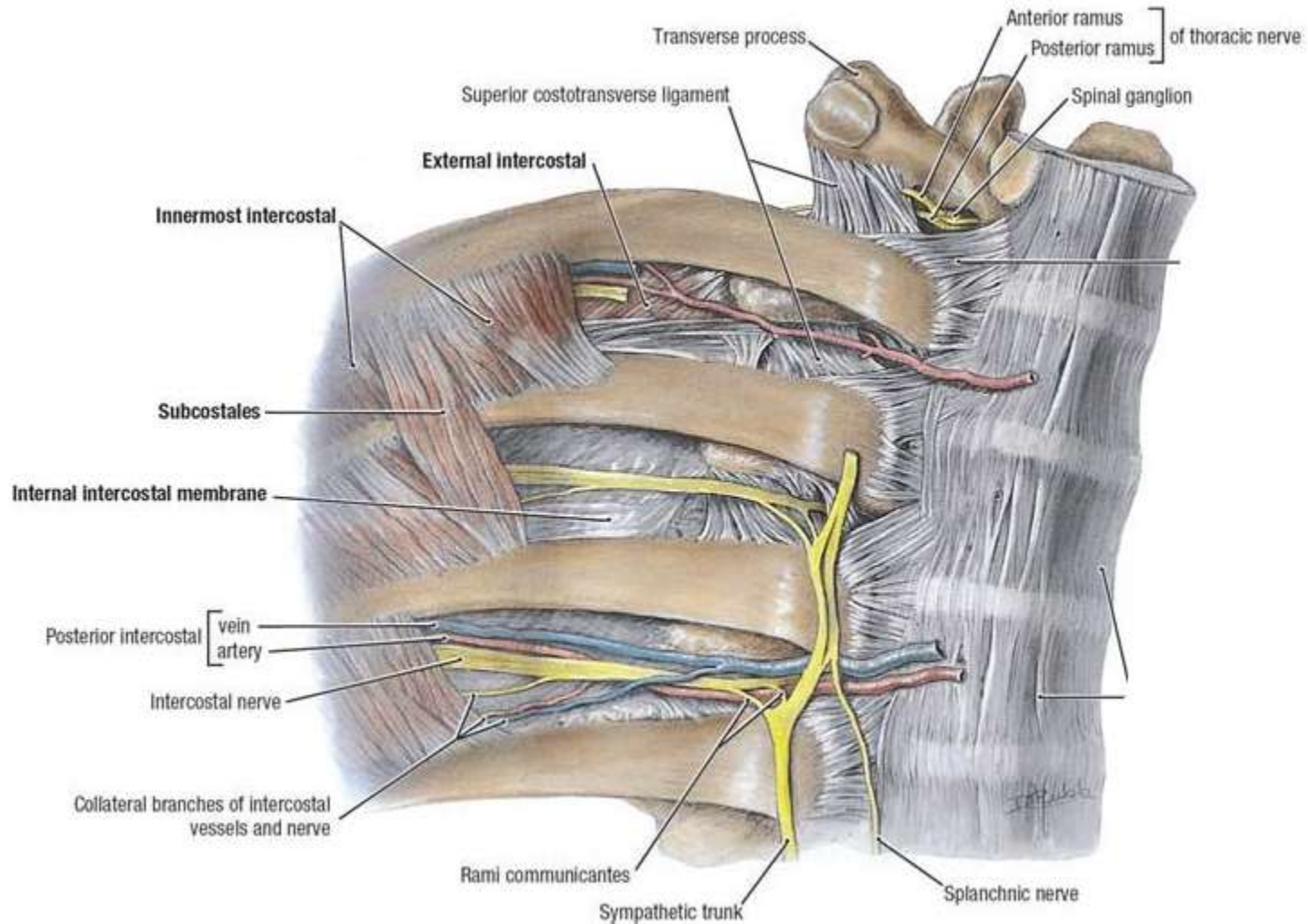
# Subcostal muscle

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- ▶ More distinct in the lower parts of the thorax
- ▶ Originates on the internal surface of the angle of one rib and inserts in the internal surface of the second or third rib inferior to the rib it originates from
- ▶ It blends with the internal intercostal muscle
- ▶ Acts to depress the ribs



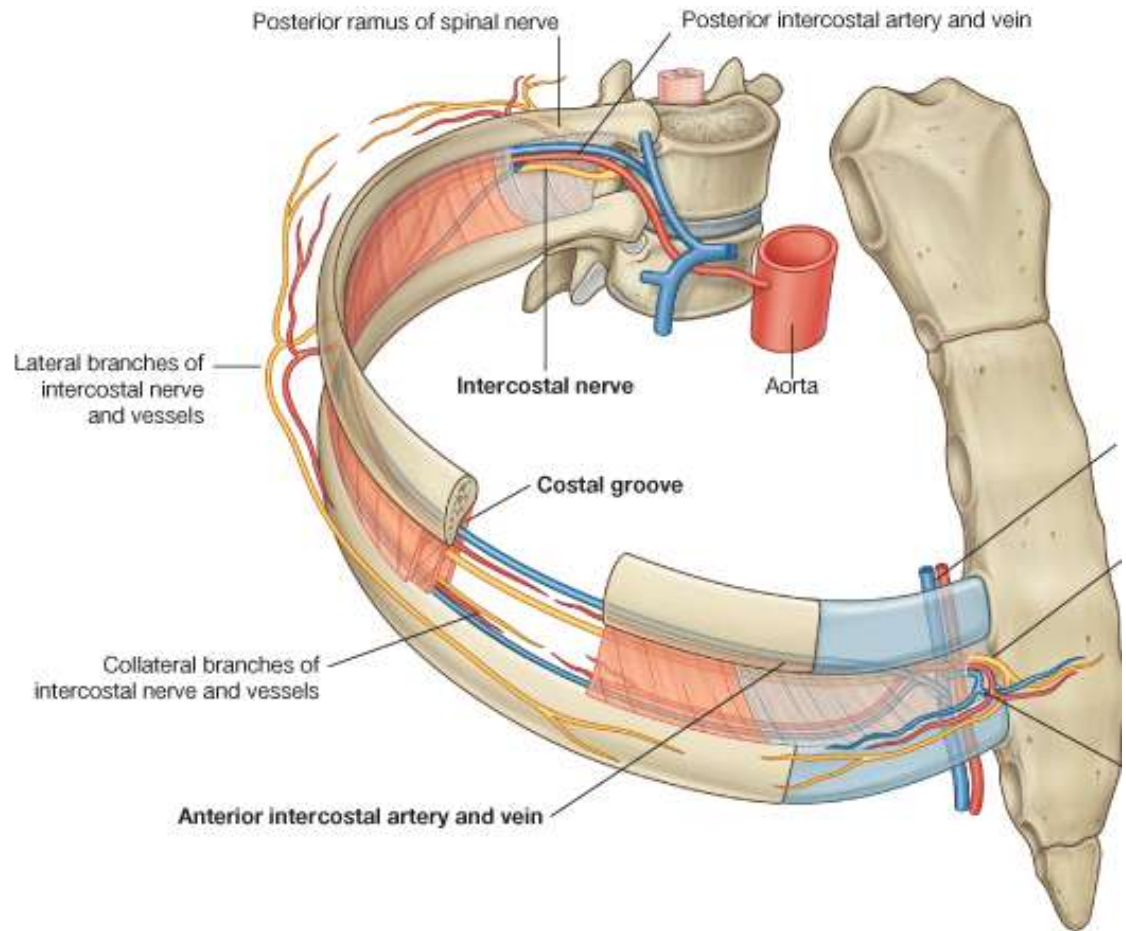
# Internal aspect of intercostal spaces



# Intercostal Arteries

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- ▶ Each intercostal space has 3 arteries:
- ▶ Two small anterior intercostal arteries from the internal thoracic artery
- ▶ One large posterior intercostal artery from the aorta



# Posterior Intercostal Arteries

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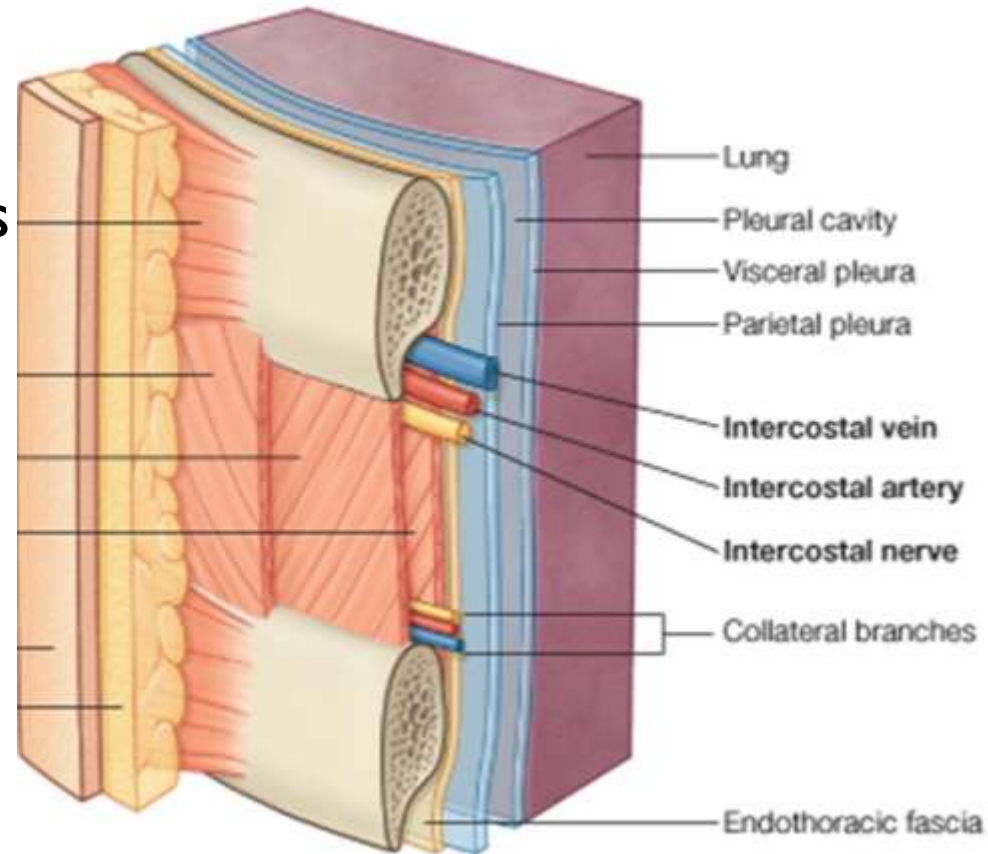
- ▶ 11 in number
- ▶ 1<sup>st</sup> and 2<sup>nd</sup> intercostal arteries originates from the supreme thoracic artery, a branch of costocervical trunk, which in turn is a branch of the subclavian artery
- ▶ 3<sup>rd</sup> - 11<sup>th</sup> intercostal arteries originates directly from the thoracic aorta
- ▶ Right posterior intercostal arteries cross the vertebral bodies and are longer than their counterparts on the left (Reason: Aorta is to the left of the midline)



# Posterior Intercostal Arteries

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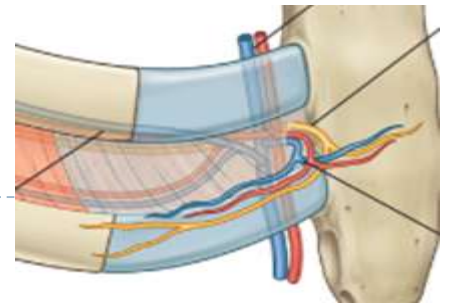
- ▶ Each intercostal artery lies in the costal grooves between the posterior intercostal vein above and the intercostal nerve below (VAN, just like the femoral triangle)



# Anterior Intercostal Arteries

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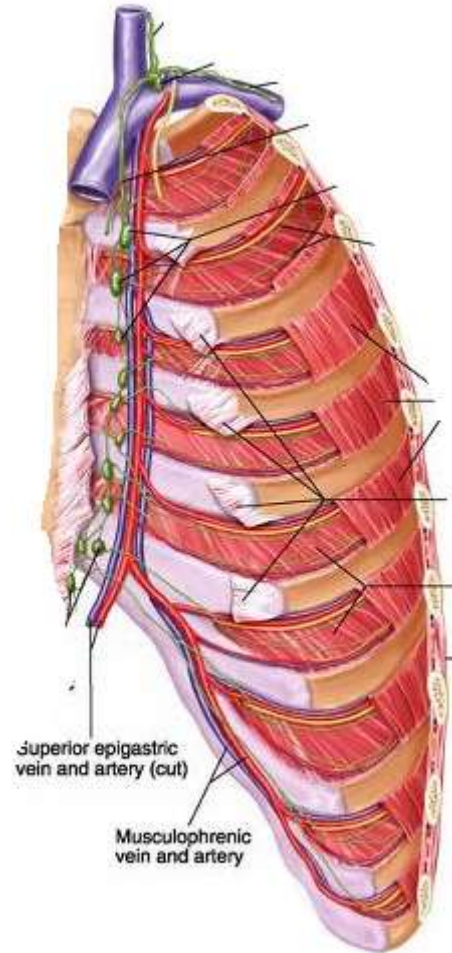
- ▶ Originate either directly from the internal thoracic artery (upper 6) or its musculophrenic branch (7 to 9) (or 7-11 when present in the 10<sup>th</sup> and 11<sup>th</sup> space)
- ▶ Usually absent from 10 and 11 intercostal spaces which are only supplied by the posterior intercostal artery
- ▶ Each intercostal space has two anterior intercostal arteries
- ▶ They pass laterally in the intercostal space, one near the inferior margin of the superior rib and the other near the superior margin of the inferior rib
- ▶ They are usually smaller than the corresponding Posterior Intercostal Artery





# Internal Thoracic Artery

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# Internal Thoracic Artery

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- ▶ Originates from the subclavian artery in the neck.
- ▶ Passes over the dome of the cervical pleural and then descends through the superior thoracic aperture
- ▶ Descend behind the anterior chest wall about 1cm lateral to the sternum
- ▶ It lies between the costal cartilage anteriorly and the transversus thoracis posteriorly
- ▶ At the 6<sup>th</sup> intercostal space, it divides into the musculophrenic and the superior epigastric arteries



# Internal Thoracic Artery

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- ▶ The Superior epigastric artery descends into the anterior abdominal wall
  - ▶ The musculophrenic artery descends along the costal margin giving rise to the following branches:
    - ▶ Anterior intercostal arteries 7 and below
    - ▶ Phrenic branches supplying parts of the diaphragm
    - ▶ Perforating branches emerge lateral to the sternum accompanied by their veins and anterior cutaneous branches of the upper six intercostal nerves. They supply the anterior thoracic wall including the breast
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# Venous drainage of the chest wall

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## ▶ **Posteriorly**

- This runs a different course to the arterial drainage
- The course is also different on the right and the left side

## ▶ **Anteriorly**

- The venous drainage is identical on either side
- The venous drainage is similar to the arterial supply until its termination into the brachiocephalic vein



# Venous drainage of the chest wall

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**Posteriorly:** This is through the posterior intercostal veins:

## ▶ **Right side**

- Most right posterior intercostal veins (4-11) drain into the azygos vein, which empties into the superior vena cava
- 1<sup>st</sup> posterior intercostal vein drain into the brachiocephalic vein on both sides
- Posterior intercostal veins 2 & 3 forms the superior intercostal vein which is the final tributary of the azygous vein



# Venous drainage of the chest wall

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## Posteriorly:

### ▶ Left side

- Most left posterior intercostal veins (4-11) drain mainly into the hemiazygos and accessory hemiazygos veins, which drain into the azygos vein.
- In a similar fashion to the right side, the 1<sup>st</sup> posterior intercostal vein drain into the brachiocephalic vein
- Posterior intercostal veins 2 & 3 forms the superior intercostal vein which enters the left brachiocephalic vein



# Venous drainage of the chest wall

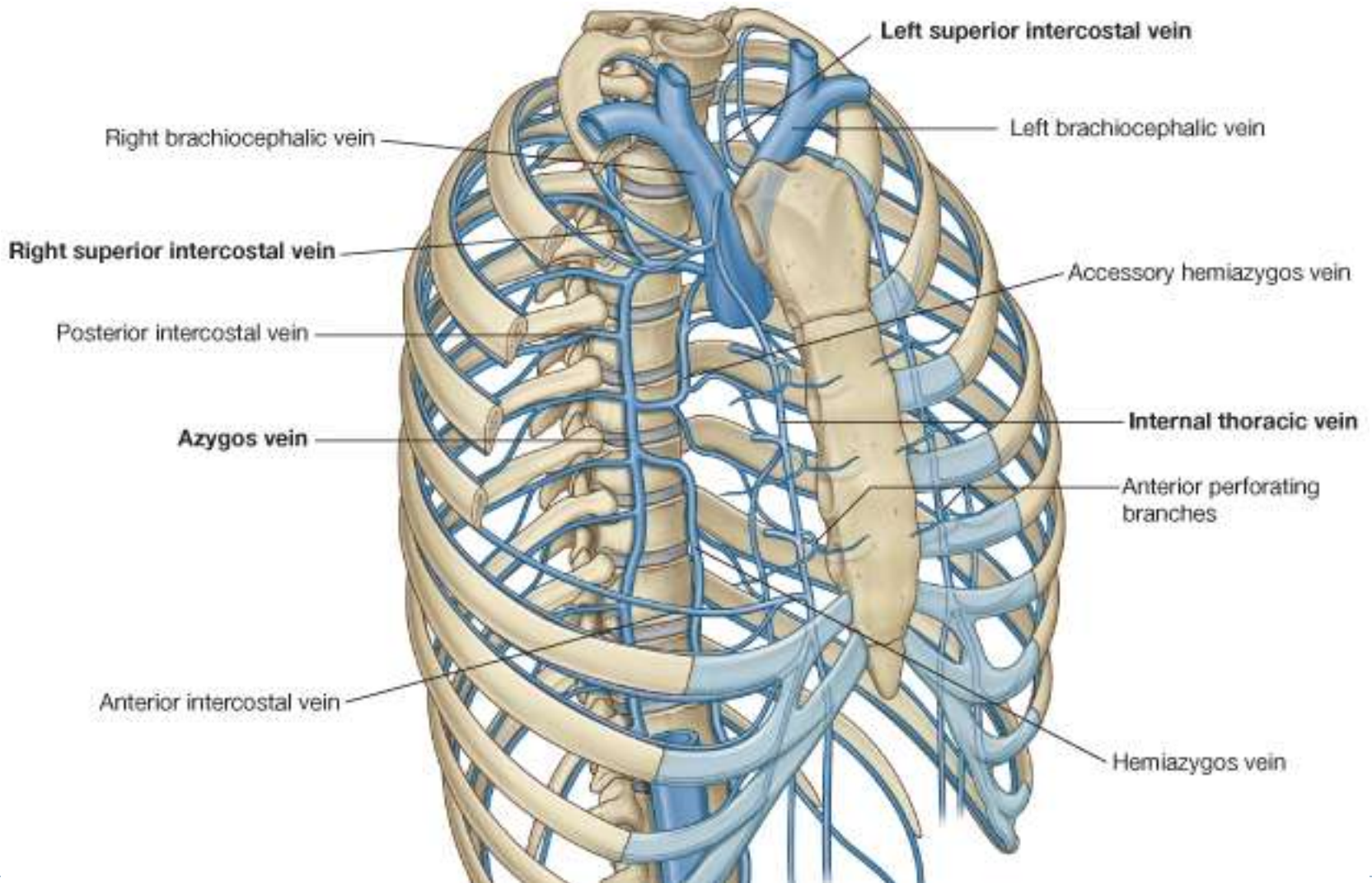
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## **Anteriorly:**

- ▶ This is through the Anterior intercostal veins:
- ▶ Drain either into the musculophrenic or the internal thoracic vein
- ▶ The musculophrenic vein drains into the internal thoracic vein and the internal thoracic vein drains into the brachiocephalic vein



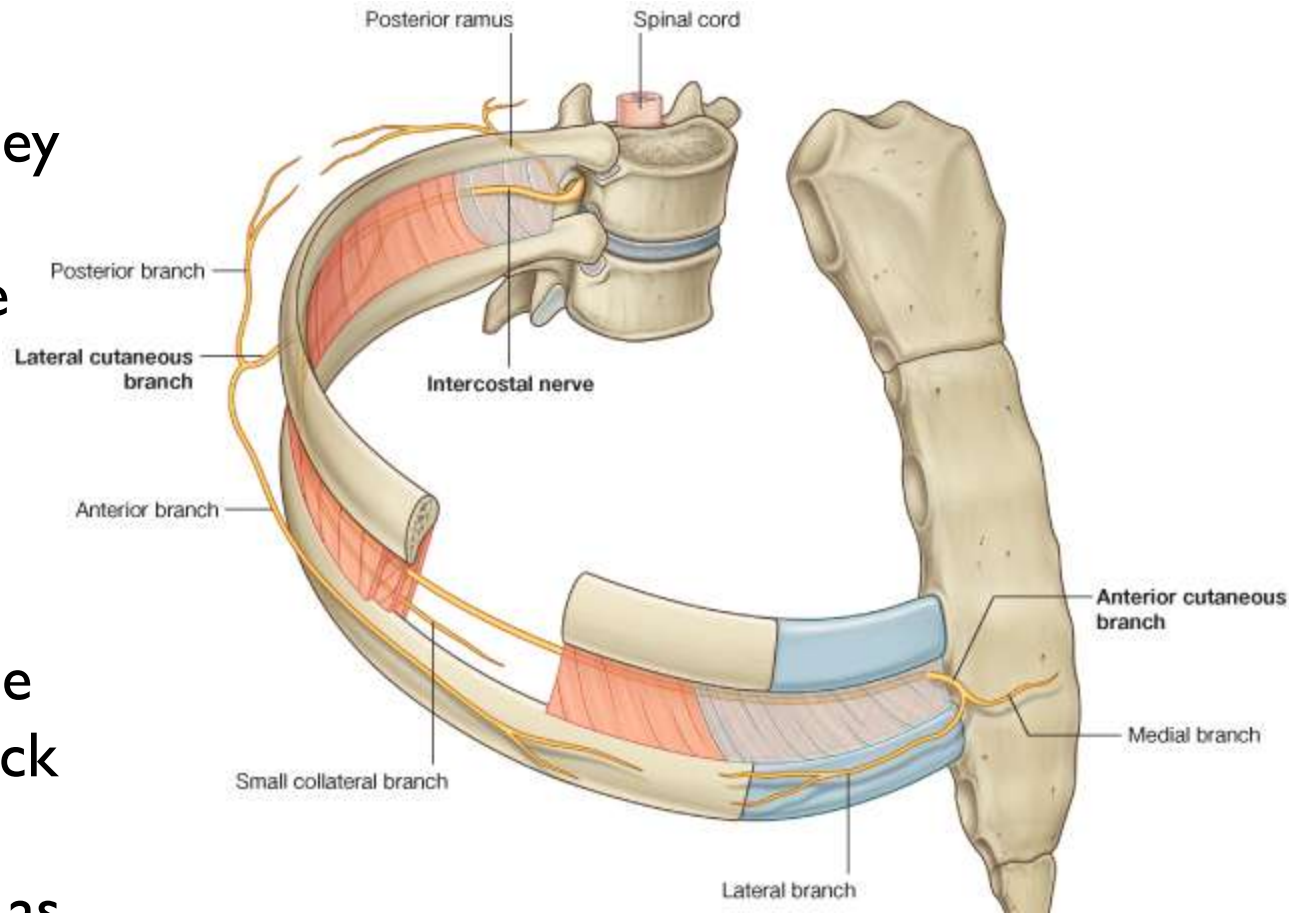
# Venous drainage of the chest wall





# Thoracic Nerves

- As it leaves the intervertebral foramina in which they are formed, each thoracic spinal nerve divides into an anterior and a posterior primary rami .
- The later supplies the structures on the back
- The anterior rami continues anteriorly as the Intercostal nerve



# Intercostal nerves

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- ▶ Each runs laterally from an intervertebral foramen
- ▶ Each enters the neurovascular plane between the innermost and internal intercostal muscles
- ▶ Near the midaxillary line, each of these nerves gives rise to a collateral branch that runs along the superior border of the rib below
- ▶ Near the angle of its respective rib the nerve runs anteriorly within the costal groove below the artery
- ▶ Each gives off a lateral cutaneous branch about midway along the intercostal space



# Intercostal nerves

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- ▶ Intercostal nerves 1-6 are confined to the thorax.
- ▶ Each of these 6 terminates as anterior cutaneous branches that emerge from the upper six intercostal spaces lateral to the sternum



# Intercostal nerves

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- ▶ Intercostal nerves 7-11 leave their intercostal spaces and enter the anterior abdominal wall by descending deep to the costal margin
- ▶ They are sometimes called thoracoabdominal nerves



# Intercostal nerves: Functions

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- ▶ Innervate the following muscles:
  - i. External intercostal muscles
  - ii. Internal intercostal muscles
  - iii. Innermost intercostal, subcostal, and the transversus thoracis muscles
- ▶ Supply thoracic skin, except for the medial part of the posterior chest which is supplied by dorsal rami of spinal nerves
- ▶ Supplies the parietal pleural
- ▶ Other body regions



# Intercostal nerves: Functions

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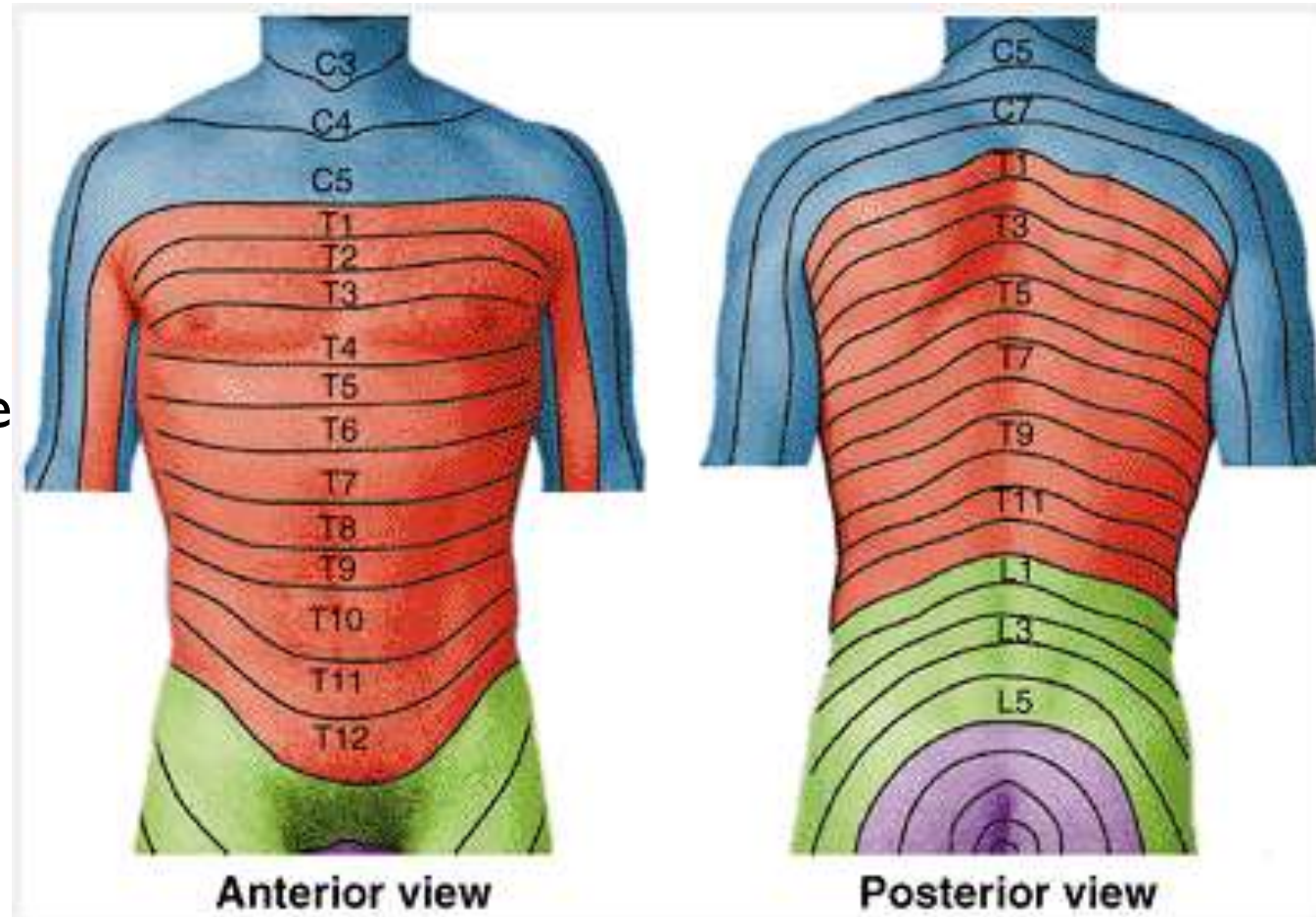
- ▶ Other body regions supplied by the Nerves are:
  - i. Brachial plexus through the anterior ramus of T1
  - ii. Skin of the medial surface of the upper arm through the lateral cutaneous branch of the second intercostal nerve (the intercostobrachial nerve)
  - iii. The abdominal wall through the lower intercostal nerves.



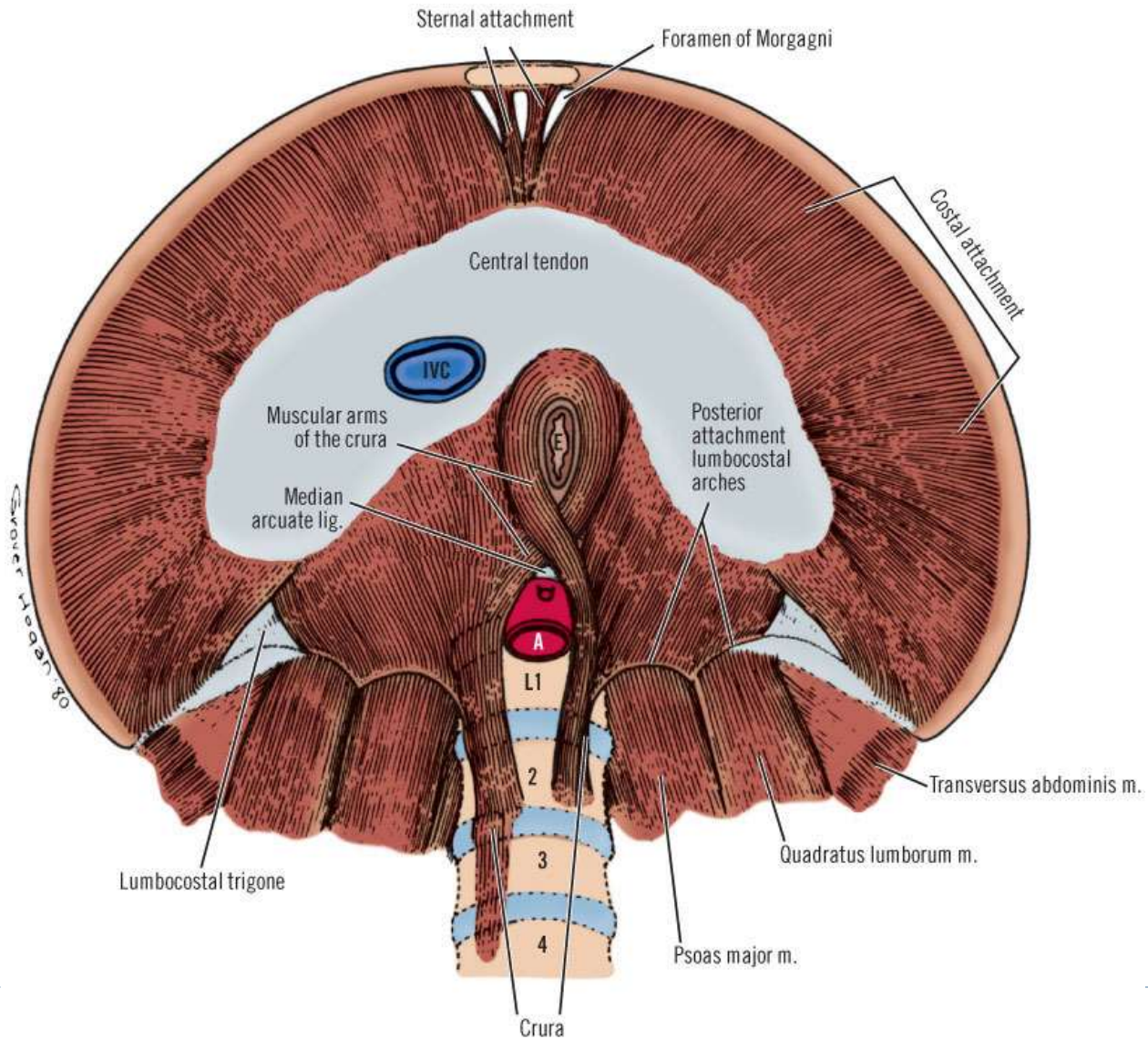
# Intercostal nerves: The Dermatomes

**NOTE:**

- Nipple: T4
- Umbilicus: T10
- C6 to C8 are not represented on the trunk anteriorly because they are innervating the upper limbs



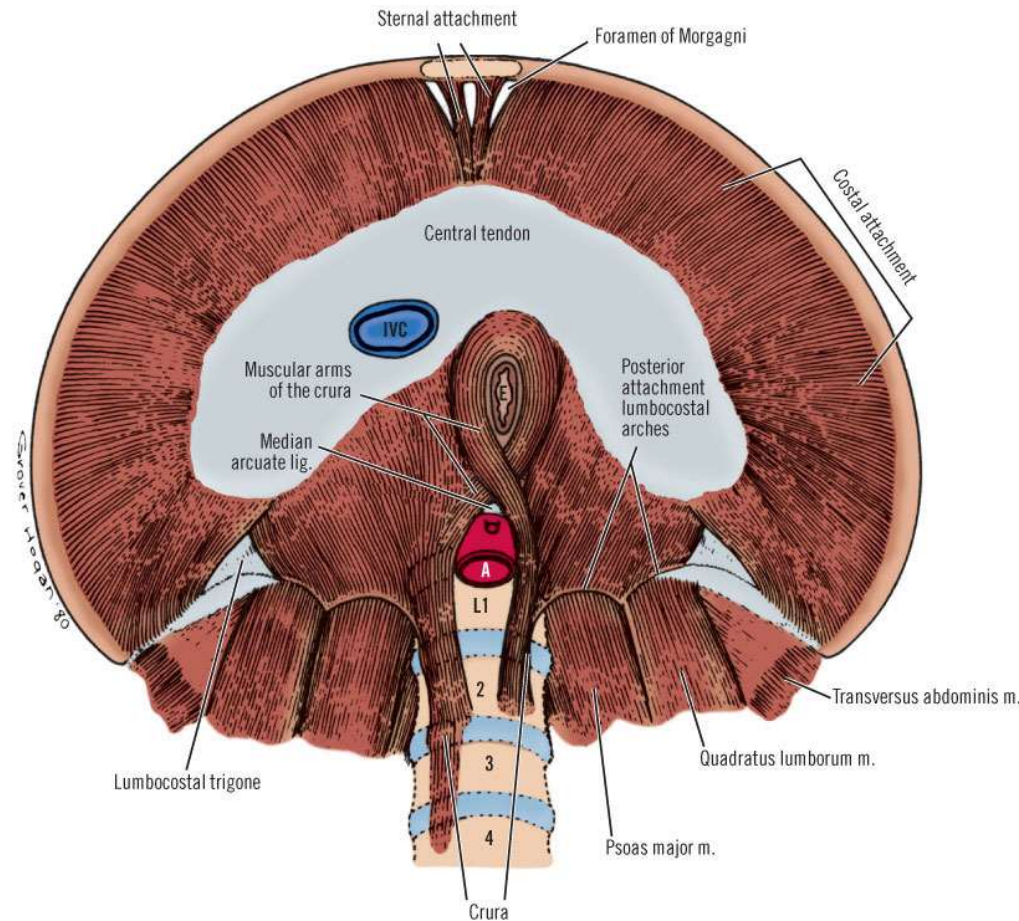
# The diaphragm





# The Diaphragm

- ▶ Musculoaponeurotic sheet that separates the thoracic cavity from the abdominal cavity
- ▶ Has right and left domes
- ▶ Divided into 4 parts



# The Diaphragm

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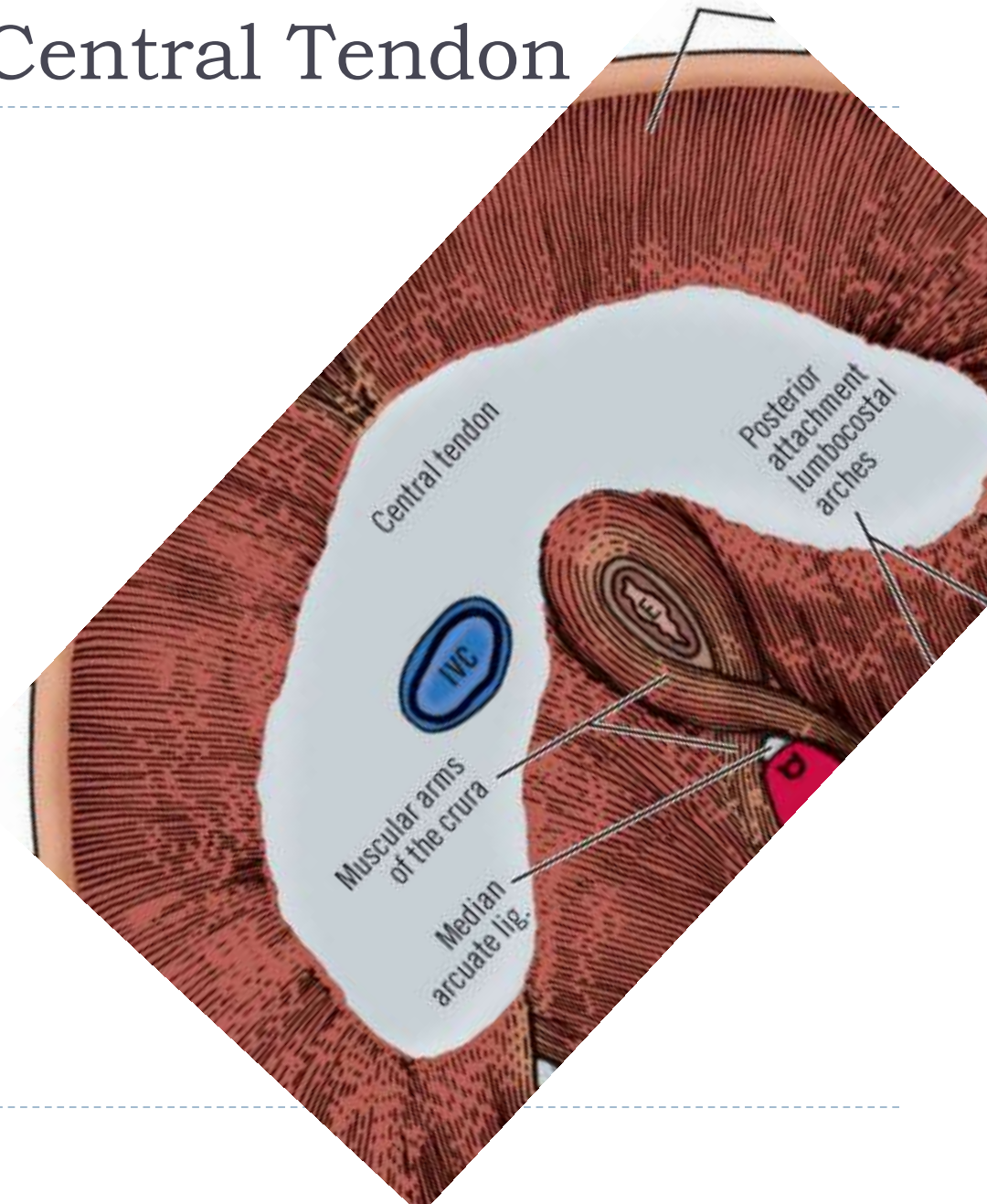
- ▶ The four parts are:
  - i. Central tendon
  - ii. Sternal part
  - iii. Costal part
  - iv. Lumbar part
- ▶ The last three parts are muscular.



# The Diaphragm: Central Tendon

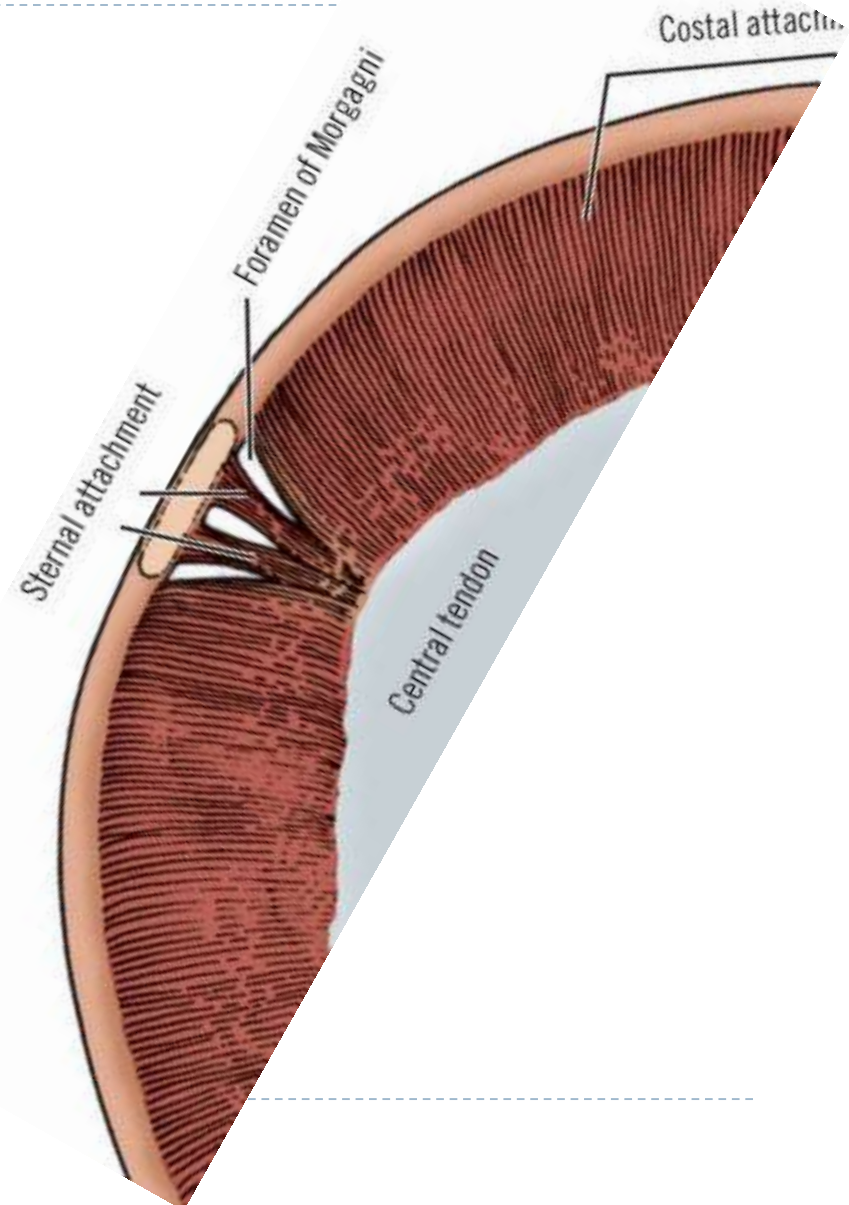
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- ▶ This is the aponeurotic portion at the center of the diaphragm.
- ▶ It serves as the insertion site for the muscular parts
- ▶ Fibers on the superior surface of the central tendon blend with those of the fibrous pericardium



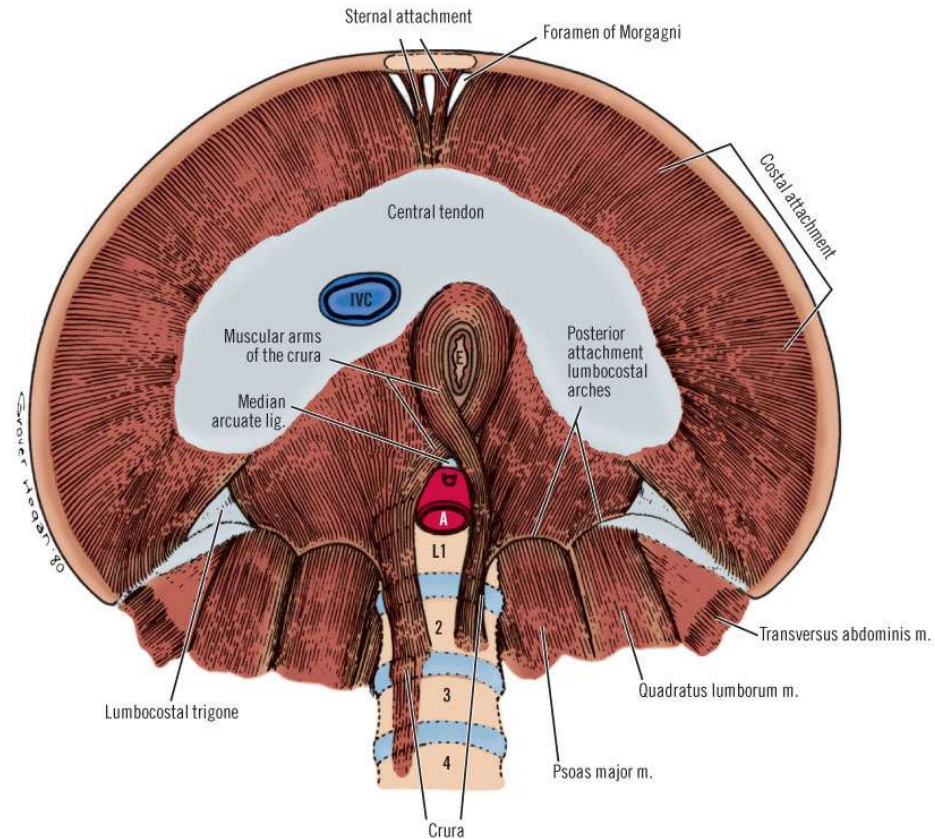
# The Diaphragm: Sternal part

- ▶ These are 2 muscle slips on either side of the midline that originate from the posterior surface of the xiphoid process
- ▶ Three triangular spaces (foramina of Morgagni) separate the muscles from the costal fibers and from each other



# The Diaphragm: Costal part

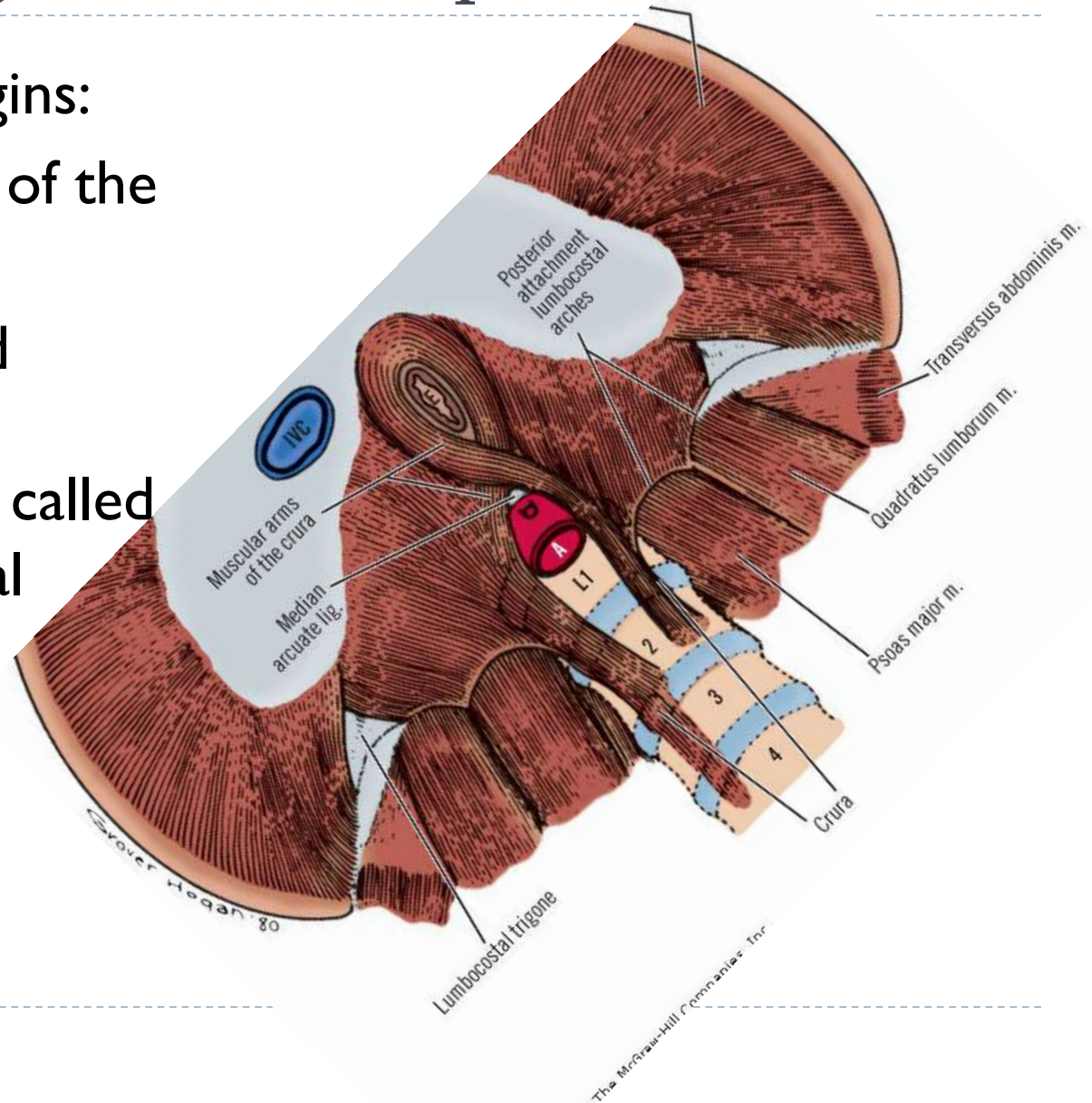
- ▶ These muscle fibers originate from the inner surfaces of the lower six rib pairs close to the perimeter of the inferior thoracic aperture



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# The Diaphragm: Lumbar part

- ▶ Consists of two origins:
  - i. The two crura of the diaphragm
  - ii. The medial and lateral arcuate ligaments (also called the lumbosacral arches)



# The Diaphragm: Lumbar part

## The Crura

- i. The right crus of the diaphragm originates from the bodies of vertebrae L1-L4.
  - ii. The left crus originates from the bodies of vertebrae L1 & L2 and sometimes L3.
- ▶ They pass antero-superiorly surrounding the aortic and esophageal hiatuses



# The Diaphragm: Lumbar part

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## **Arcuate Ligaments** (lumbocostal arches)

- ▶ Consists of two parts: Lateral and medial
  - i. The lateral arcuate ligament is the thickened aponeurotic tissue covering the proximal part of the Quadratus lumborum muscles. It attaches to the twelfth rib laterally and to the transverse processes of the first lumbar vertebra medially.
  - ii. The medial arcuate ligaments lies over the Psoas muscle and it attaches to the transverse process of L1 laterally and the body of L1 or L2 medially
- ▶ The posterior diaphragm arises from these two ligaments and attaches to the central tendon





# Apertures of the Diaphragm

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There are three apertures in the diaphragm:

- i. The opening for the **inferior vena cava**: At T8. It is placed in the central tendon to the right of the midline and it also transmits the right phrenic nerve.
- ii. The **esophageal hiatus**: At T10. It is surrounded by the muscular fibers of the right crus of the diaphragm. It transmits, apart from the esophagus, esophageal branches of the left gastric vessels and the two vagus nerves.
- iii. The **aortic hiatus**: at the level of T12. It transmits the abdominal aorta, the thoracic duct and sometimes the azygos vein



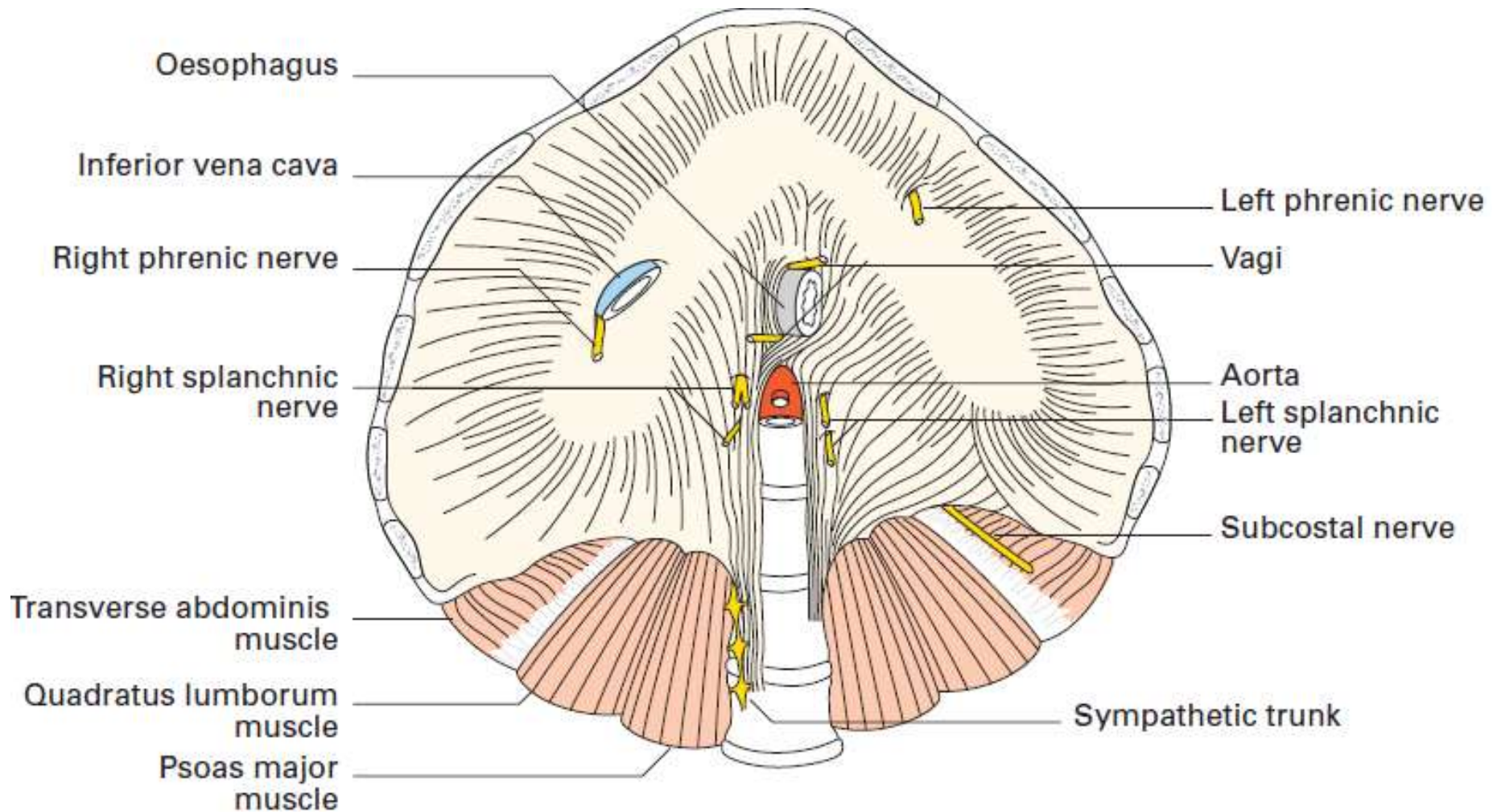
## Other structures passing through the diaphragm

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- i. The **superior epigastric vessels** penetrate the diaphragm between its sternal and costal parts
- ii. The **greater, lesser, and least splanchnic nerves** enter the abdomen through the crura of the diaphragm;
- iii. The **azygos and hemiazygos** veins are formed posterior to the crura and then ascend on lumbar and thoracic vertebral bodies
- iv. The **sympathetic trunks** and **subcostal nerves** descend into the abdomen posterior to the medial arcuate and lateral arcuate ligaments respectively



# Structures passing through the diaphragm



# Blood supply

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- i. Superior phrenic: Branches of the thoracic aorta
  - ii. Inferior phrenic: Branch of the abdominal aorta or the celiac trunk. Largest arterial supply of the diaphragm
  
  - iii. Musculophrenic
  - iv. Pericardiophrenic vessels
- } Branches of the internal thoracic.  
Supplies the superior surface  
Relatively small



# Nerve supply

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- ▶ Phrenic nerves: derived from ventral rami C3, 4, and 5, especially C4.
- ▶ The parietal peritoneum covering the inferior surface of the diaphragm receives its sensory innervation from the phrenic and intercostal nerves



Thank You

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