

Anatomy & Embryology - MSS

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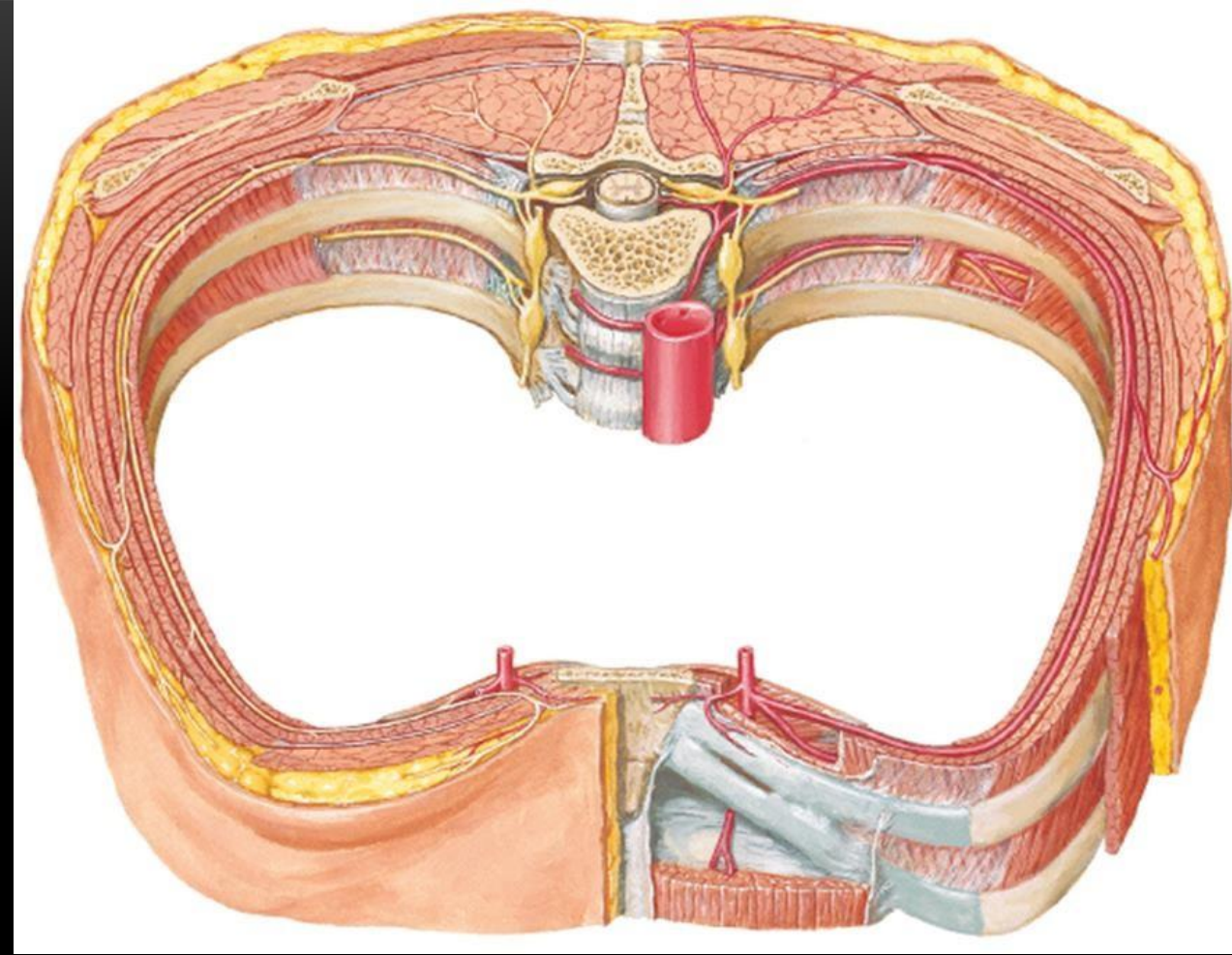
النادي الطلابي
كلية الطب

Intercostal nerves

Intercostal nerves 3-7 are typical intercostal nerves.

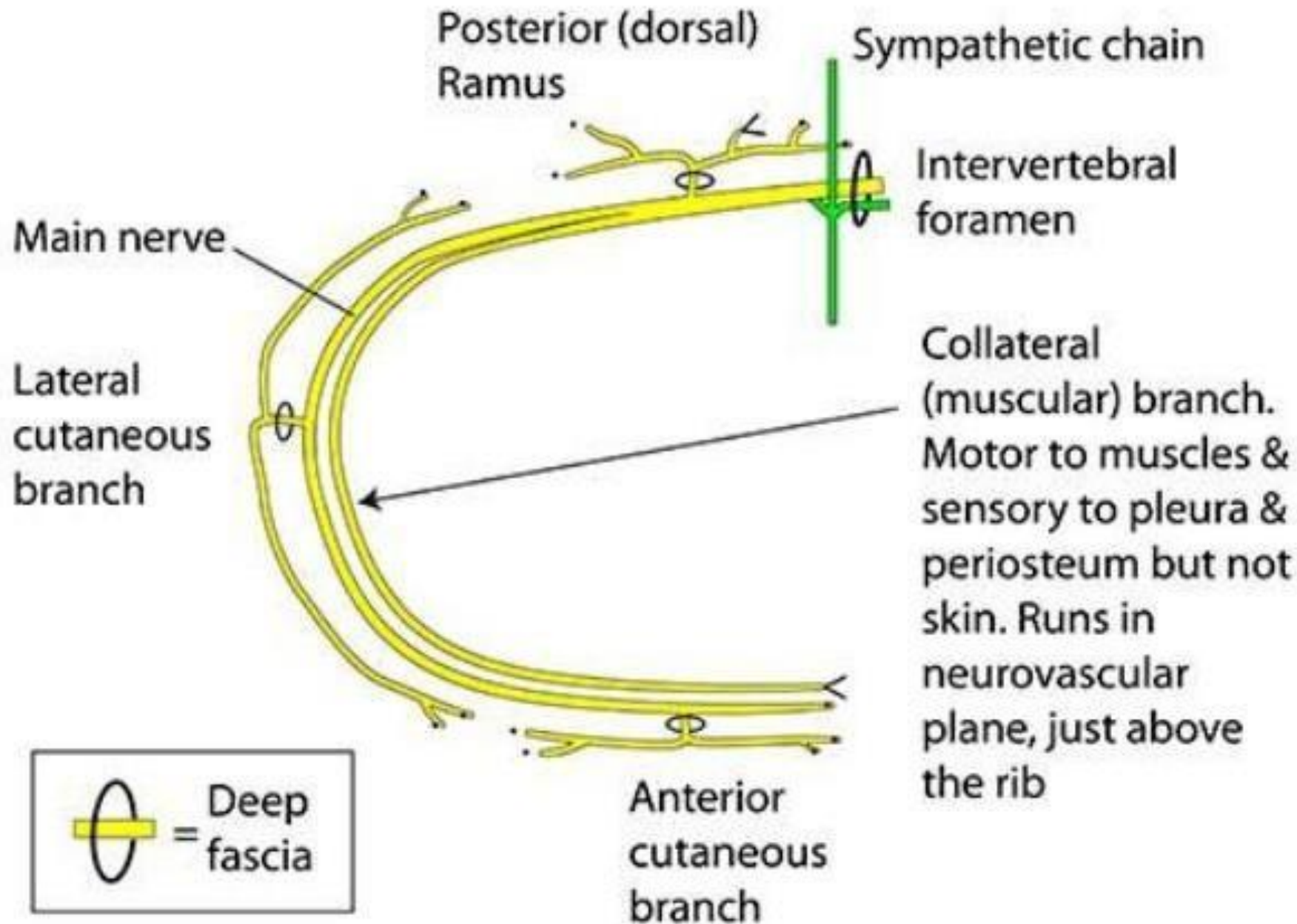
Intercostal nerves 1-2 & 8-12 are atypical.

- **No. 1**: ascends in front of the neck of the 1st rib to join the cervical plexus.
- **No. 2**: its lateral cutaneous branch does not divide. It forms the intercostobrachial nerve.
- **No. 7-11**: are thoracoabdominal; they supply abdominal muscles.
- **No. 12**: is subcostal.



Usually the 1st spinal segment gives 2 nerves (Large & small) , the large one joins the brachial plexus . No.2 passes toward the lateral aspect and supplies the medial aspect through the process (supplies the breast & Axilla) . When the lateral cutaneous branches reach the intercostal space , they divide into anterior & posterior branches , BUT this lateral cutaneous branch doesn't divide and completes as whole .No. 7-11 pass through the abdominal cavity supplying the abdominal muscles segmentally + supplying the intercostal muscles . Remember that T10 is found near the umbilicus , L1 is near the symphysis pubis . No.12 passes through abdominal cavity .

TYPICAL INTERCOSTAL NERVE



The origin pierces the deep fascia

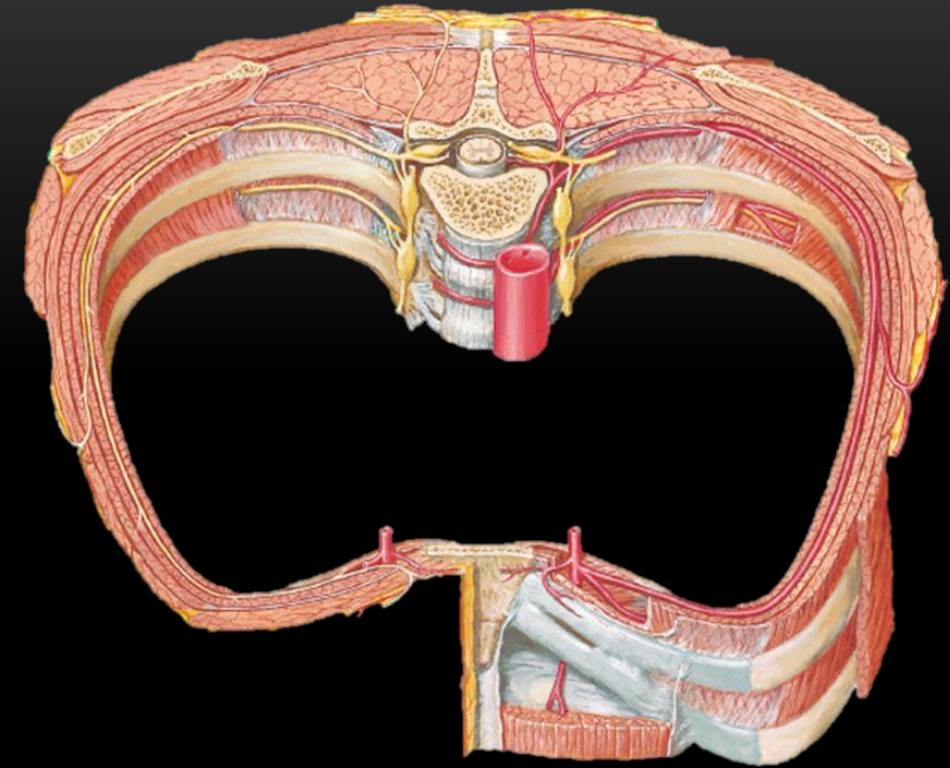
Recurrent and collateral: When a nerve/artery give branches to muscles we either call them muscular branches (or by the name of the muscle). In other cases, the branch passes in the same direction of the parent nerve/artery (they are parallel to each other), in this specific case, we call the branch a collateral branch, but if this branch passes into the opposite direction we call it a recurrent branch (remember the recurrent laryngeal nerve). Another example on that is the brachial artery @ the elbow joint, it gives collateral branches then divide into radial and ulnar arteries, the ulnar artery gives recurrent branches. This is important to avoid the closure of the main artery during muscular movements

Typical intercostal nerves .. 1

They are the nerves in the intercostal spaces 3-6.

They are the primary rami of the of the corresponding thoracic nerves.

Runs forward between the internal intercostal membrane and the pleura then between the internal and innermost intercostal muscles.



We mentioned in the previous lecture something called the neurovascular plane which is found between the 2nd and 3rd layers of the muscles . In the thorax , the 2nd layer was the internal intercostal muscles and the 3rd layer was the inner most muscles . Same thing applies to the abdomen , 2nd layer is the internal oblique muscle and the 3rd layer is the transversus abdominal muscle .

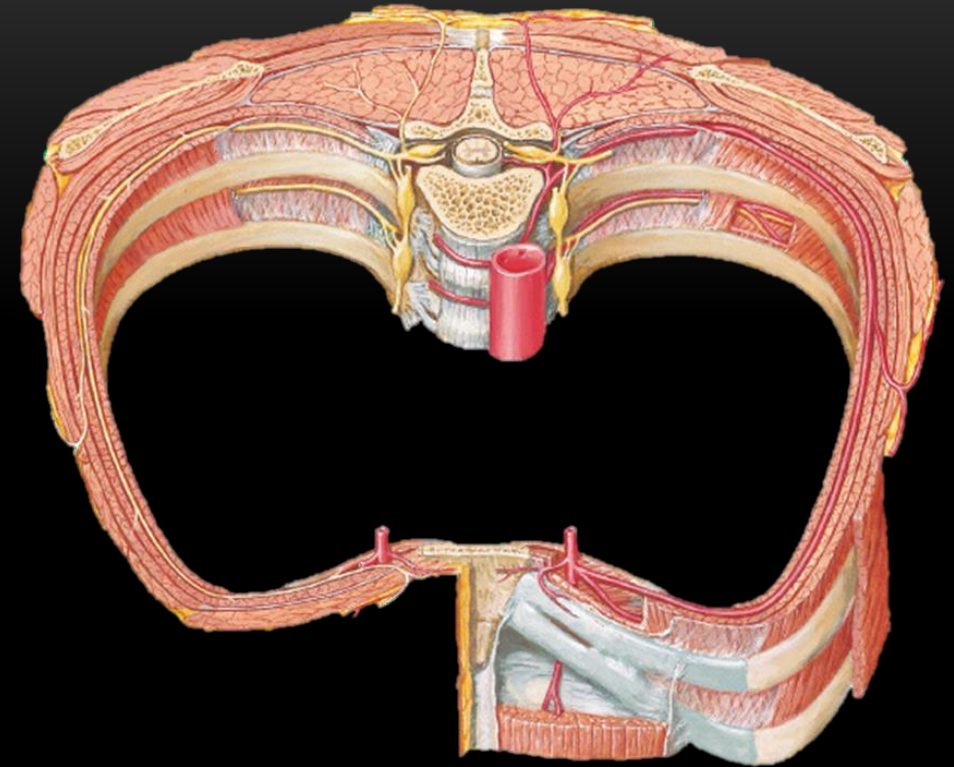
Typical intercostal nerves .. 2

At the mid-axillary line, each nerve gives the lateral cutaneous branch.

- The lateral cutaneous branch pierces the internal and external intercostal muscles to supply the skin on the side of the thorax. **Divides into anterior or posterior branches .**

The intercostal nerve continues and at the parasternal line pierces the internal intercostal muscle, the anterior intercostal membrane and the pectoralis major.

- It divides into medial and lateral branches to supply the skin on the front of the thorax.



Typical intercostal nerves .. 3 (Branches)

Nerves coming out of the sympathetic chains divides to gives whiter ramus communicans

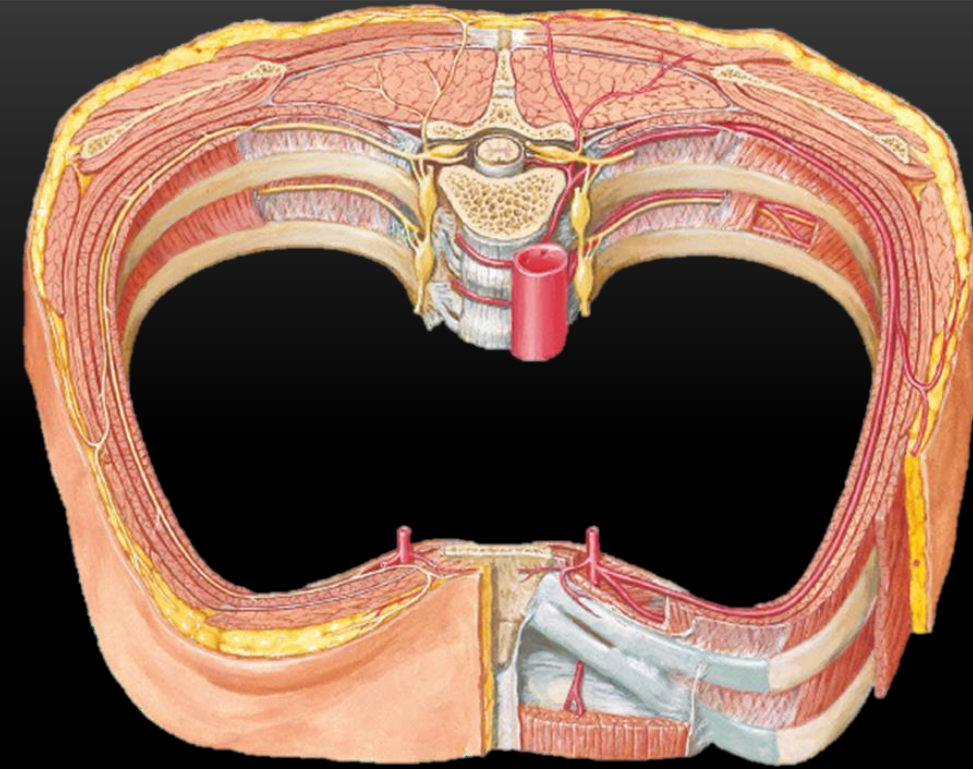
White ramus communicans to the nearby sympathetic ganglion (from which it receives grey ramus communicans).

Collateral muscular branches to the intercostal muscles.

Articular branches to the joint of the ribs.

Lateral cutaneous branch.

Anterior cutaneous branch.



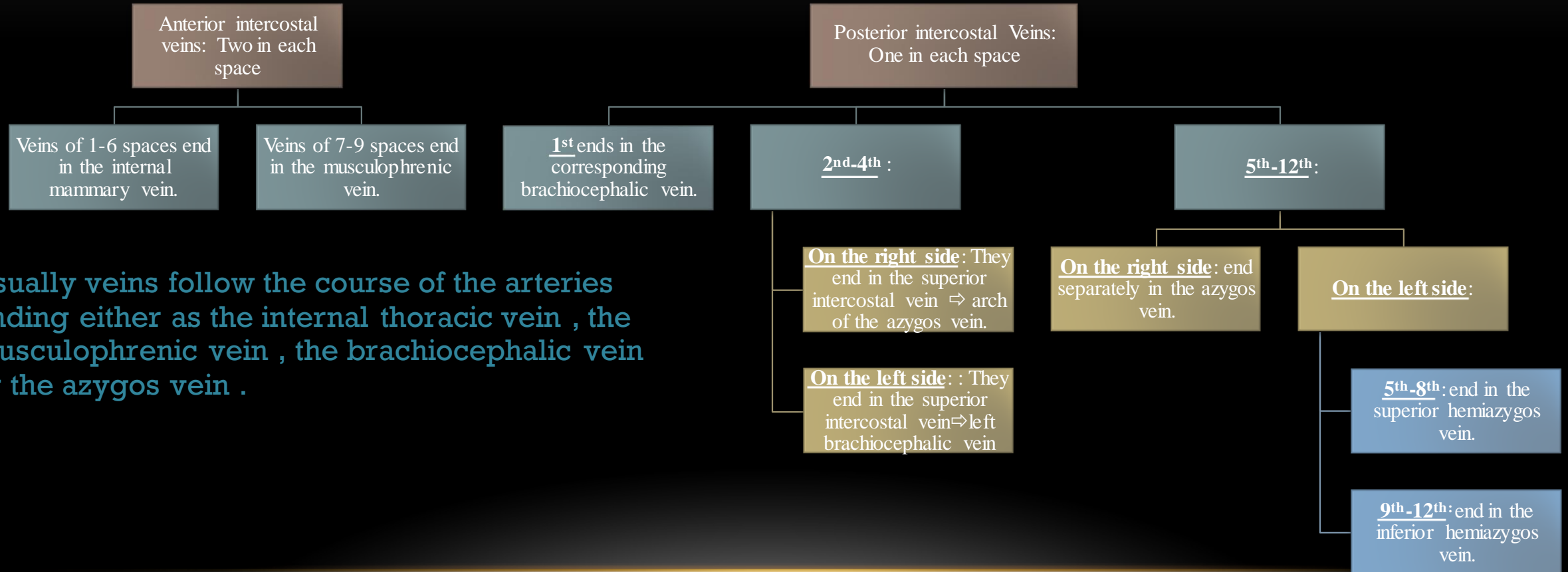
Intercostal nerves main stem is found in the costal groove , so if we want to insert a chest tube , we insert it on the upper border or the rib not the lower to avoid any injury to that costal nerve . If we injured the main stem by accident , this will lead to paralysis of the intercostal muscles in that space . Normally when we inhale (inspiration process) the size of the thorax increases , intercostal muscles will be pushed toward the outside and the pressure inside will decrease . But , In that area where the nerve was injured , intercostal muscles will be sucked toward the inside due to negative pressure , so the muscles will appear ss if they are pushed to the outside . This is one way of telling there's an injury to a costal nerve in a specific region . Recovery of the injured nerve will be hard .

Intercostal arteries

Anterior intercostal arteries	Posterior intercostal arteries
<p>2 in every space: 1 <u>Upper one</u> anastomoses with the posterior intercostal artery.</p> <p>2 <u>Lower one</u> anastomoses with the collateral branch of the posterior intercostal artery.</p>	<p><u>Single</u>, gives collateral branch.</p> <p>Practically, they are 2 due to the existence of a branch</p>
<p>9 in number: 1 Upper 6 originate from the internal mammary artery. (internal thoracic artery)</p> <p>2 Lower 3 originate from the musculophrenic artery.</p>	<p>11 in number and 1 subcostal artery: 1- Upper 2 originate from superior intercostal artery.</p> <p>2- From 3-12 originate from the descending aorta.</p>

Intercostal veins

The only constant fact about veins is that they aren't constant



Usually veins follow the course of the arteries ending either as the internal thoracic vein , the musculophrenic vein , the brachiocephalic vein or the azygos vein .

Scalenus anterior muscle

Internal thoracic artery ..1/2

It passes through the inlet of the thorax

Still called clinically the internal mammary artery.

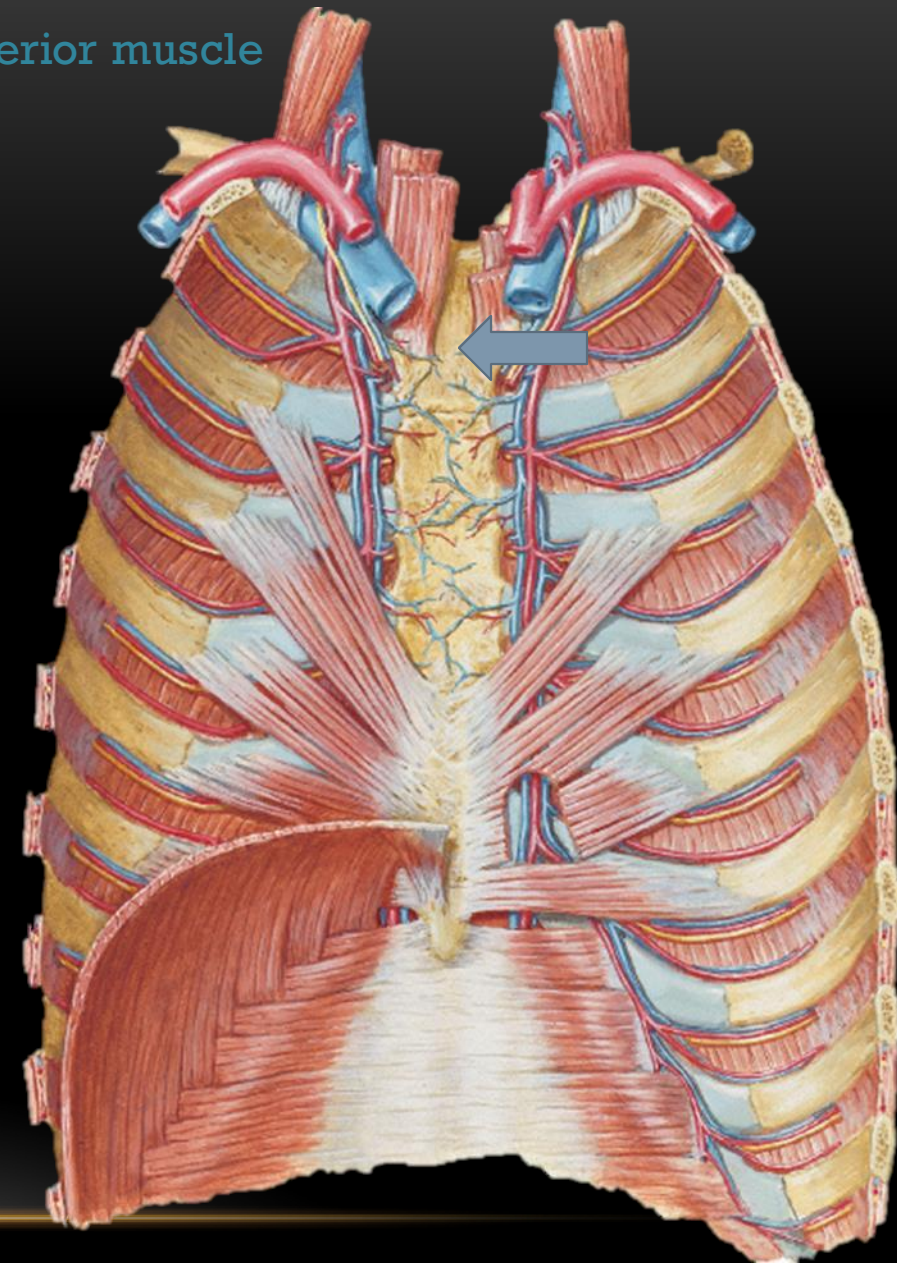
Arises from the lower surface of the first part of the subclavian artery.

Descends downwards behind the upper 6 costal cartilages, 1 cm from the margin of the sternum.

It divides in the 6th intercostal space into:

- Superior epigastric artery. It passes to the abdomen
- Musculophrenic artery. It has 2 parts , muscular and phrenic .

1st part is found before the scalenus anterior .
2nd part is behind the scalenus anterior .
3rd part is after the scalenus anterior .



Internal thoracic artery ..2/2 Branches

Anterior intercostal branches in the upper 6 intercostal space.

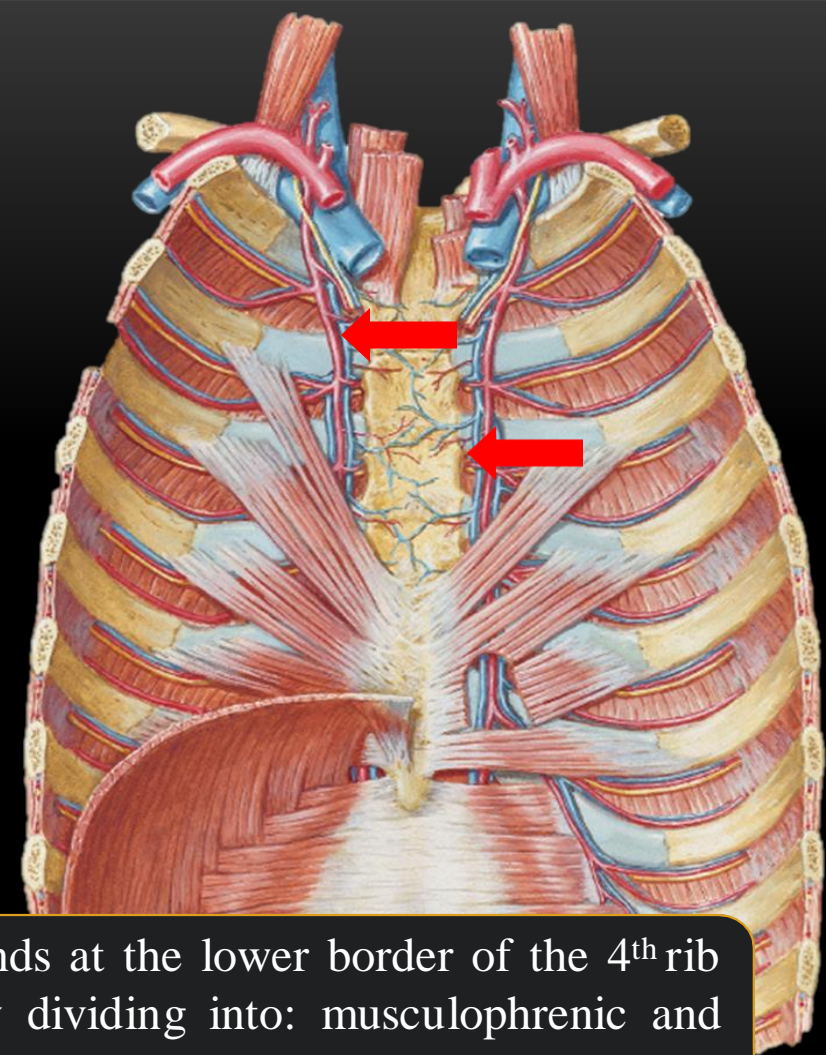
Perforating branches to the breast (in the 2nd-4th intercostal spaces).
Blood supply to the breast

Muscular branches to the transversus thoracis.

Pericardial branches to the upper part of the pericardium.

Mediastinal branches.

Pericardio-phrenic branches to accompany the phrenic nerve.



Ends at the lower border of the 4th rib by dividing into: musculophrenic and superior epigastric arteries

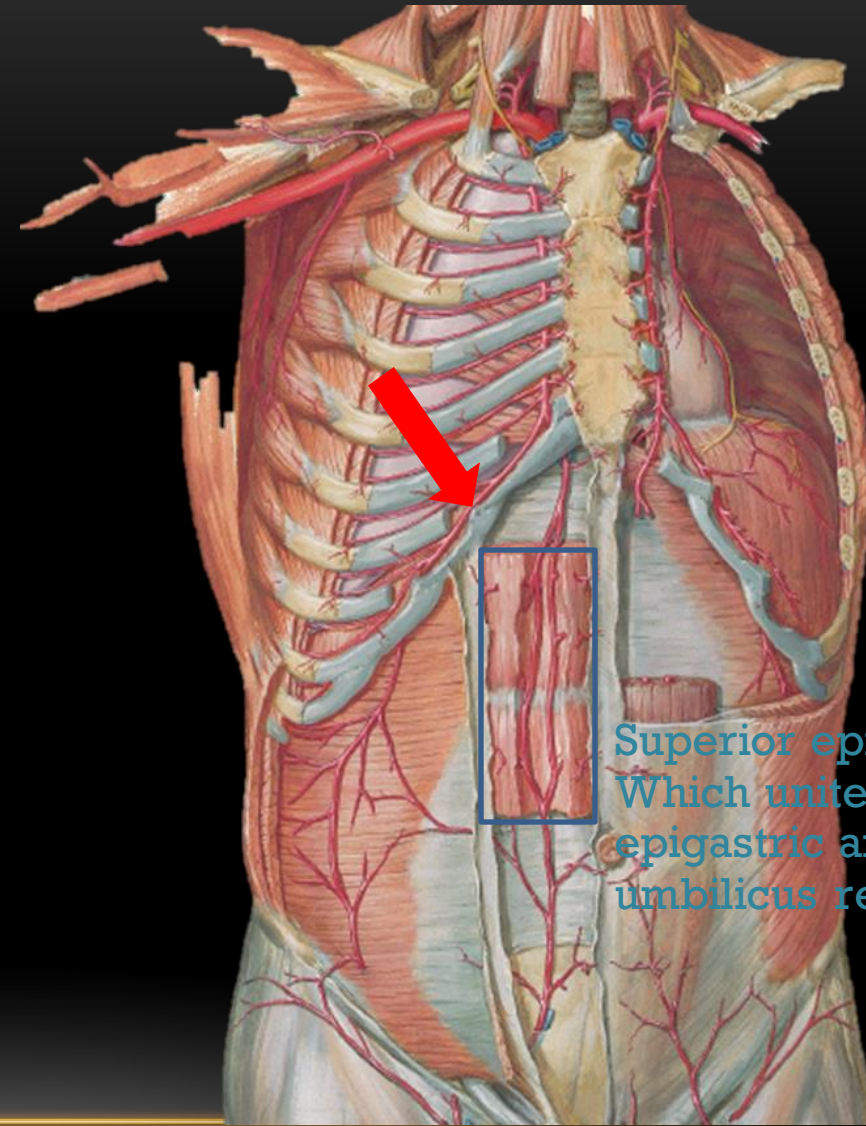
There's a clinical procedure known as bypass where we change some of the occluded heart arteries, one of the options in case we have 1 occluded artery and the segment is small, is to take a graft from the internal thoracic artery and replace the occluded segment. ITA is one of the arteries that won't suffer arteriosclerosis, so the segment we used in the bypass is perfect because we know it won't close. The reason why arteriosclerosis won't affect the ITA isn't known yet. The segment we removed won't affect the patient due to the presence of collateral circulation.

Branches of the musculophrenic artery

Anterior intercostal arteries in the intercostal spaces 7-9.

Pericaridal branches to the lower part of the pericardium.

Muscular branches to the abdominal muscles.



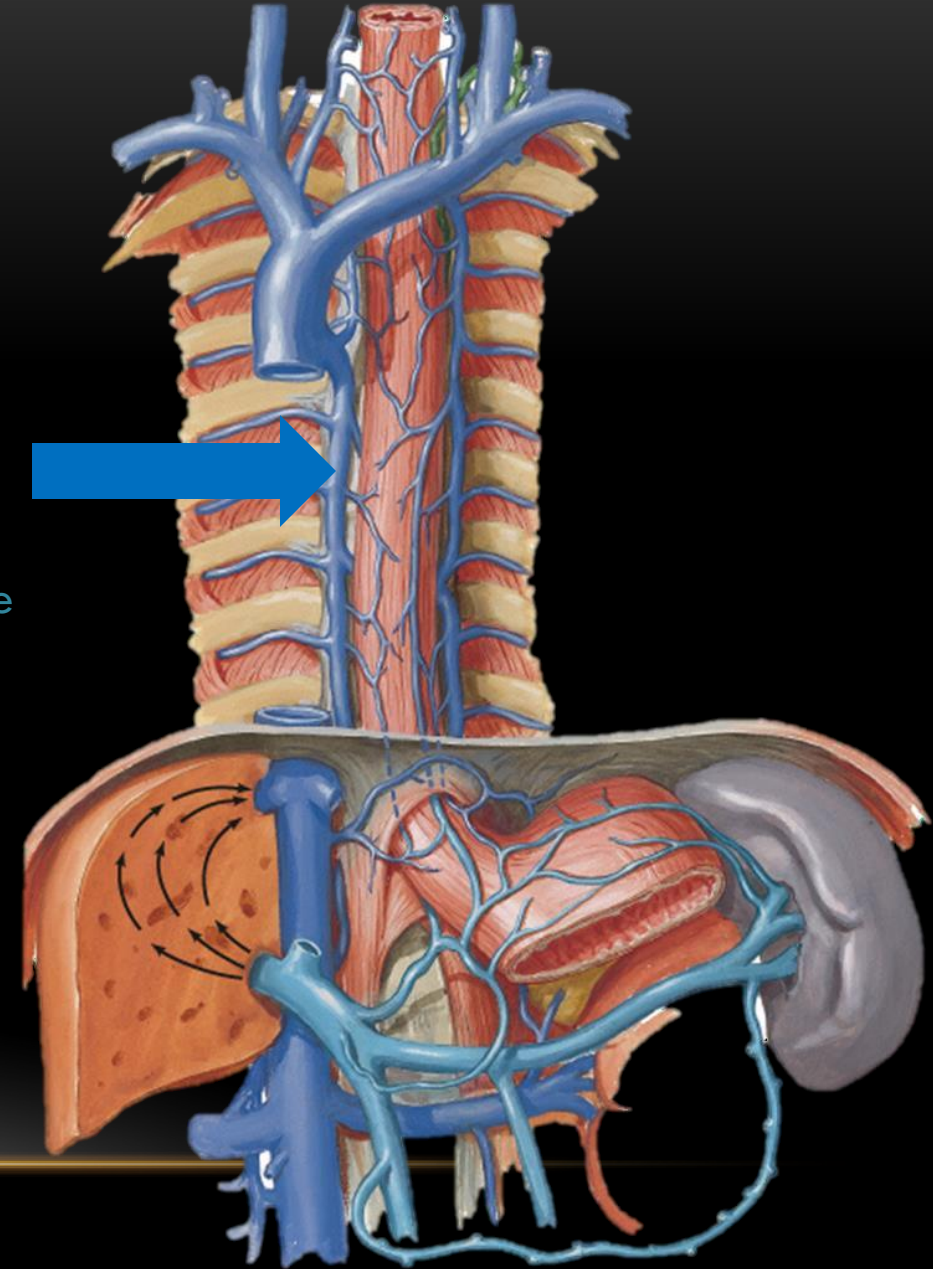
Superior epigastric artery
Which unites with the inferior
epigastric artery at the
umbilicus region

Azygos vein

Arises in the abdomen either:

- From the back of the inferior vena cava at the level of L2. and completes upward to reach the SVC , it links the inferior VC to the superior VC , meaning that if one of them was closed the collateral circulation can link the IVC to the SVC .
- As a continuation of the right subcostal vein. (it changes it' name inside the thoracic cavity) , it terminates at the SVC
- By union of the right subcostal and right ascending lumbar veins. it terminates at the SVC

Enters the thorax through the aortic opening and ascends upwards. It passes behind the root of the right lung then arches above it to terminate in the superior vena cava at the level of T4.

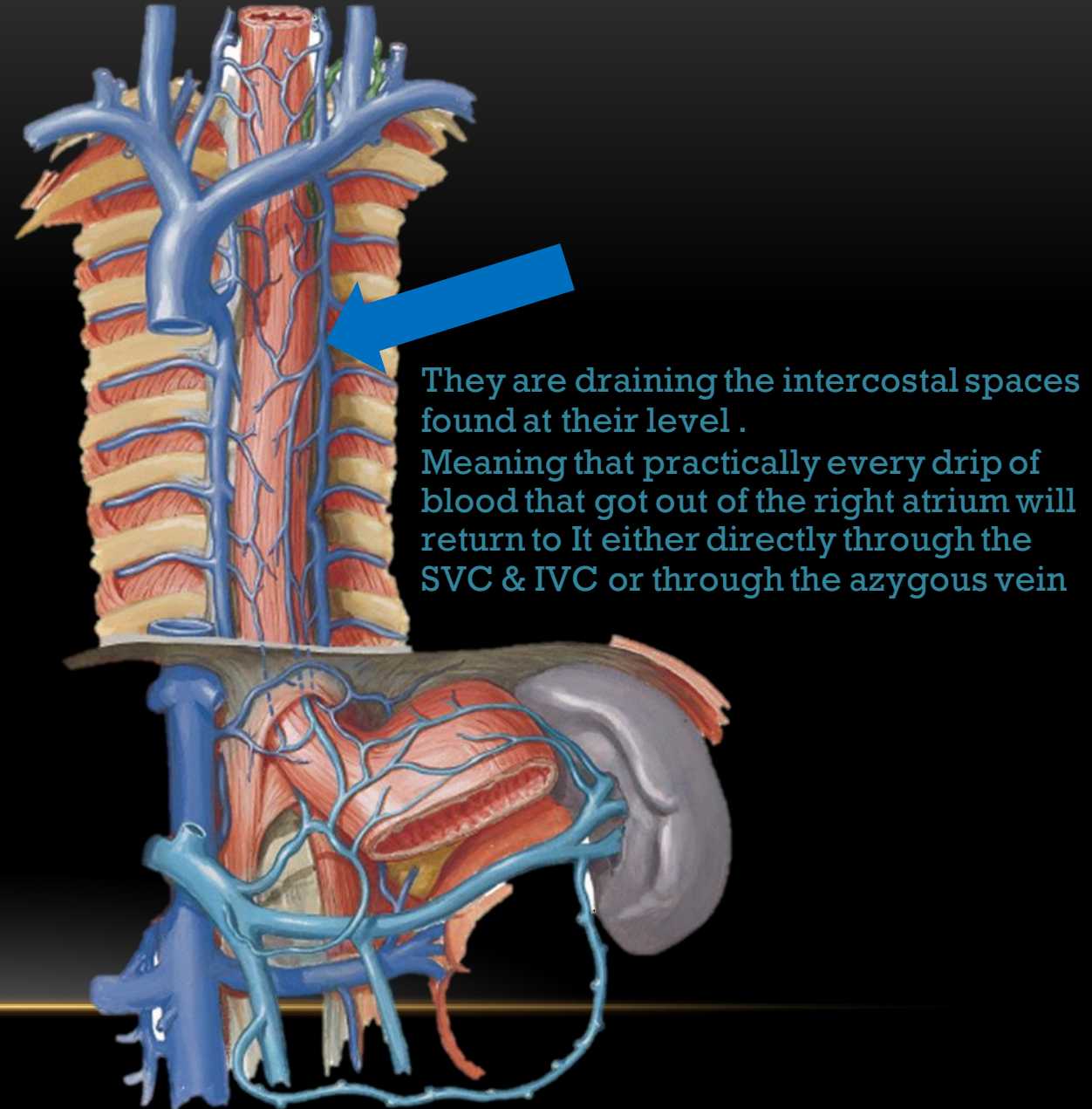


Superior (accessory) hemiazygos vein

Receives the posterior intercostal veins in the intercostal spaces 5-8.

Descends to the left of the vertebral column till the level of T8.

Curves behind the aorta, esophagus and thoracic duct to end in the azygos vein.

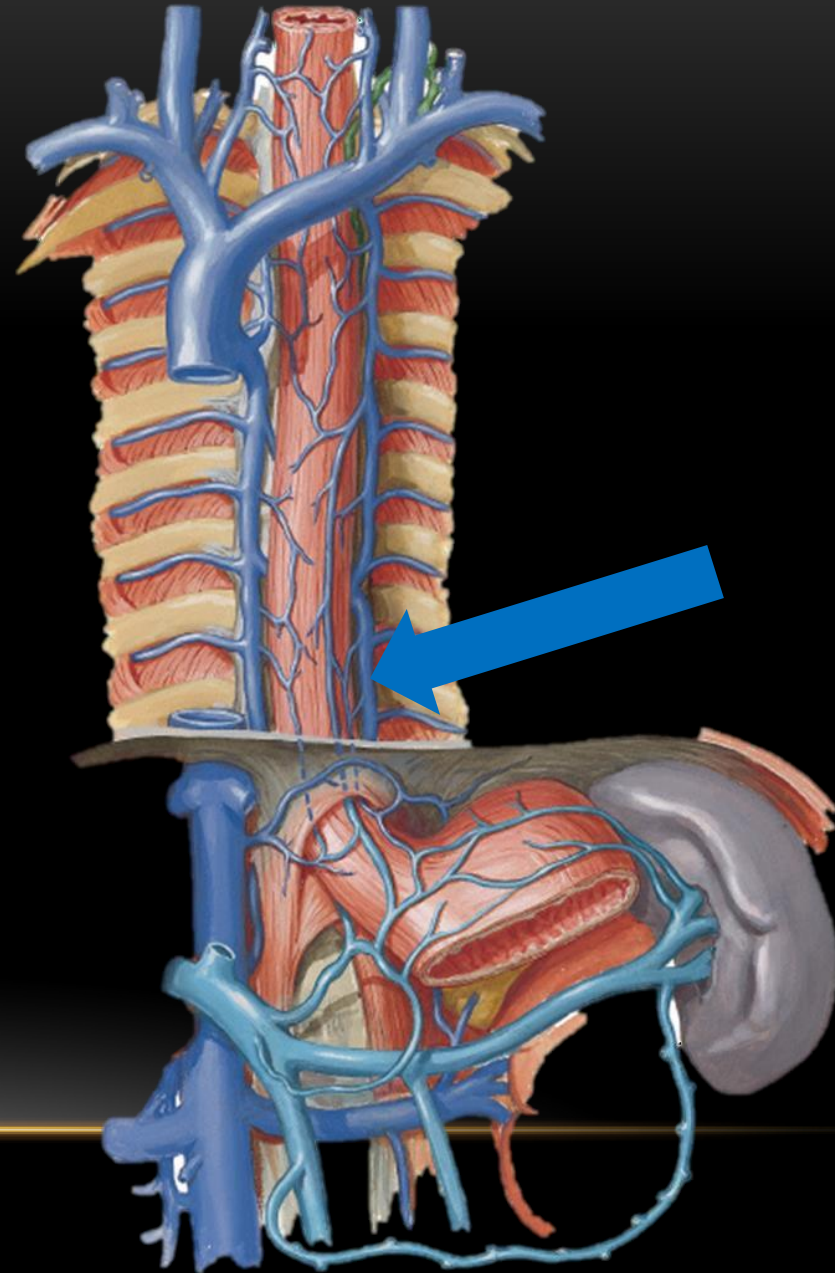


Inferior hemiazygos vein

Arises in the abdomen from either:

- Left renal vein. **Communication with the SVC**
- Union of the left ascending lumbar vein and the left subcostal vein.

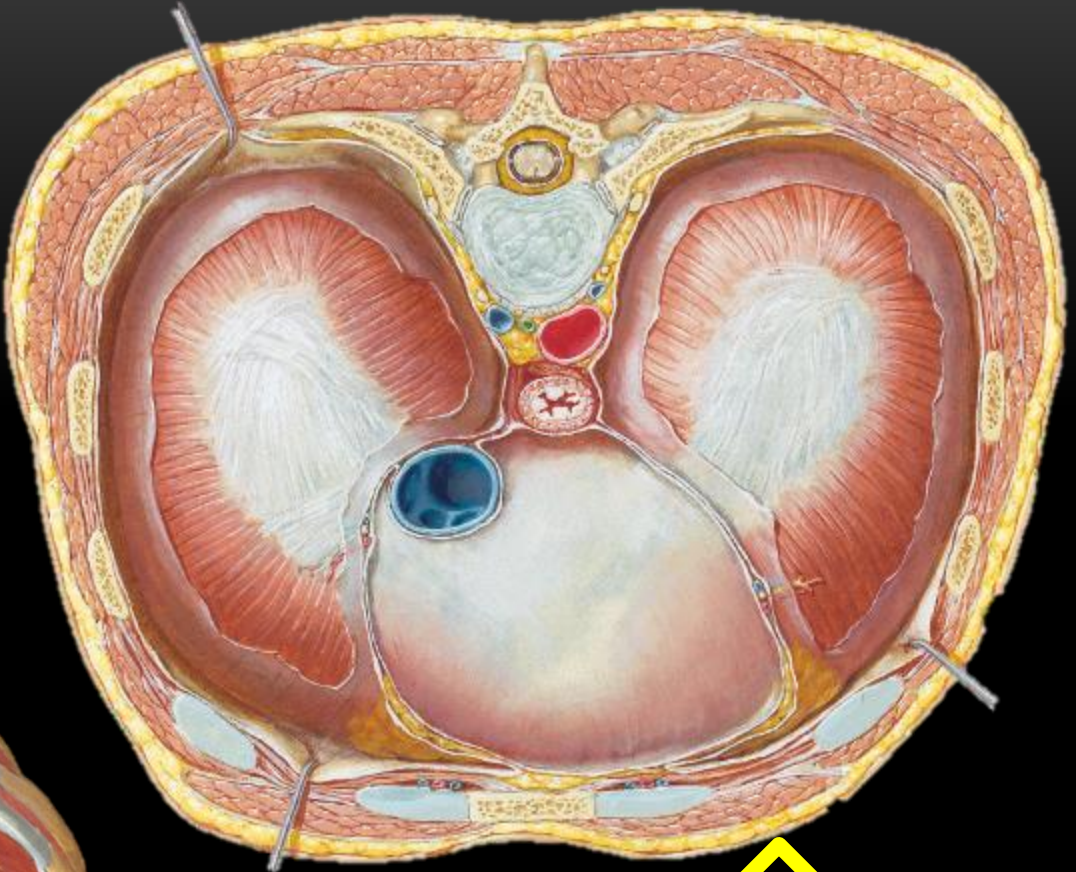
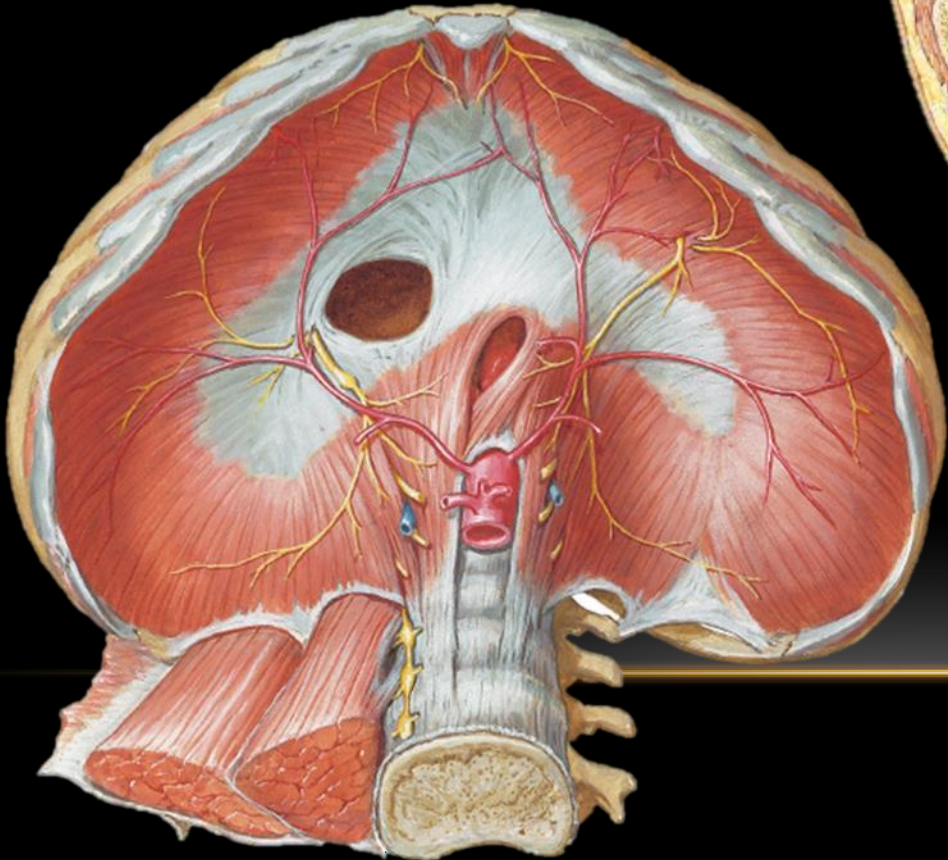
ascends through the left crus of the diaphragm till the lower border of T8 where it curves to the right to terminate in the azygos vein.



Inferior Thoracic Aperture
(Thoracic outlet)
(The Diaphragm)

The thoracic outlet is completely closed by diaphragm. It has two surfaces, one facing thoracic and one facing abdominal, and it related to organs in both cavities.

Inferior view
(Abdominal)



Superior view
(Thoracic)

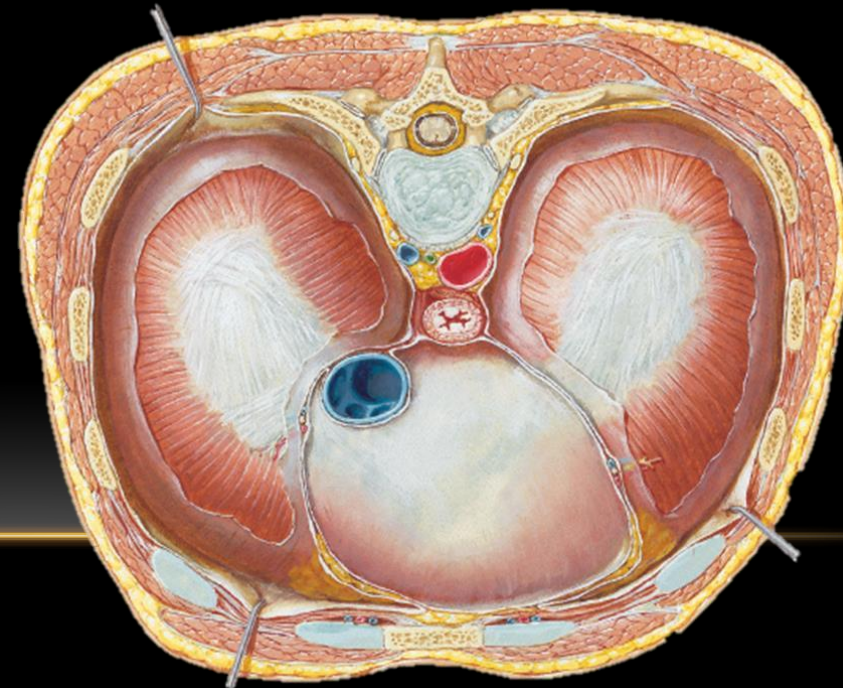
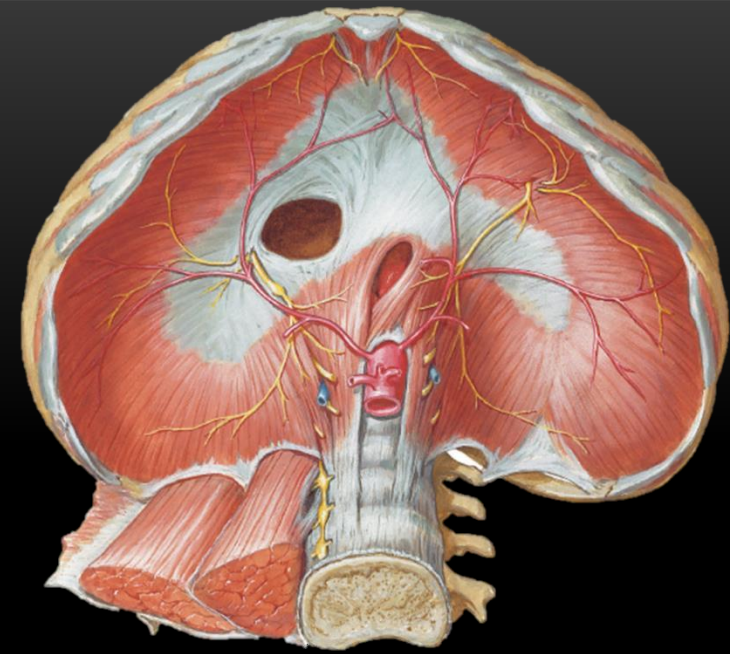
Explanation of the previous figure

- The area in the middle is in the shape of the heart, the fibrous pericardium of the heart is fused with the central tendon of the diaphragm. Inferior vena cava, esophagus, aorta. The diaphragm is an extensive structure.
- In the inferior view, we have the psoas major and quadratus lumborum muscle and the aorta.
- There is something coming out of the diaphragm and inserted to the lumbar vertebrae 1, 2, and 3 and on the left, it is only on 1 and 2, so on the right side it is larger in size. Right crus of diaphragm is larger than the left crus. The both of them unite to form a tendinous structure called the median arcuate ligament.
- The condensation of connective tissue from above the lumbar vertebrae passed over the upper margin of the psoas major muscle, it might be from a fascia called the psoas fascia, but because there is a ligament that got attached to the diaphragm, we call it the medial arcuate ligament.
- There is another condensation that kept going in the direction of the quadratus muscle and is called the lateral arcuate ligament. They are 5 in total, two medial and lateral on both sides and on medial in the middle above the aorta.
- The median arcuate ligament located in front of the aorta and not a muscle and this is because a muscle is contractile and if it contracts then this will lead to the closing or compression on the aorta.
- Another important thing we should notice is that there is a sling coming from the right crus, and this is where the esophagus goes through and this is because at the lower end of the esophagus has no sphincter at the lower end and so when you take a breath this will lead to the contraction and closing the lower end of the esophagus and acts as a physiological sphincter.

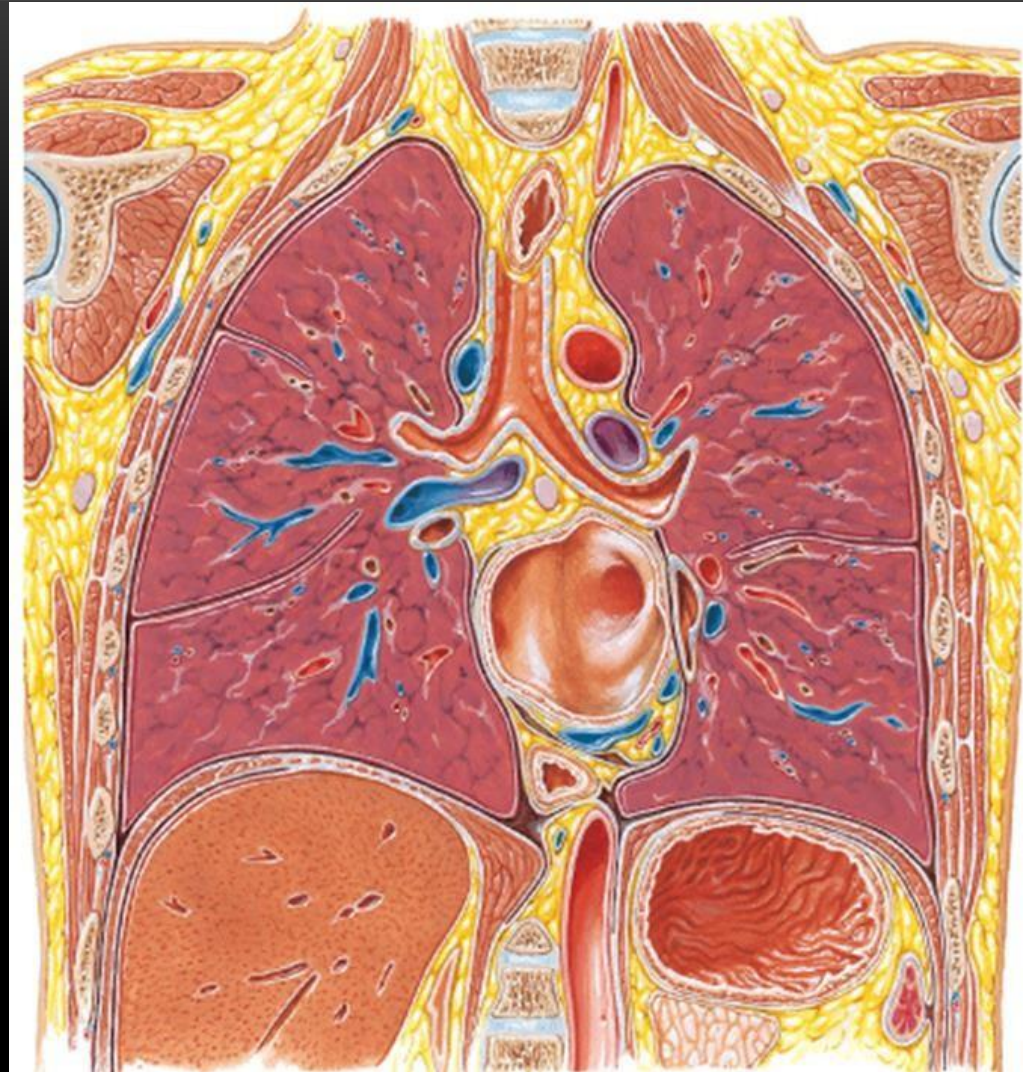
It is a dome-shaped Musculo-fibrous septum that separates the thoracic from the abdominal cavity, its convex upper surface forming the floor of the thorax, and its concave under surface forming the roof of the abdomen.

Its peripheral part consists of muscular fibers that take origin from the circumference of the inferior thoracic aperture and converge to be inserted into a central tendon.

The diaphragm is dome in shape, it has a left and right dome, and they are united in the center with a central tendon. There are openings for the passage of structures to and from the abdomen.



This extensive origin all comes together to form a tendon we call the central tendon, and this is its insertion, it is slightly shifted into the anterior aspect of the diaphragm.

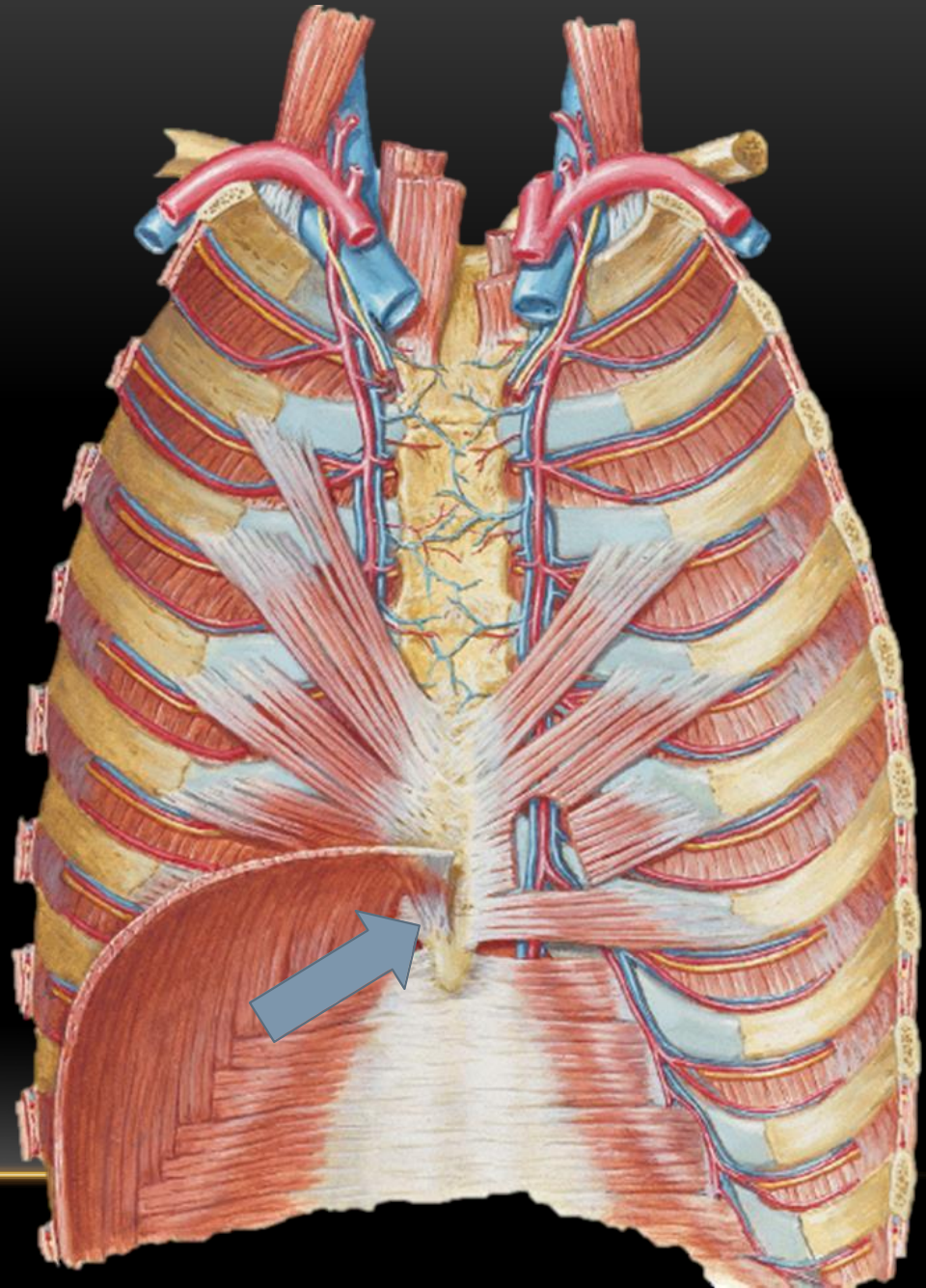


Compared to the spleen on the left side which is smaller and lighter and so it is elevated on the right side.

It is elevated on the right side due to the presence of the liver

Sternal origin:

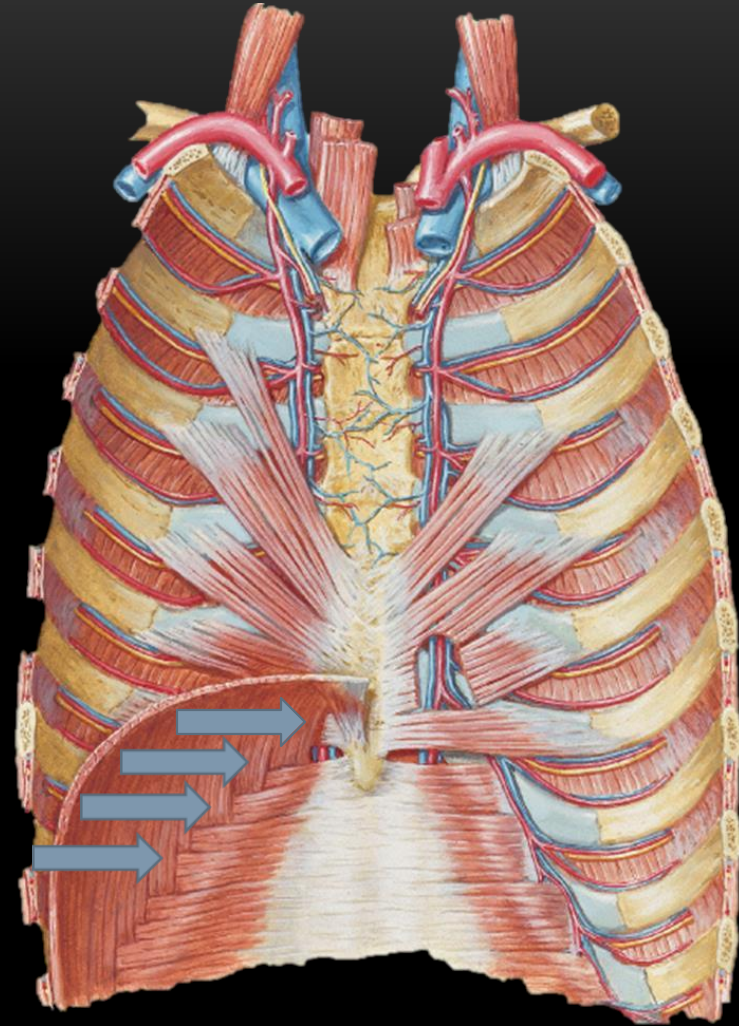
- By 2 slips the back of the xiphoid process



Costal origin:

- By 6 slips from the inner surface of the lower 6 ribs and their costal cartilage.

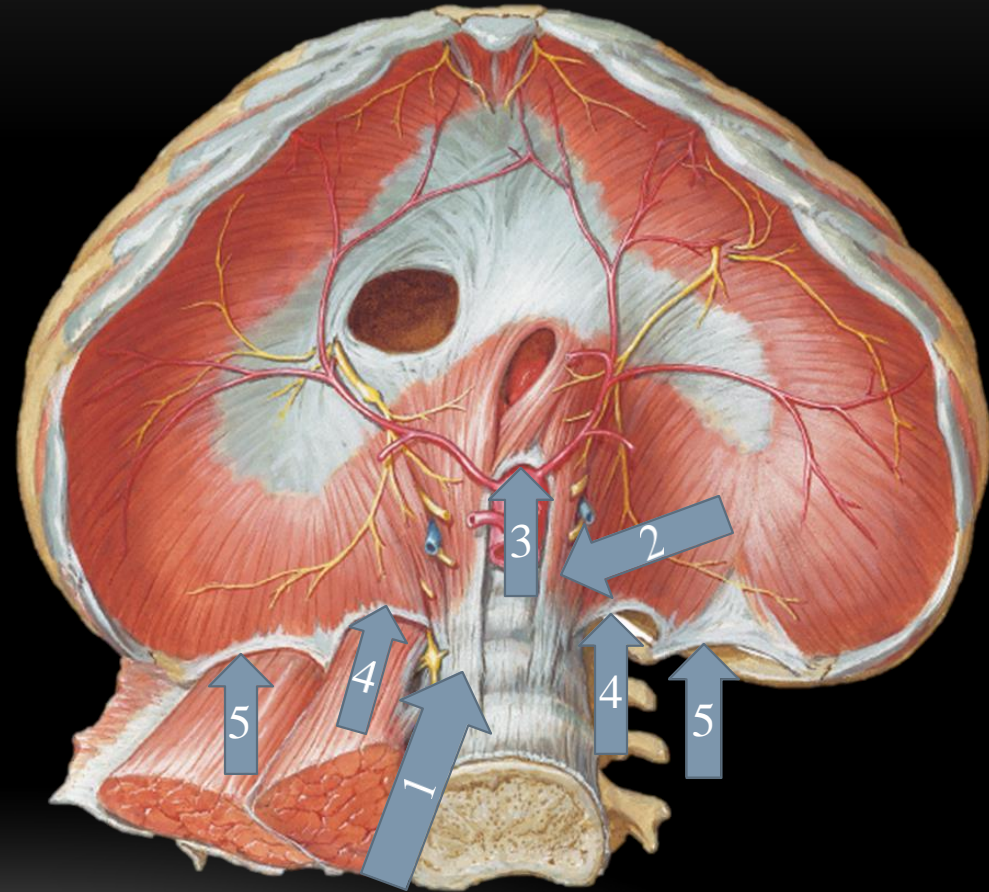
The slips of the costal origin interdigitate with the transversus abdominis muscle



Origin of the diaphragm ..3 / 3

Vertebral origin:

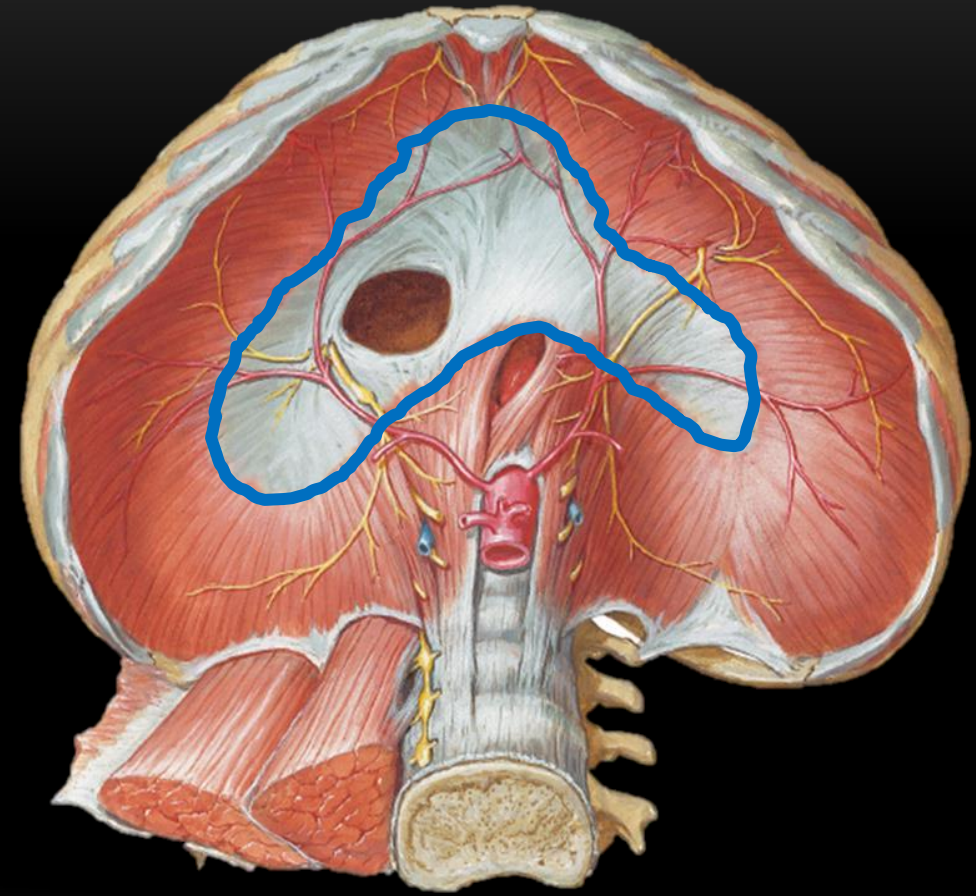
- **Right crus**: from the bodies of the upper 3 lumbar vertebrae (1).
- **Left crus**: from the bodies of the upper 2 lumbar vertebrae (2).
- **Median arcuate ligament**: arches over the aorta between the right and left crura (3).
- **2 medial arcuate ligaments**: arch over the psoas major muscles, each extends from the corresponding crus to the tip of the transverse process of the L1 (4).
- **2 lateral arcuate ligaments**: arch over the quadratus lumborum muscles, each extends from the transverse process of L1 to the 12th rib (5).



Insertion of the diaphragm

It is inserted into the central tendon.

The central tendon is shifted anteriorly (not central in position).



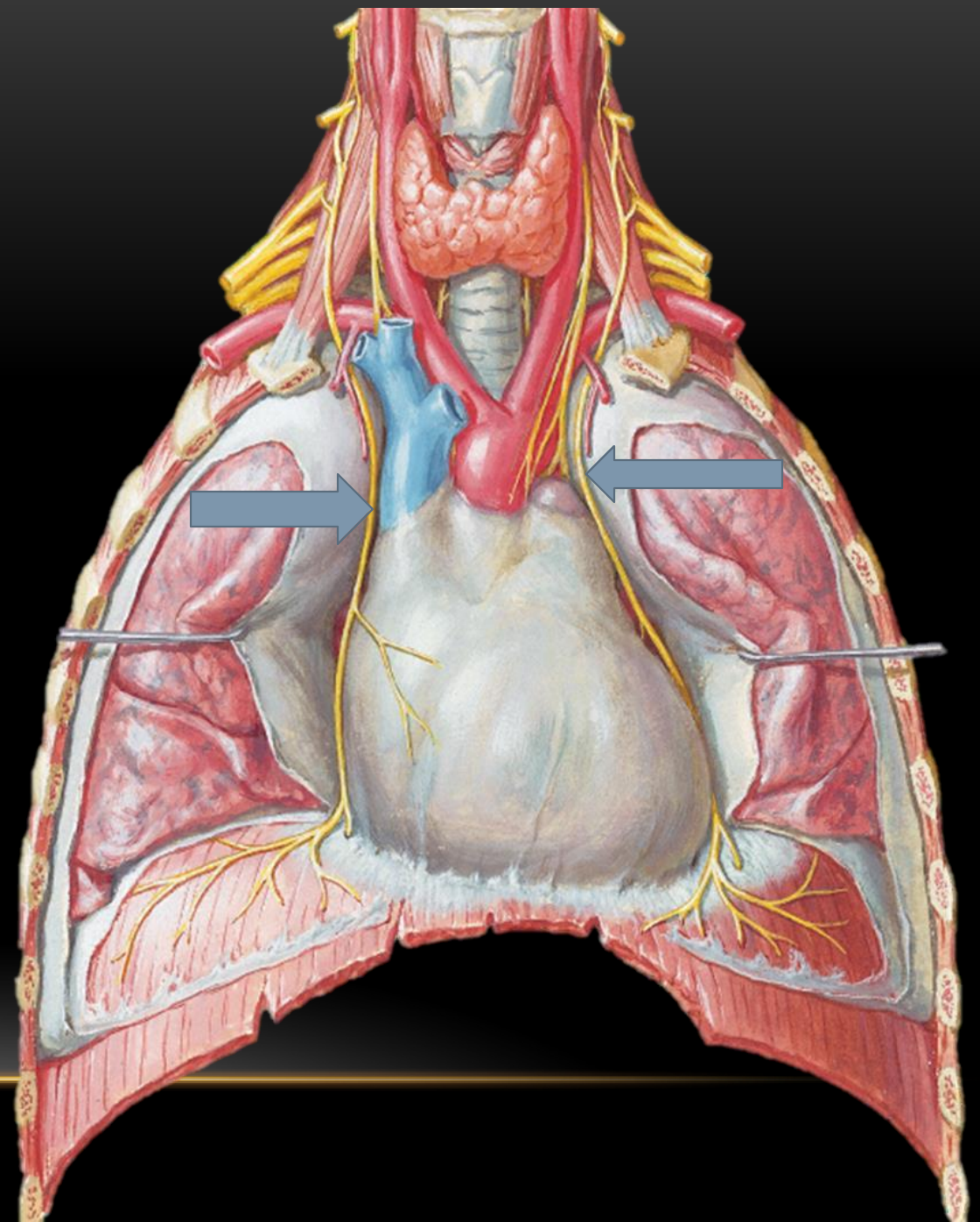
Innervation of the diaphragm

Right and Left Phrenic nerves (Mainly C4).

Both nerves supply motor fibres to the diaphragm and sensory fibres to the fibrous pericardium, mediastinal pleura, and diaphragmatic peritoneum.

The pericardiaco-phrenic arteries and veins travel with their respective phrenic nerves.

The accessory phrenic nerve is a branch of the nerve to the subclavius and connects to the phrenic nerve in the thorax or the root of the neck. It may contain numerous phrenic nerve fibers.

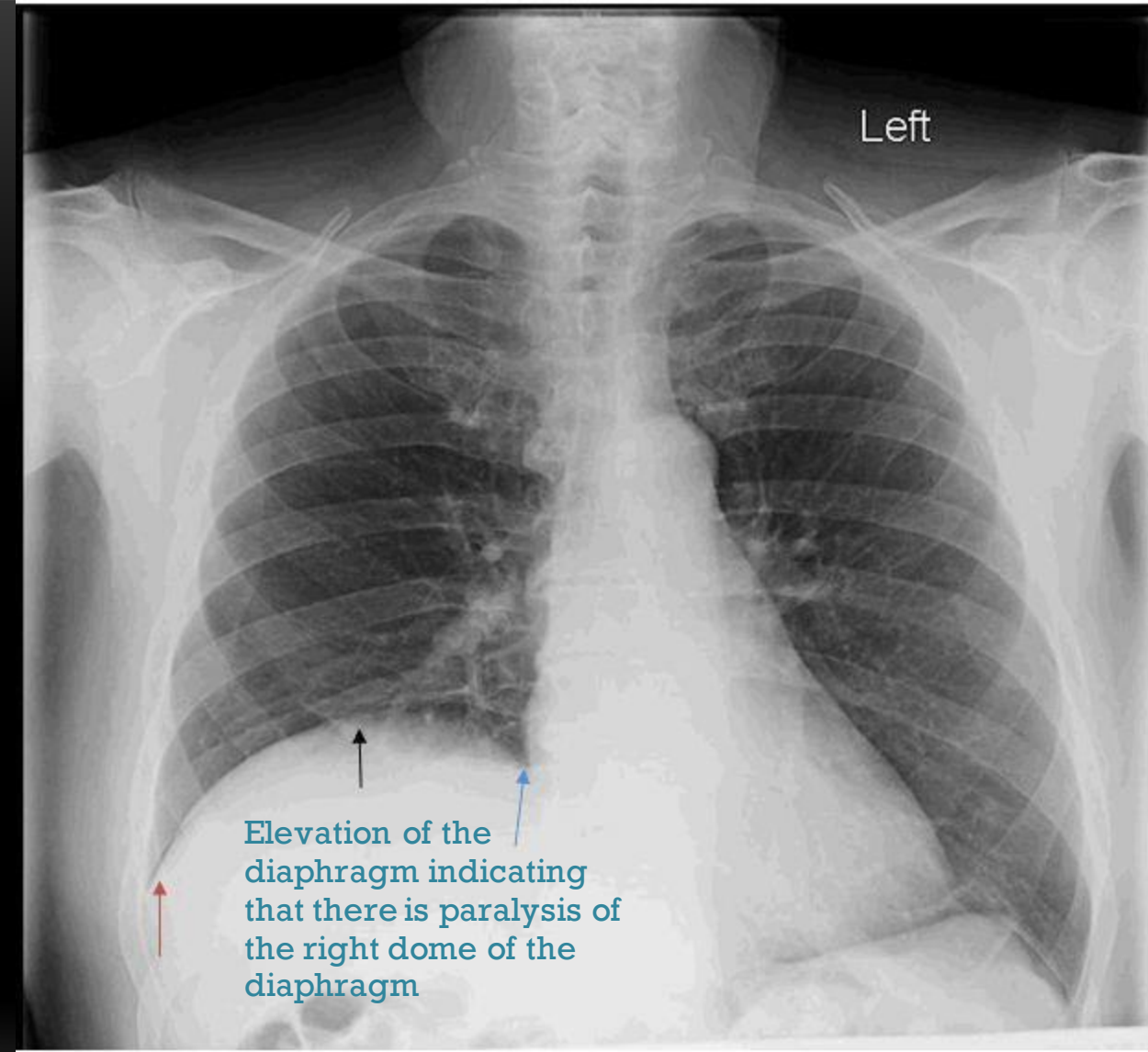


Explanation of the previous slide

- The phrenic nerve supplies the diaphragm from both its thoracic and abdominal surfaces (c4)
- When patients comes in with an infarction, he feel pain at the distribution of C4 (left shoulder and medial aspect of the arm in the left side) (referred pain)

Clinical note

Injury of the phrenic nerve can occur by multiple mechanisms; one common cause is from surgery (iatrogenic), primarily thoracic and cardiac surgery. The phrenic nerve can also be damaged from blunt or penetrating trauma, metabolic diseases like diabetes, infectious causes such as herpes zoster, direct invasion by tumor, neurological diseases such as cervical spondylosis and multiple sclerosis, myopathy (i.e., muscular dystrophy) and immunological disease (e.g., Guillain-Barre syndrome).



Black arrow = dome of the diaphragm (Elevated)

Red arrow = costophrenic angle

Blue arrow = cardiophrenic angle.

Major openings of the diaphragm ..1 / 3

Aortic Hiatus

Lies exactly in the mid line at the level of the lower border of T12.

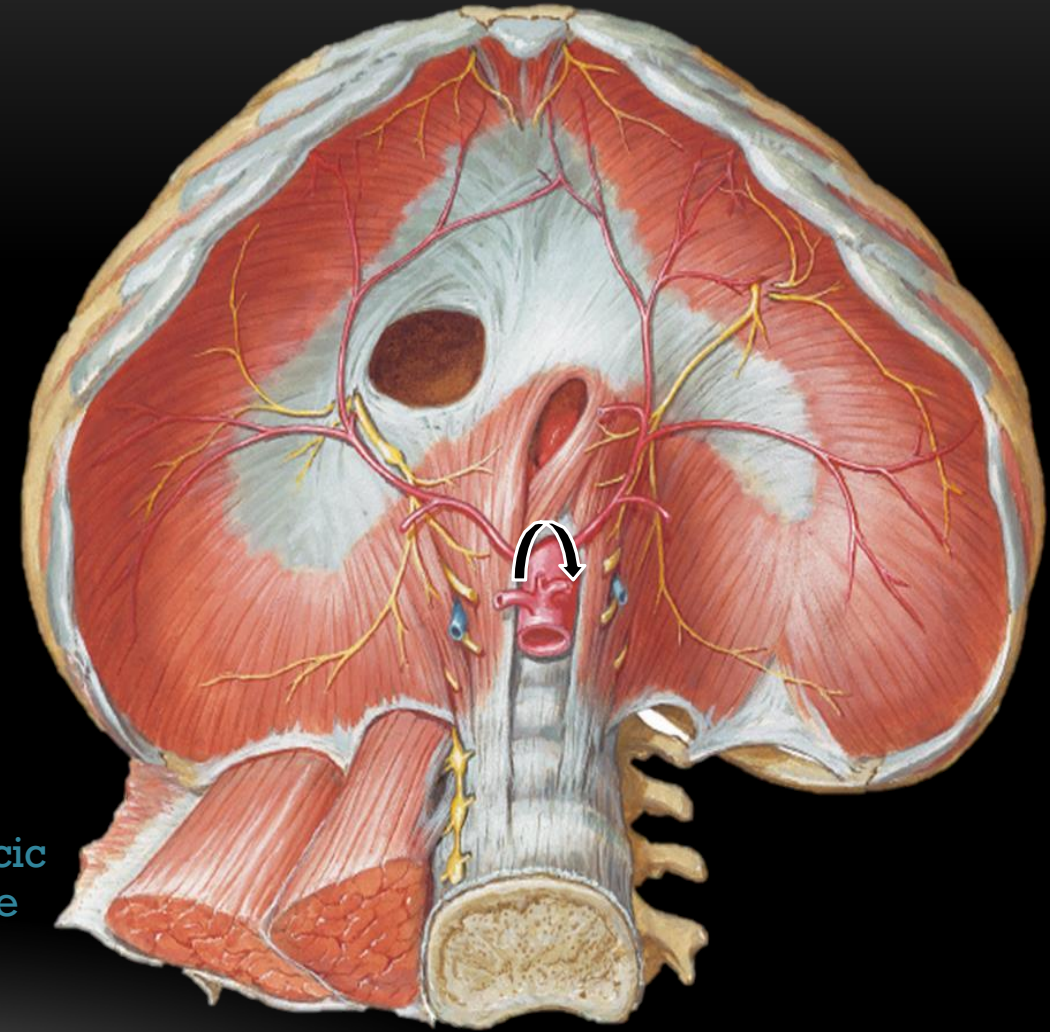
Lies behind the median arcuate ligament.

It transmits the:

- Aorta.
- Azygos vein.
- Thoracic duct.(continuation of cisterna chyli)
- Lymphatics from the thorax to the cisterna chyli.

We said that the median arcuate ligament is located in the front of aorta so The blood flow in the aorta is not affected by contraction of the diaphragm.

It's said that the pulsation of the aorta can be considered as a massage for the wall of the thoracic duct so helps the lymphatics to move upward



Major openings of the diaphragm..2 / 3

I. V. C. Hiatus

Lies one inch to the right of the mid line at the level of the lower border of T8.

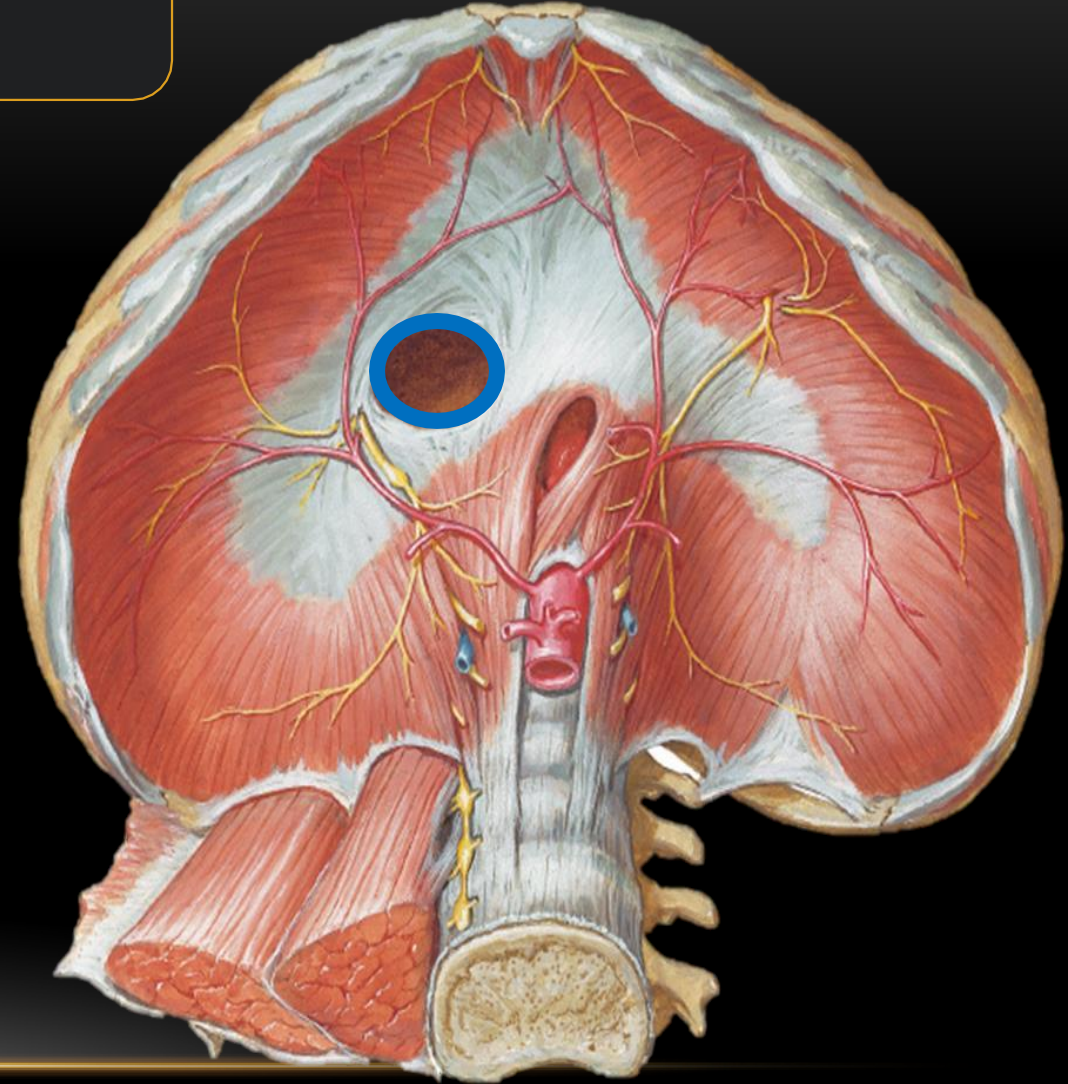
Lies in the central tendon.

It transmits the:

- I. V. C.
- Right phrenic nerve.
- Lymphatics from the liver to the mediastinal lymph nodes.

The adventitia of I.V. C. fuses fibres of the central tendon (the outer layer of the blood vessels is called tunica adventitia and it contains collagen fibers and these fibers pass into the central tendon)

When the diaphragm contracts the tendon is pulled apart on the wall of the vena cava and widens it thus helping in increasing the venous return into the heart



Major openings of the diaphragm ..3 / 3

Esophageal Hiatus

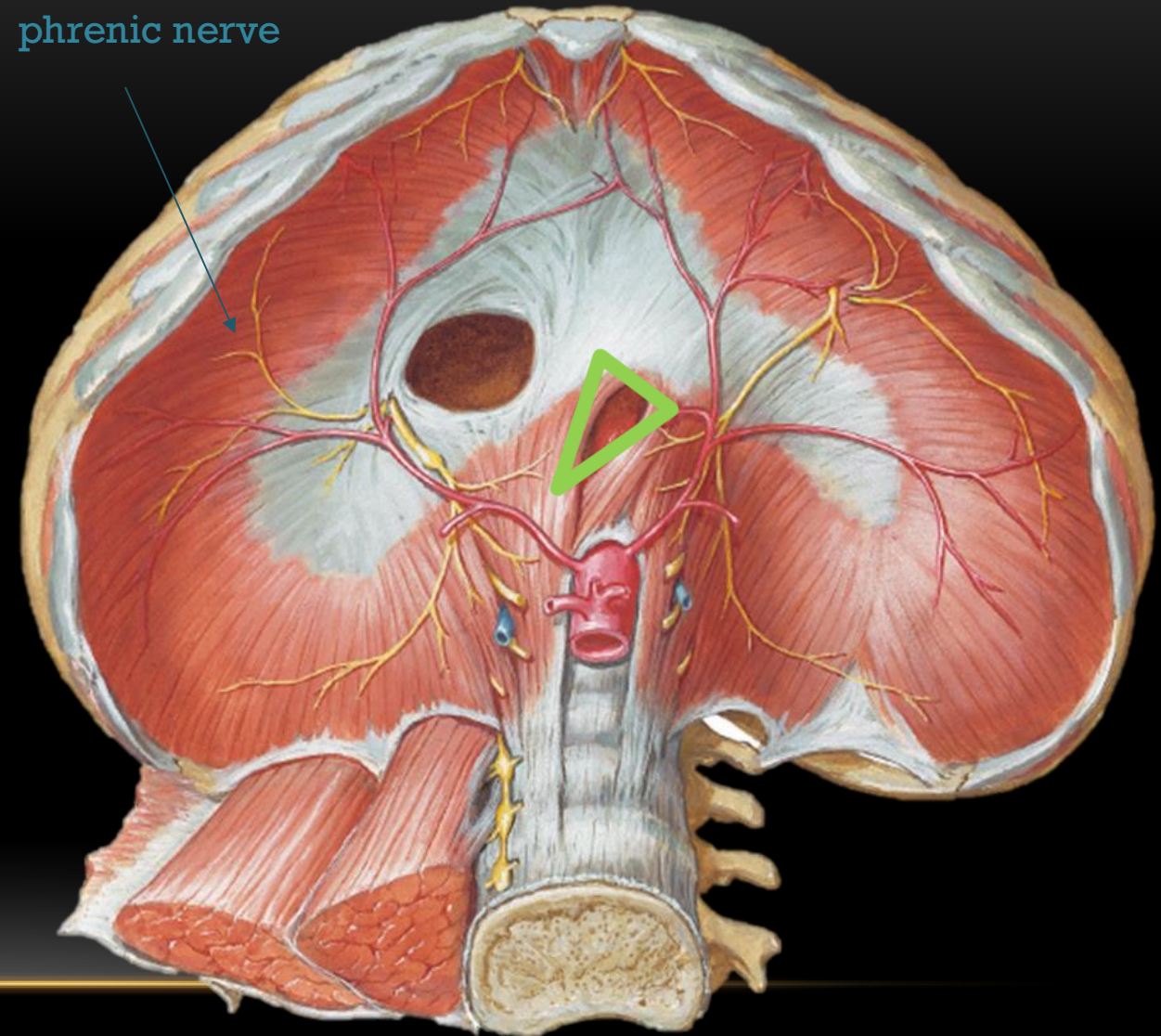
Lies one inch to the left of the mid line at the level of the lower border of T10.

Lies in the left crus but is surrounded by a sling from the right crus. This acts as a physiological sphincter at the lower end of the oesophagus.

It transmits the:

- Esophagus.
- Anterior and posterior gastric nerves. (at the lower end of the vagus , the right and left vagus nerves are named the posterior and anterior gastric nerves respectively)
- Esophageal arteries and veins. (To supply the esophagus)

Branches of the phrenic nerve



Explanation of the previous slide

- I.V.C hiatus >> at the level of T8 >> hiatus for blood vessels
- Esophageal hiatus >> at the level of T10 >> for esophagus
- Aortic hiatus >> at the level of T12 >> for blood vessels

Two for blood vessels and in the middle for esophagus, Why this arrangement?

Imagine a boy is running , he is breathing quickly ,the diaphragm is contracting all the time , the muscles of the legs need more blood supply so the venous return also increases , the pumping to the aorta increases but the contraction of the diaphragm does not affect the aorta , because if it affects the boy will not be able to run as the blood supply to the lower limb will be weak

At the same time the venous return into the heart increases as the contraction of the diaphragm pulls the wall of the I.V.C , The negative pressure of the thorax will suck the blood towards the heart which also helps .

The boy sweats and drinks water , the water moves through the esophagus into the stomach , why the water doesn't return back ? The contraction of the diaphragm closes the lower end of the esophagus (acts as a physiological sphincter)

Minor openings of the diaphragm ..1 / 2

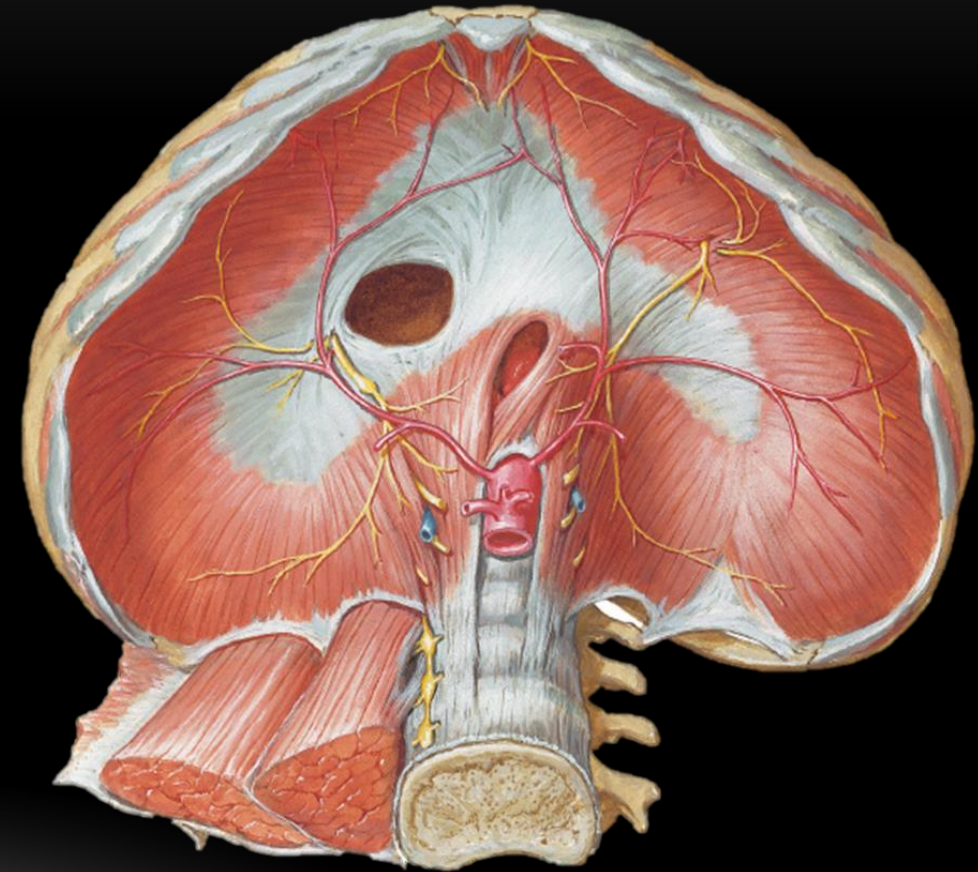
The positions of them could be changed sometimes

The superior epigastric artery passes between the sternal and costal origins of the diaphragm. (Because it is going to join the inferior epigastric artery anteriorly)

The musculophrenic artery passes between the 7th and 8th slips of costal origin.

The lower 5 intercostal nerves pass between all slips of costal origin of the diaphragm.

Subcostal nerves and vessels pass behind the lateral arcuate ligament.



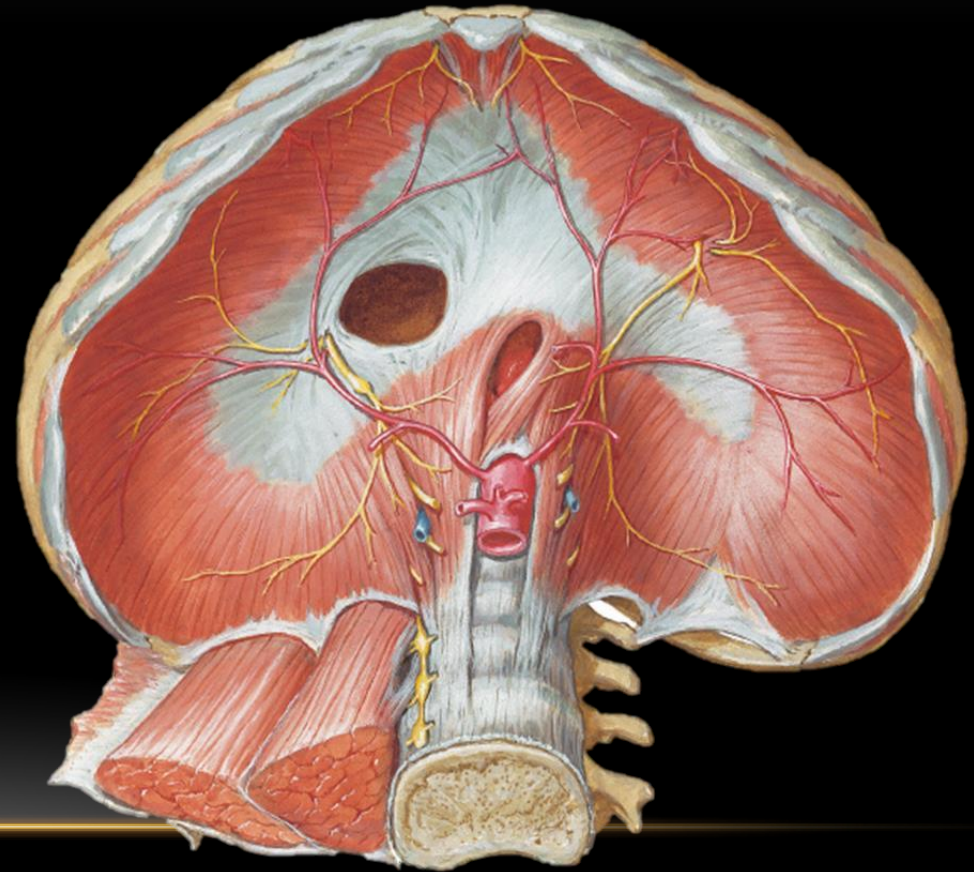
Minor openings of the diaphragm ..2 / 2

The sympathetic chain passes behind the medial arcuate ligament.

The greater and lesser splanchnic nerves pass through the corresponding crus of the diaphragm.

The inferior hemiazygos vein passes through the left crus.

The left phrenic nerve passes through the left crus.



Functions of the Diaphragm

- **Main Muscle of Inspiration:** The diaphragm pulls the central tendon down during contraction and increasing the vertical diameter of the thorax. This increases the negative pressure inside the thoracic cavity, which draws in air.

- **Muscle of Abdominal Straining:** The contraction of the diaphragm will assist in the contraction of the muscles of the anterior abdominal wall in raising the intra-abdominal pressure will normal processes like micturition, defecation, and parturition.

- **Weightlifting Muscle:** When a person takes and holds a deep breath, the diaphragm will assist the muscles of the anterior abdominal wall to raise the intra-abdominal pressure. This maneuver is also called as Valsalva maneuver and is used to augment heart murmurs and classify them whether they are clinically right-sided or left-sided.

Paralysis of c4 >>no respiration

Clinical note : During parturition, some women do purposeless movements so all their energy is lost , instead they should take a deep breath with every shot in order to increase the intra-abdominal pressure which helps the baby to get out