- What is the most important muscle of the body?

- **Dia** --------- between
- **phragm** ---- barrier

Diaphragm

By

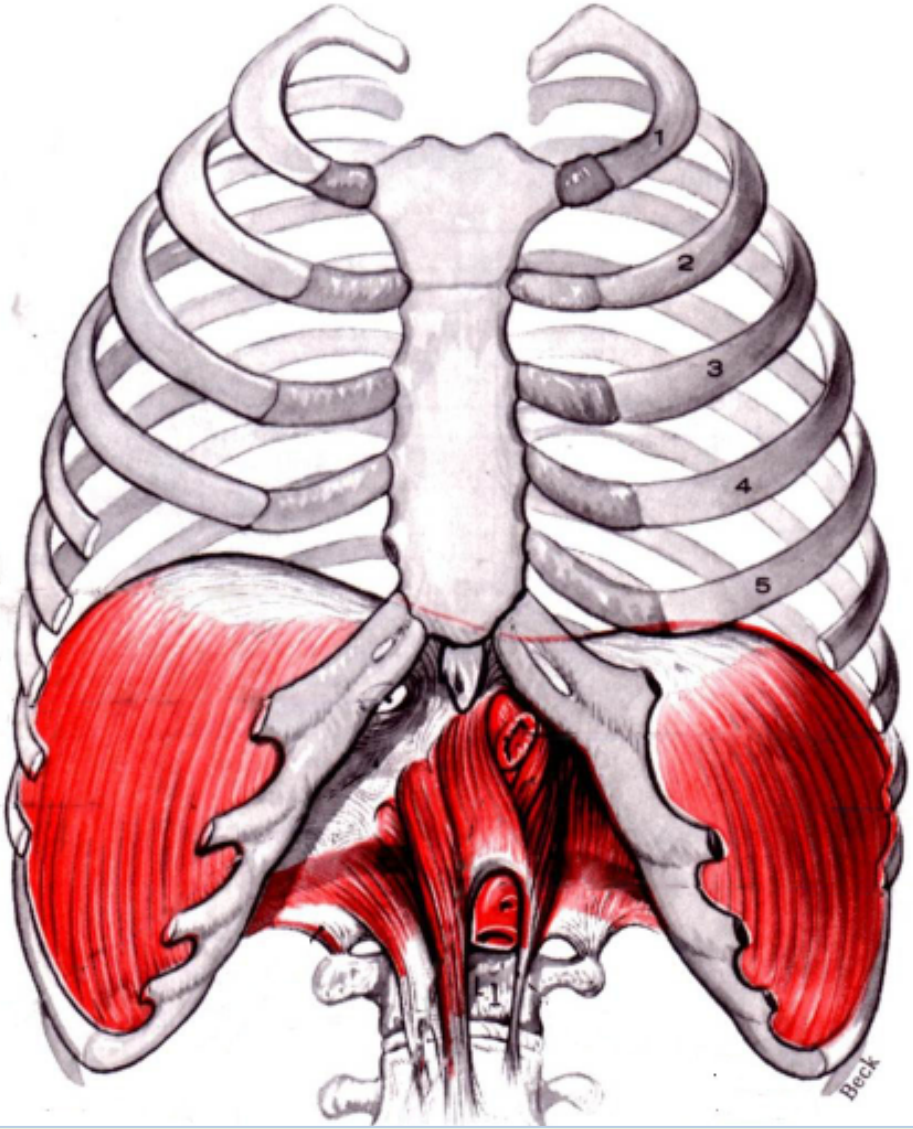
Basma Emad Aboulhoda

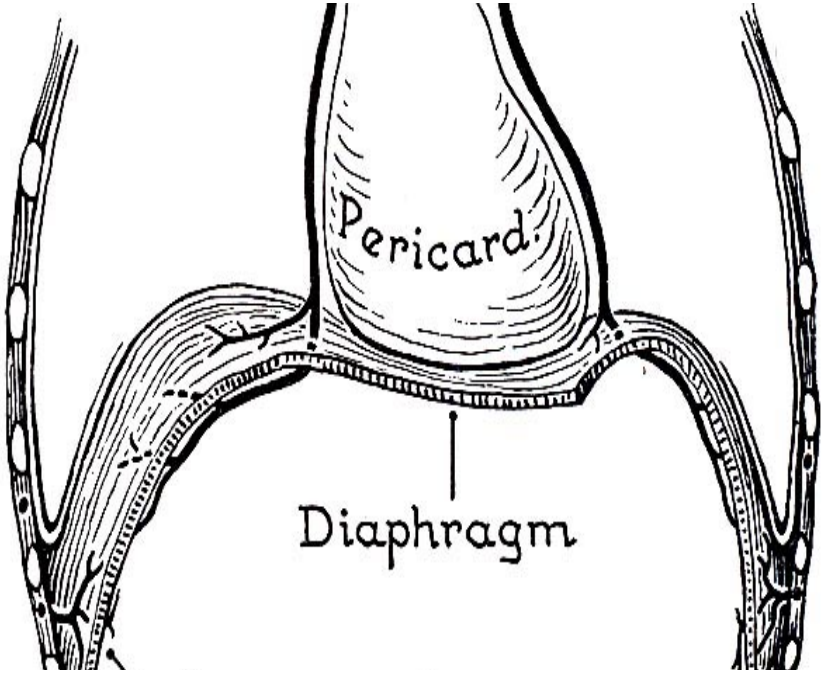
Lecturer of Anatomy and Embryology

Faculty of Medicine, Cairo University

Diaphragm is a muscle

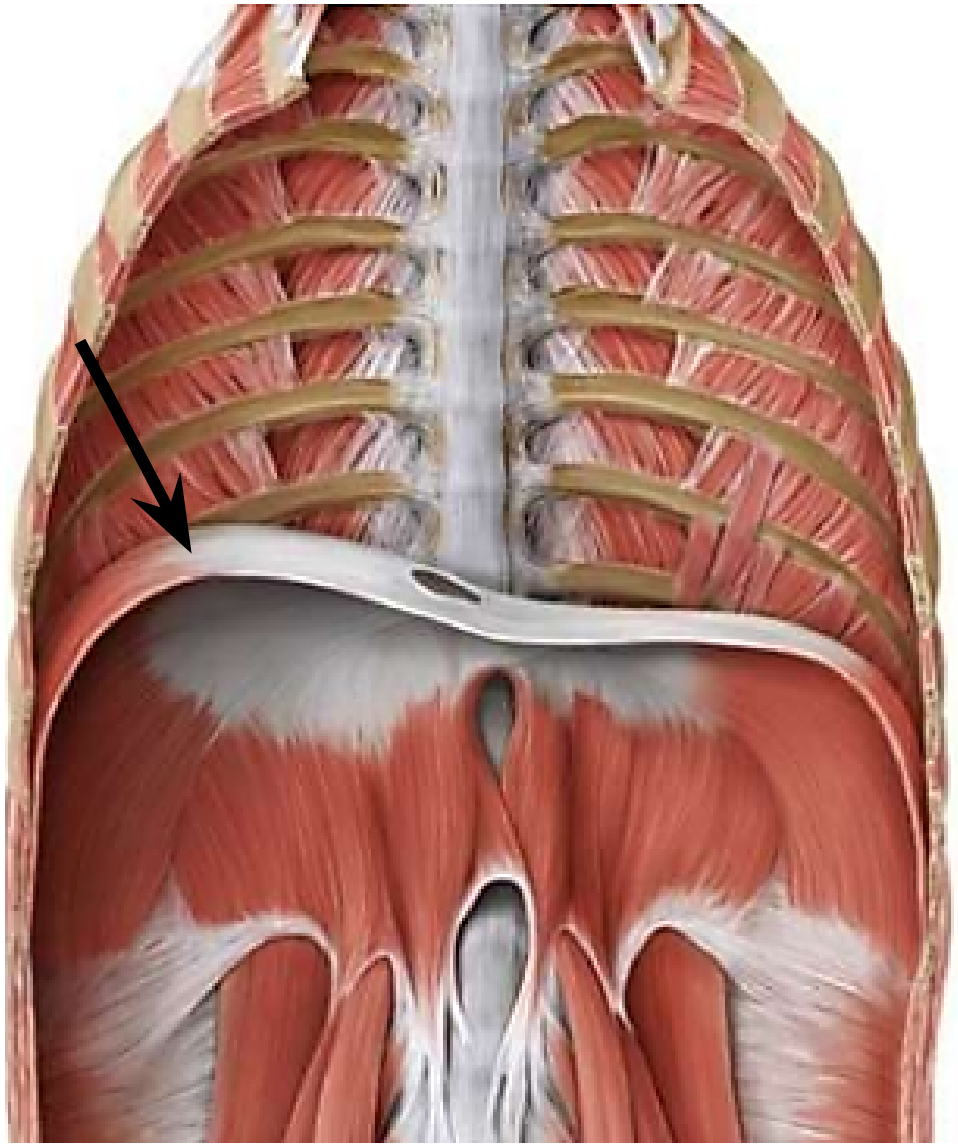
- Origin
- Insertion
- Nerve Supply
- Action
- Relations
- Openings

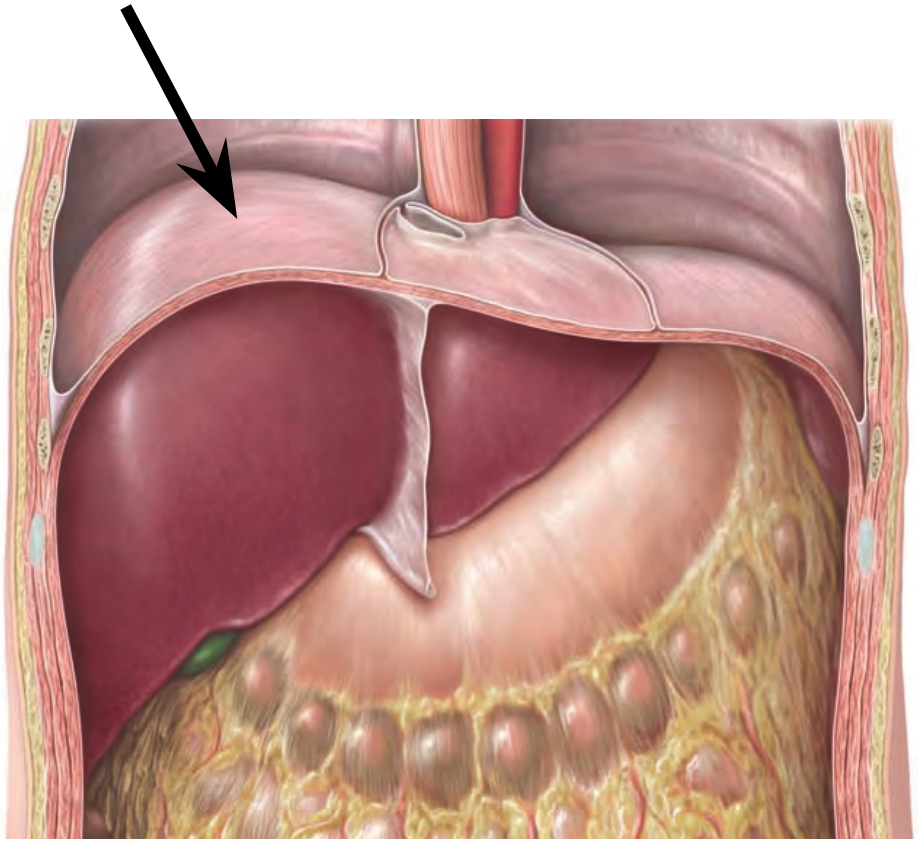




1. Central tendinous part **2. Peripheral muscular part**

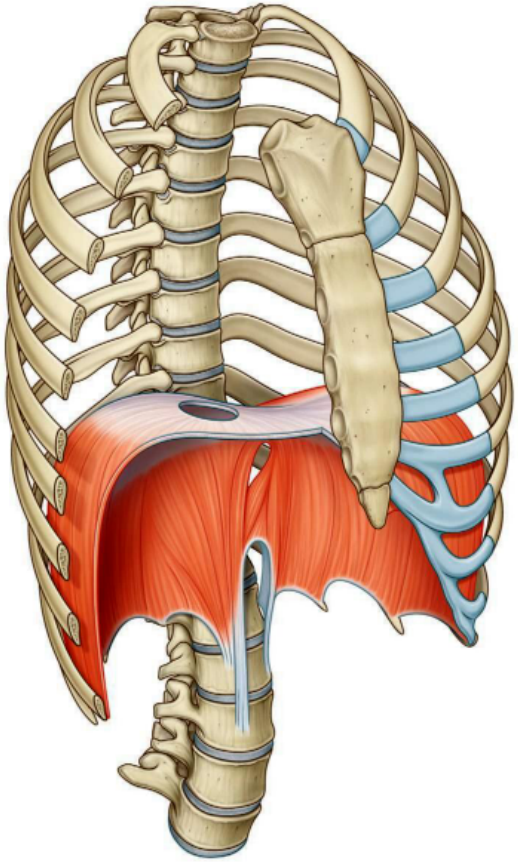
Two rounded arched muscular parts called ***cupolas***, one on each side.
 A depressed central tendon.

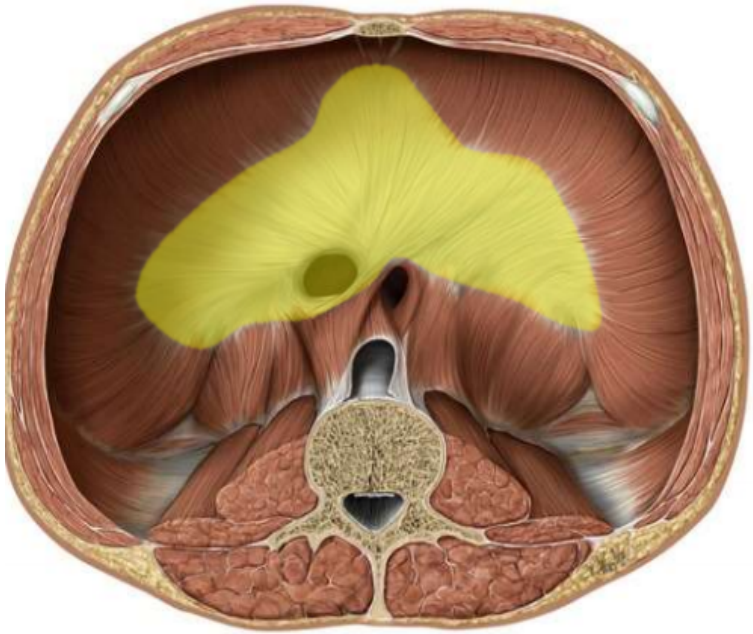




Shape:

- Large dome-shaped fibromuscular partition-separates thoracic cavity from abdominal cavity.
- Convex upwards.



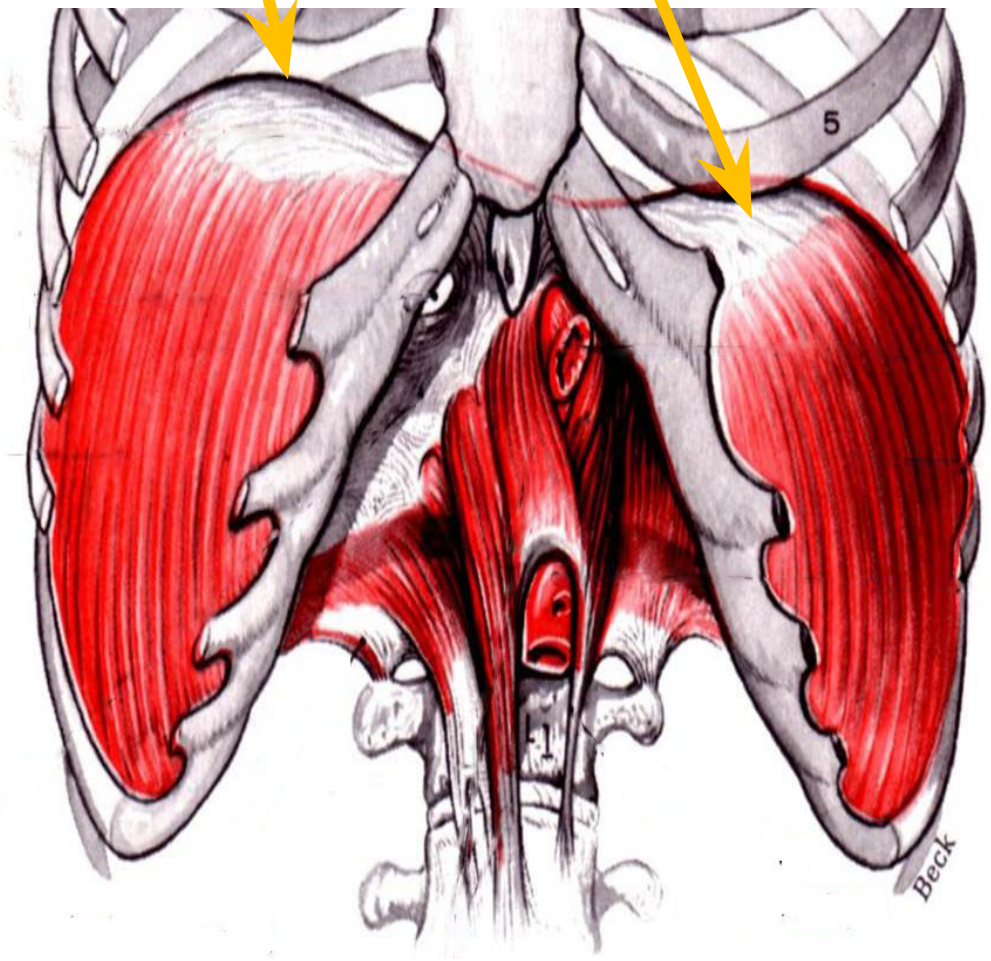


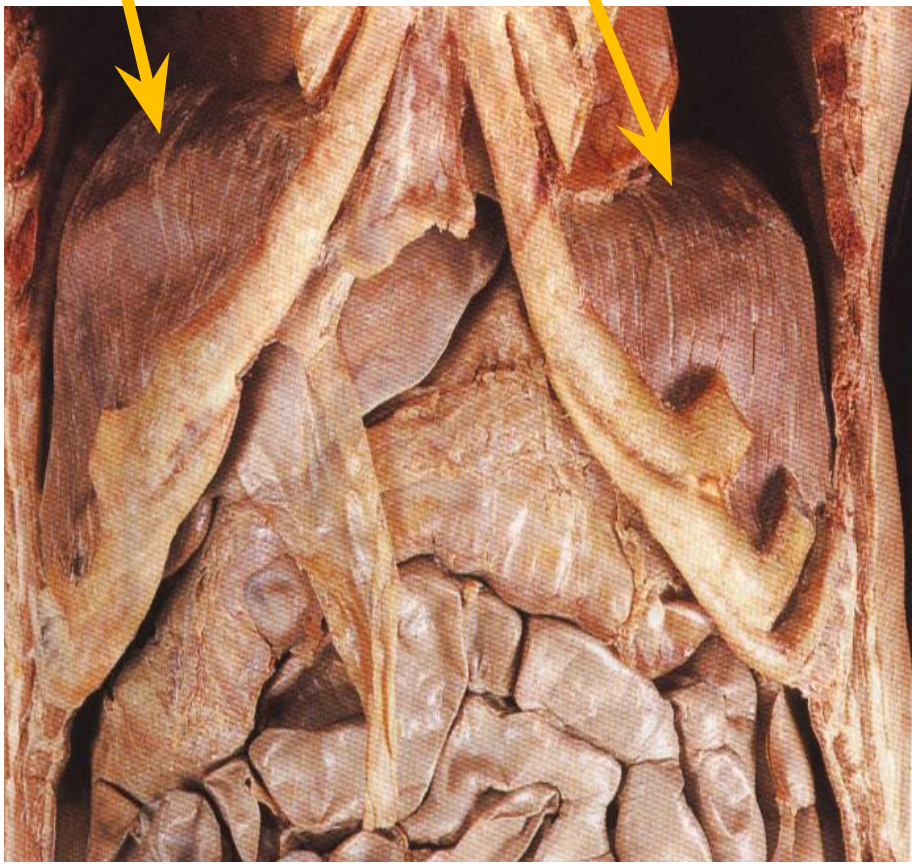


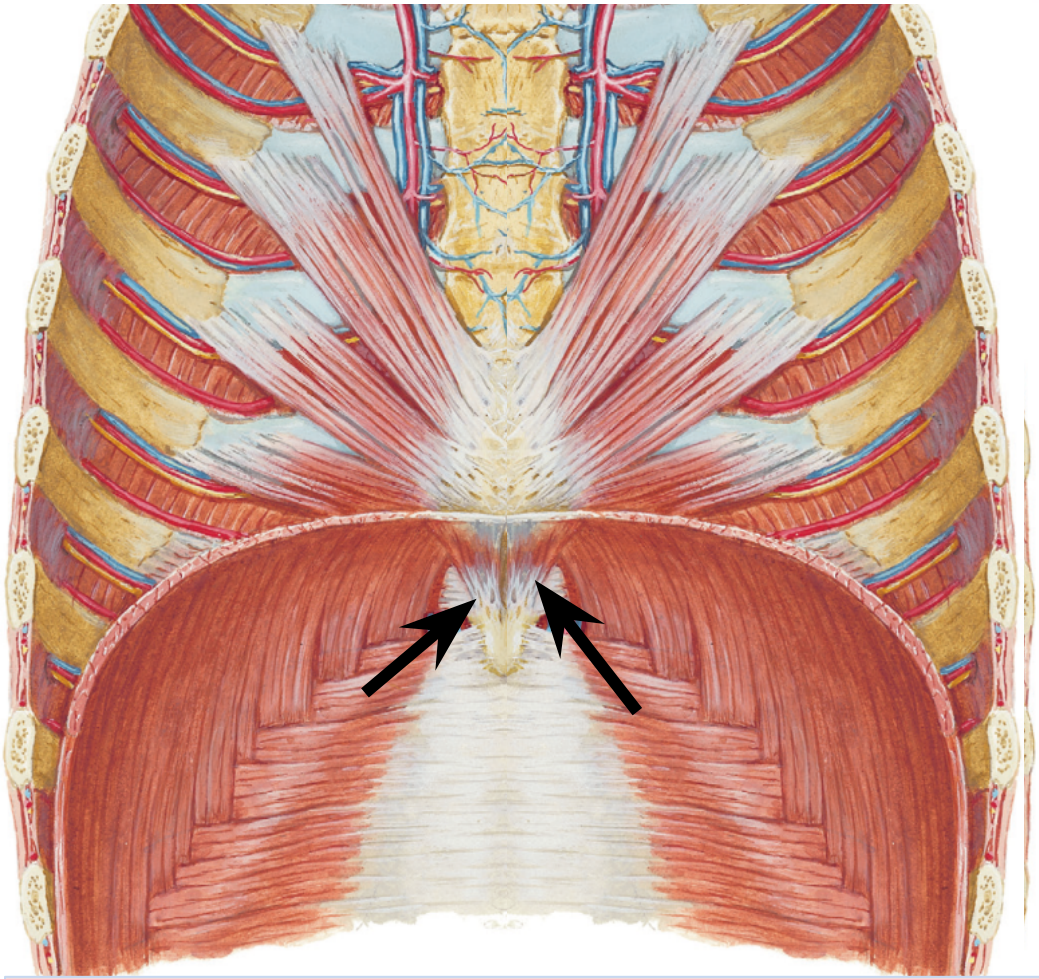
Origin: sternal origin, costal origin, vertebral origin.

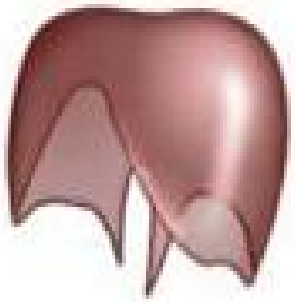
(In order to separate the thoracic cavity from abdominal cavity it takes origin from the walls of thorax from inside)

copula of diaphragm





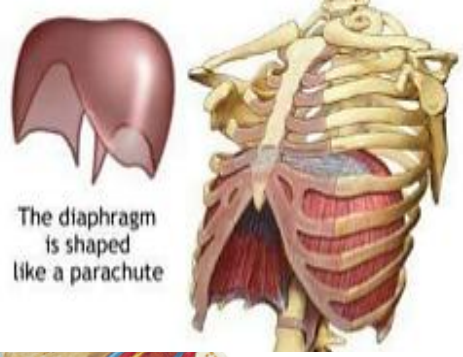


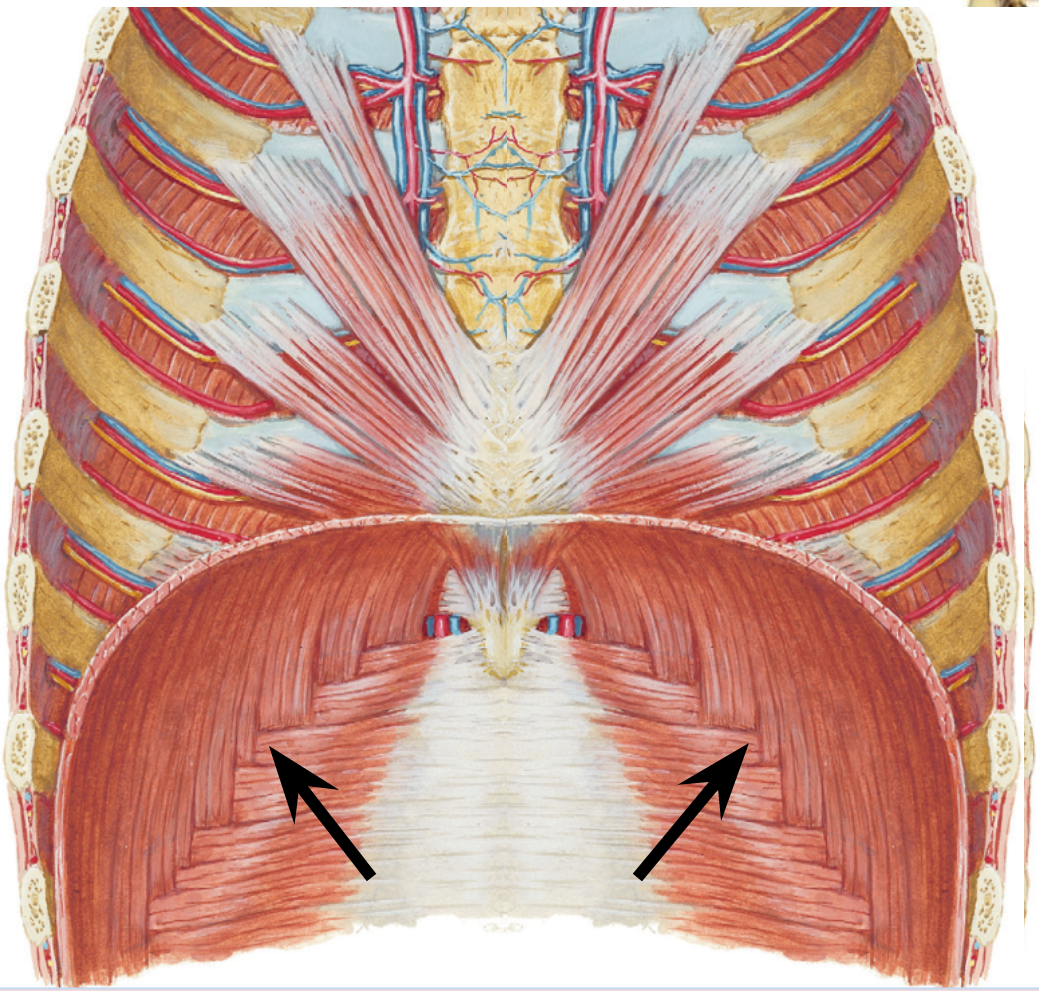


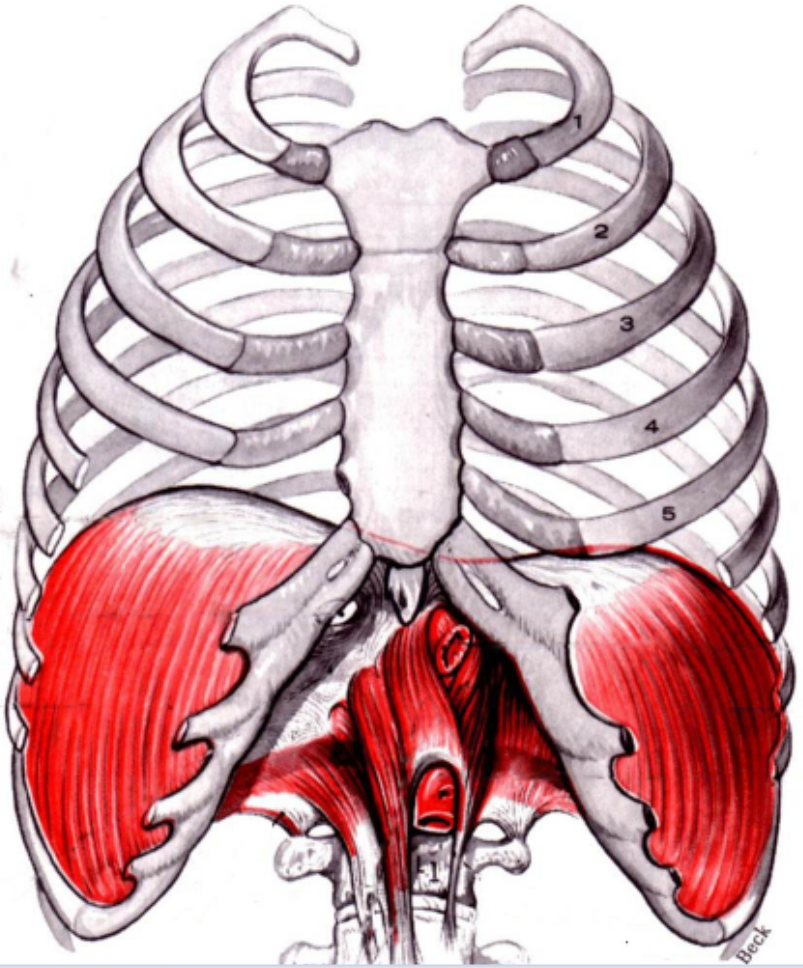
The diaphragm is shaped like a parachute



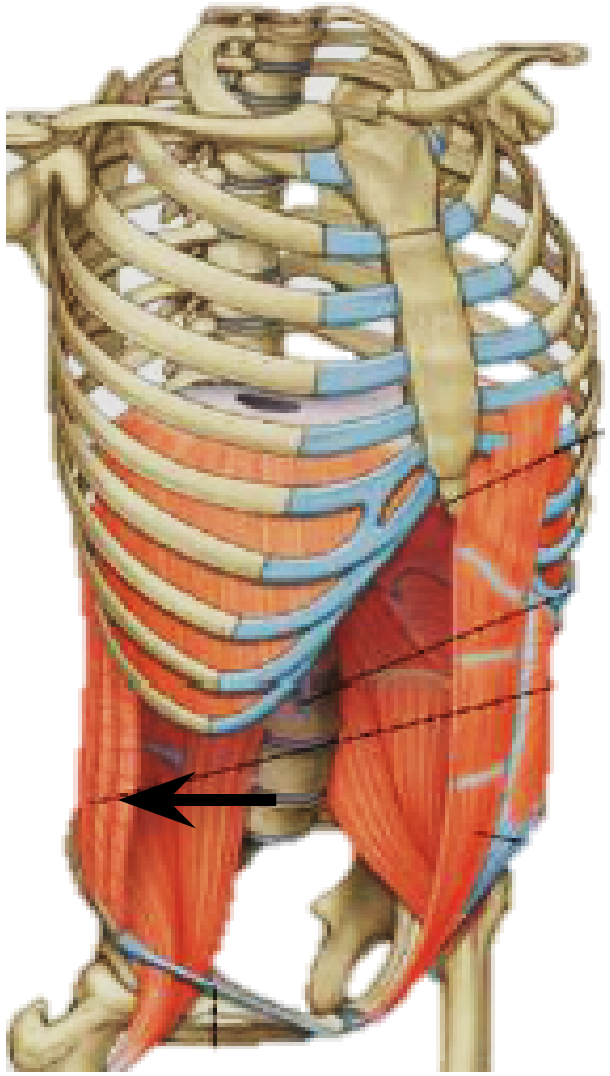
Sternal origin: From the back of xiphoid process by two fleshy slips.



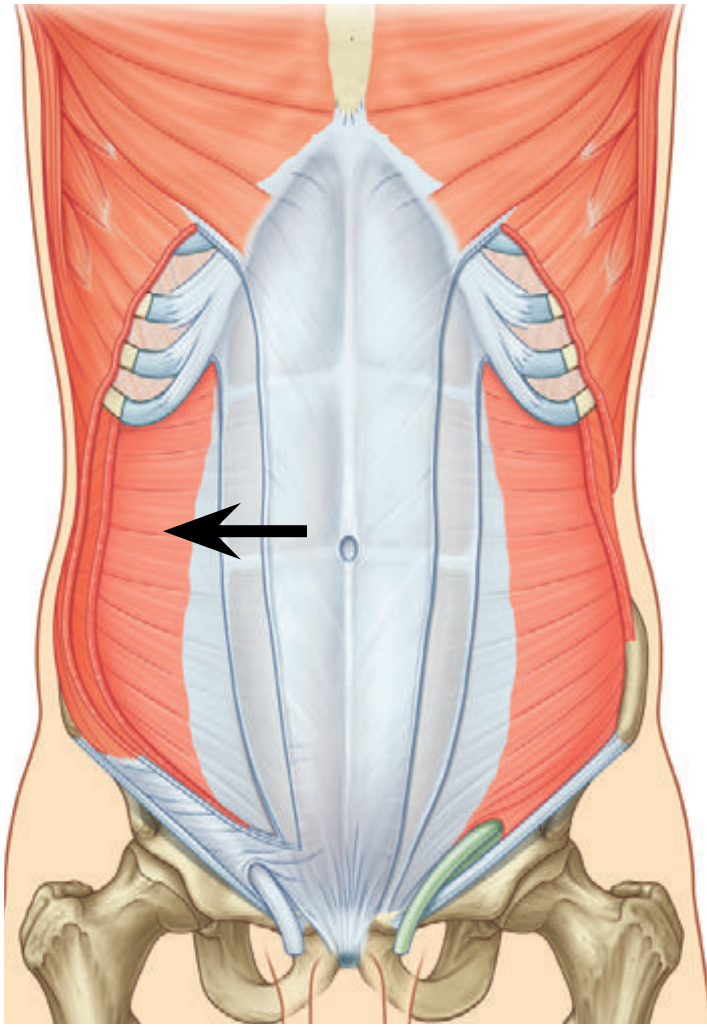




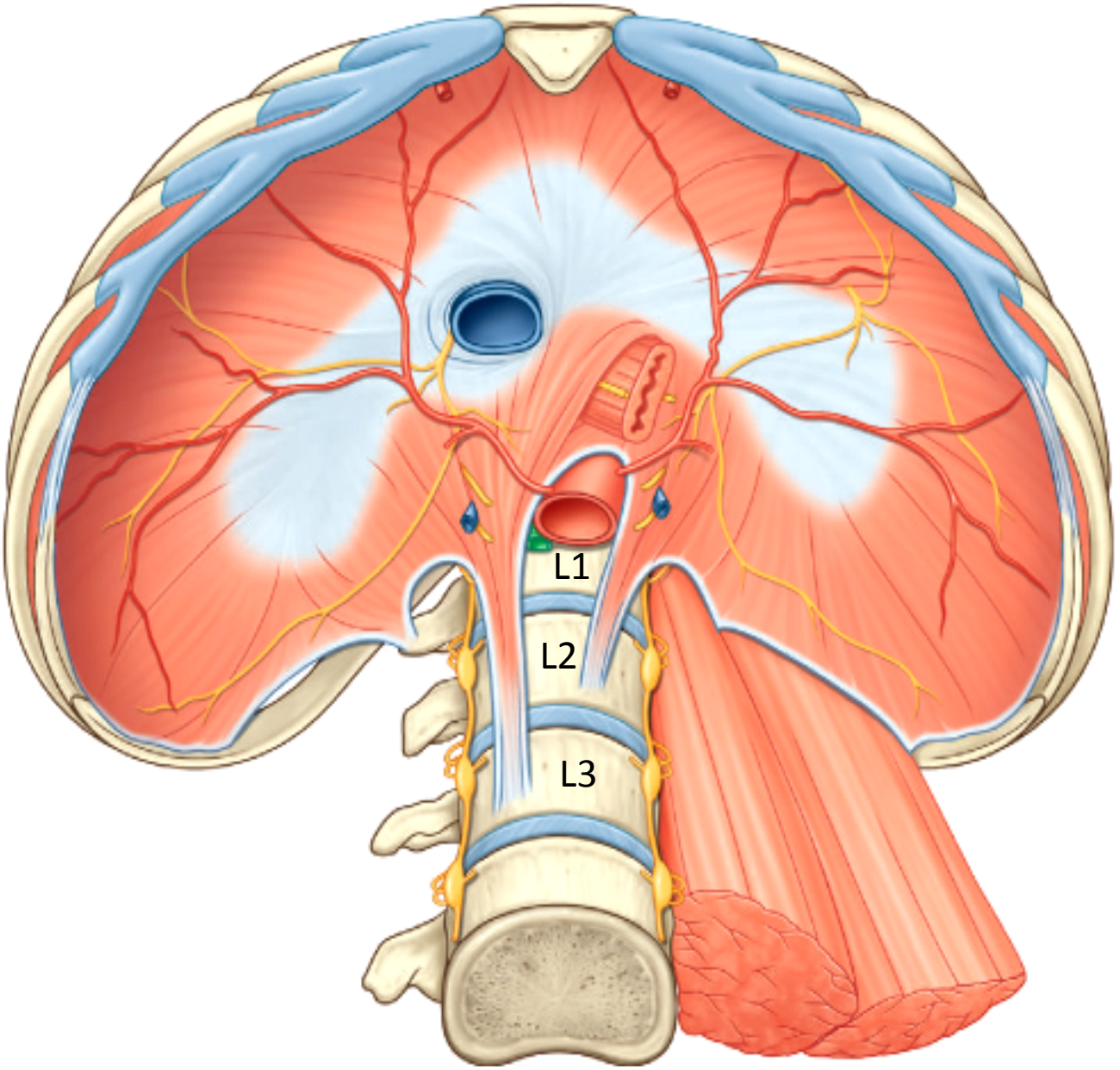
Costal origin: inner surface of ***lower six*** *costal cartilages*







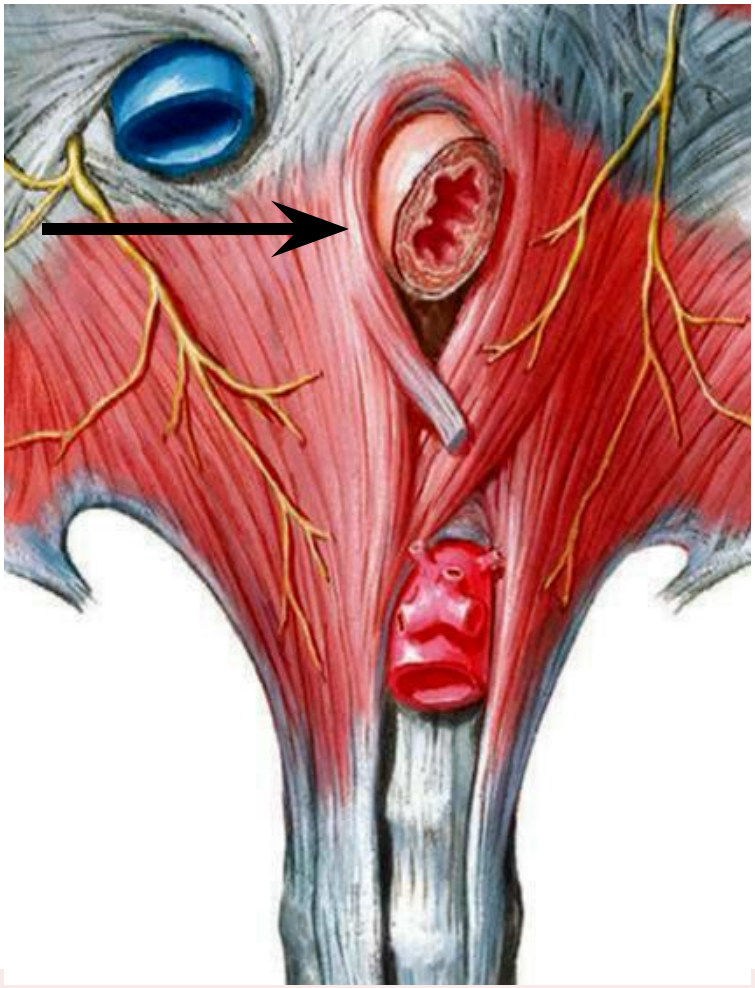
Costal origin: inter-digitating with origin of the transversus abdominis muscle **(Both from inner surface of lower 6 costal cartilages)**

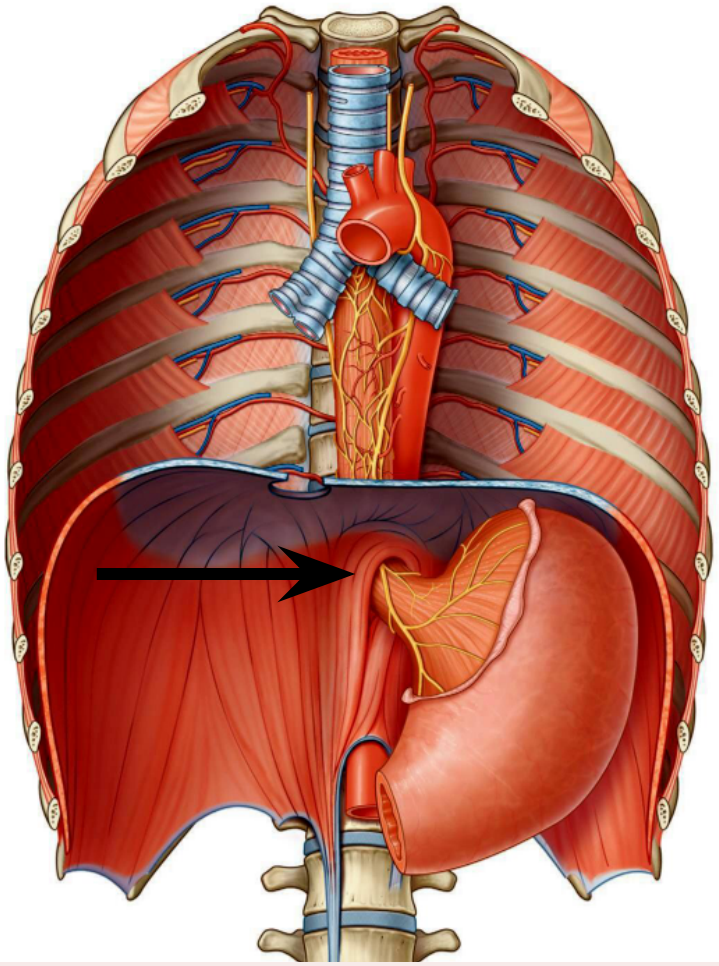


Vertebral origin: two crura (right and left) and five arcuate ligaments(median,2 medial,2 lateral)

- Attachments

Rt crus larger than left (to contract against the



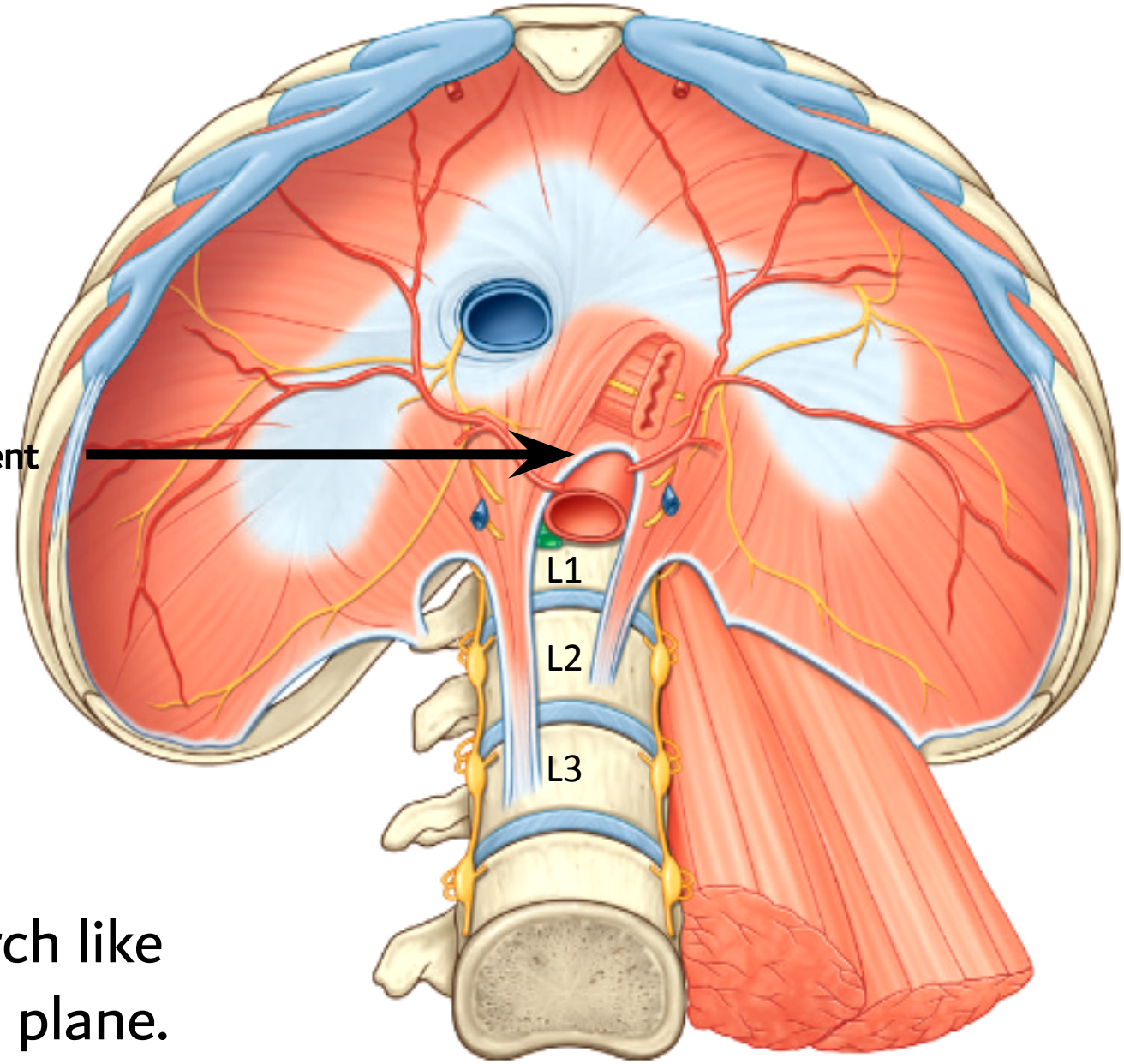


Right crus:

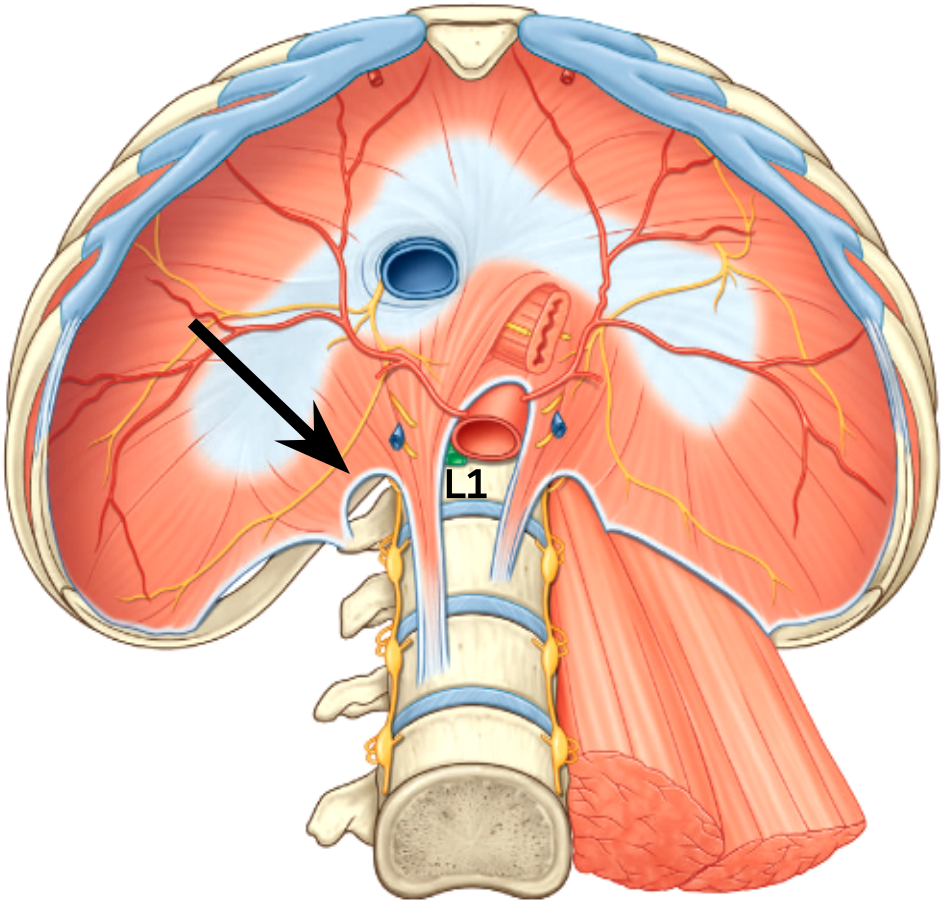
- Arises from bodies of upper 3 lumbar vertebrae.
- It is larger than left crus (as it has to contract against liver).
- Its fibers extend up to surround lower end of oesophagus forming a physiological sphincter around cardiac end of the stomach.

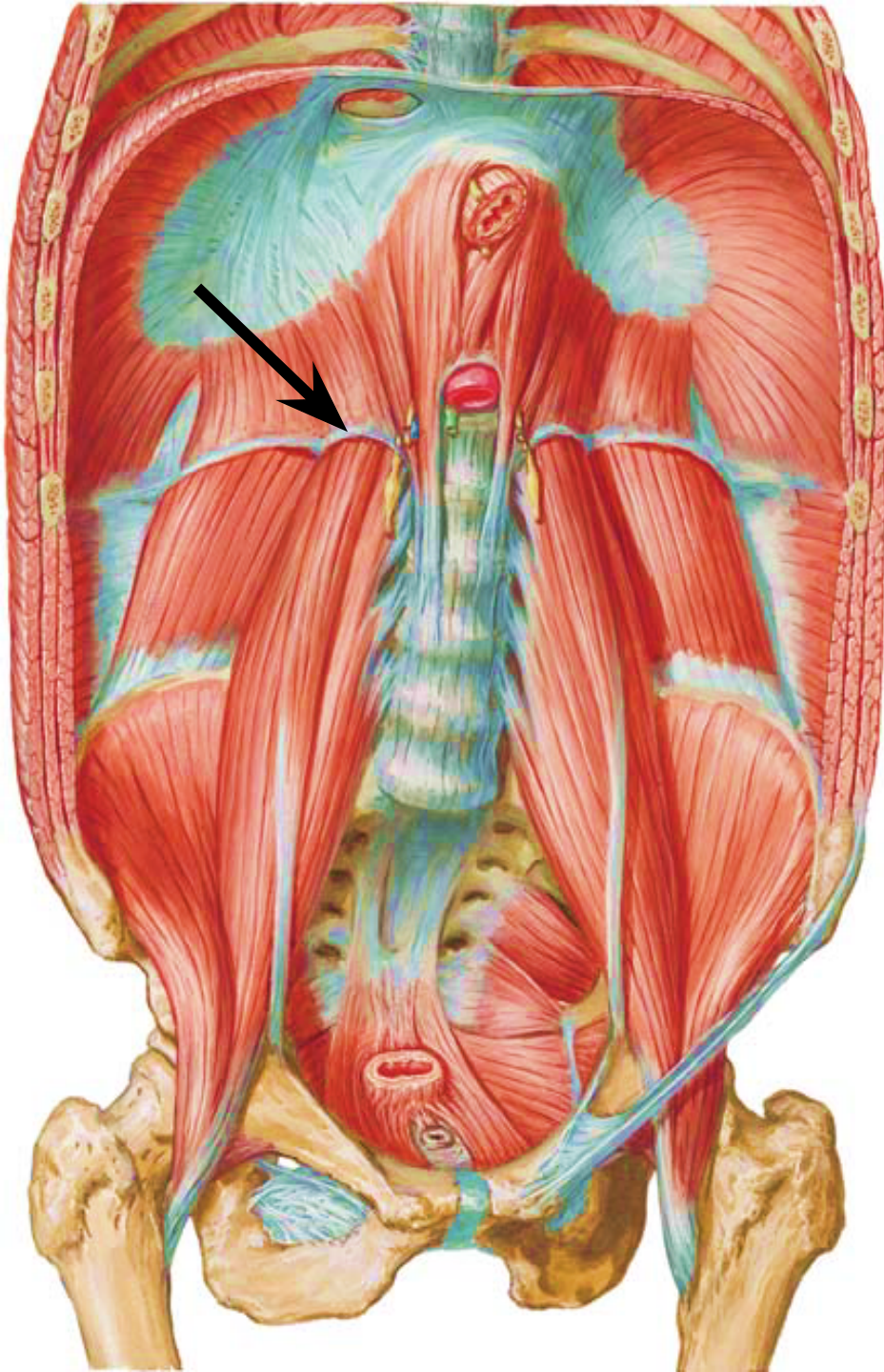
Left crus: smaller and arises from bodies of upper 2 lumbar vertebrae.

Why right crus and not left crus while oseophagus is on left side (longer course------Starling Law) , acts as a sphincter to prevents reflux of gastric contents into esophagus during increased abd pressure with descent of diaphragm during



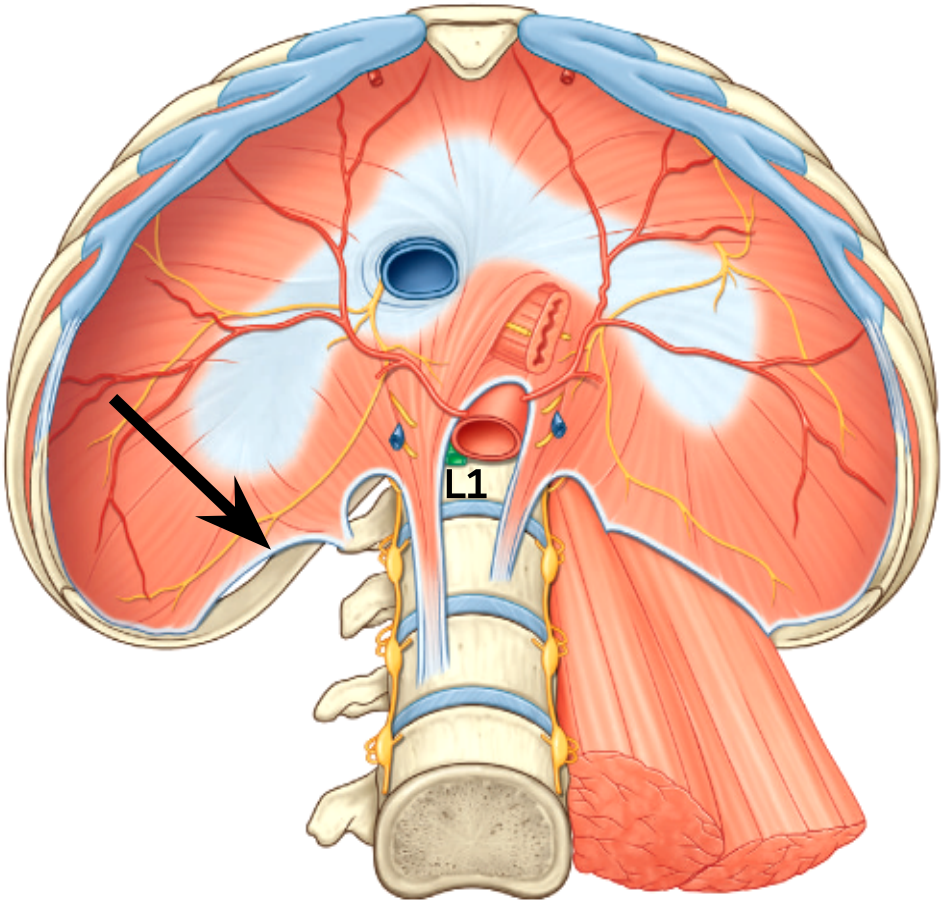
- Arcuate means arch like
- lies in the median plane.
- Extends between the right and left crura.
- It arches over the aorta.

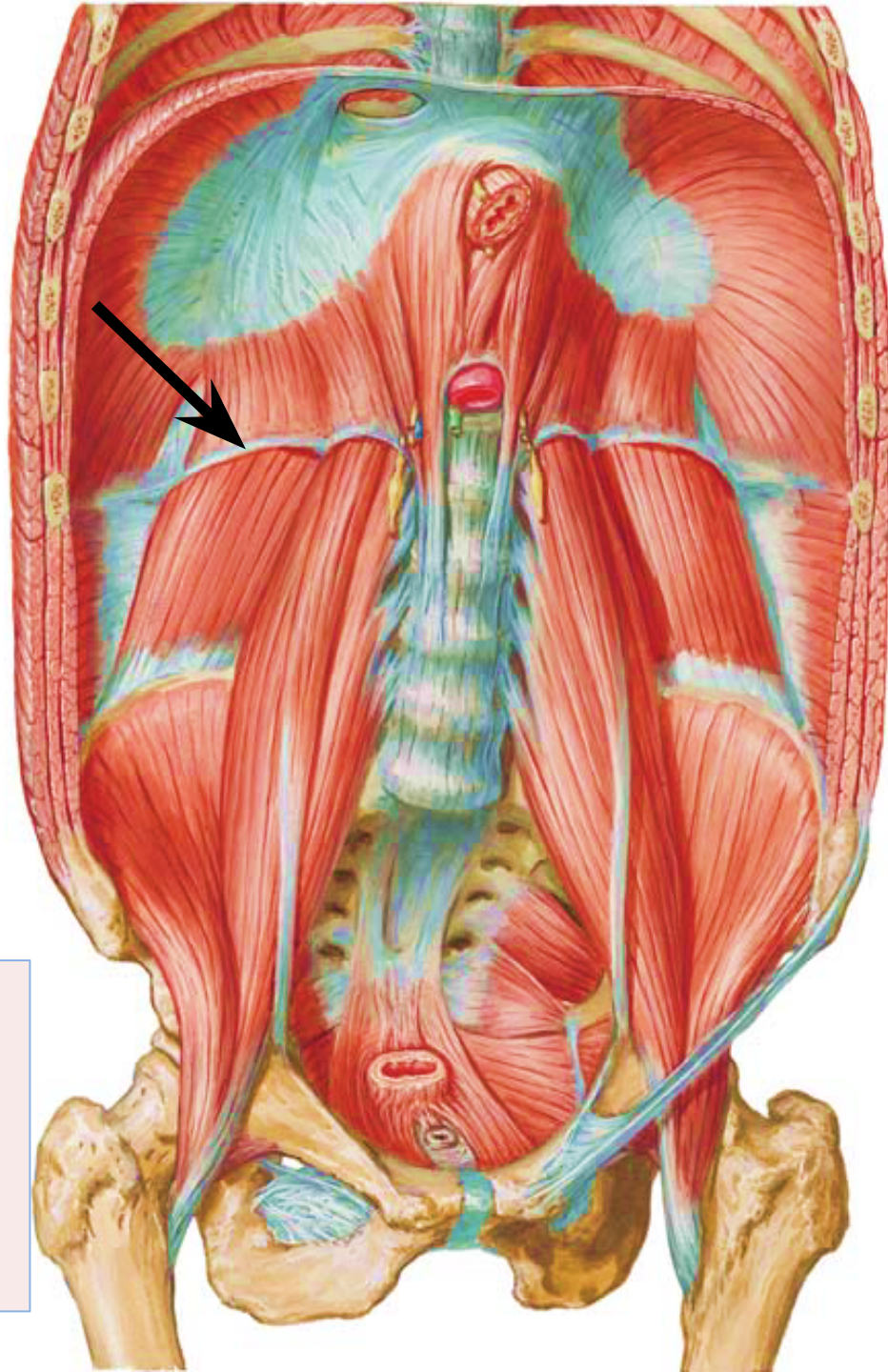




Medial arcuate ligament (right & left)

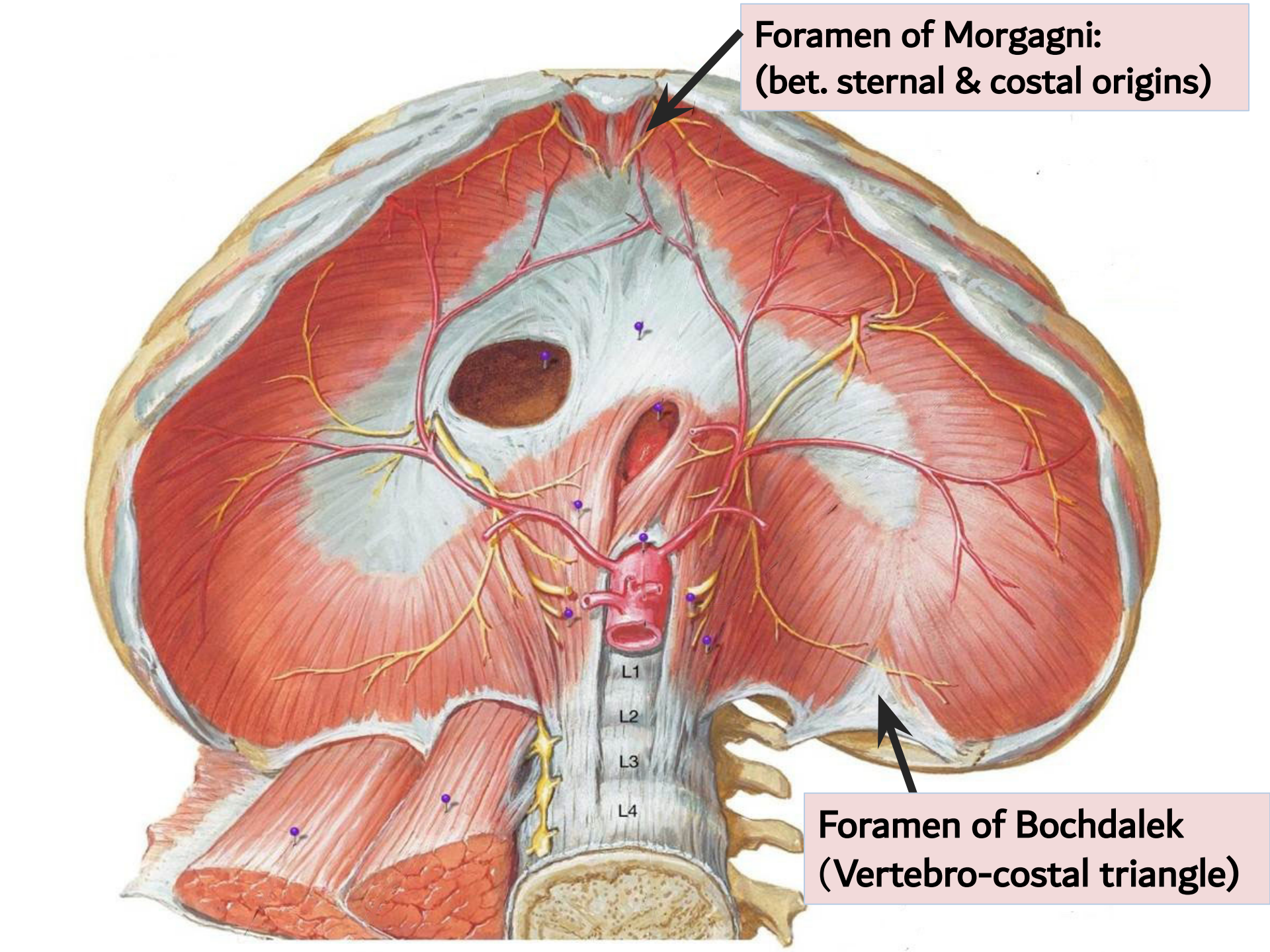
- Connects the crus with the tip of the transverse process of L1.
- Arches over the psoas major muscle

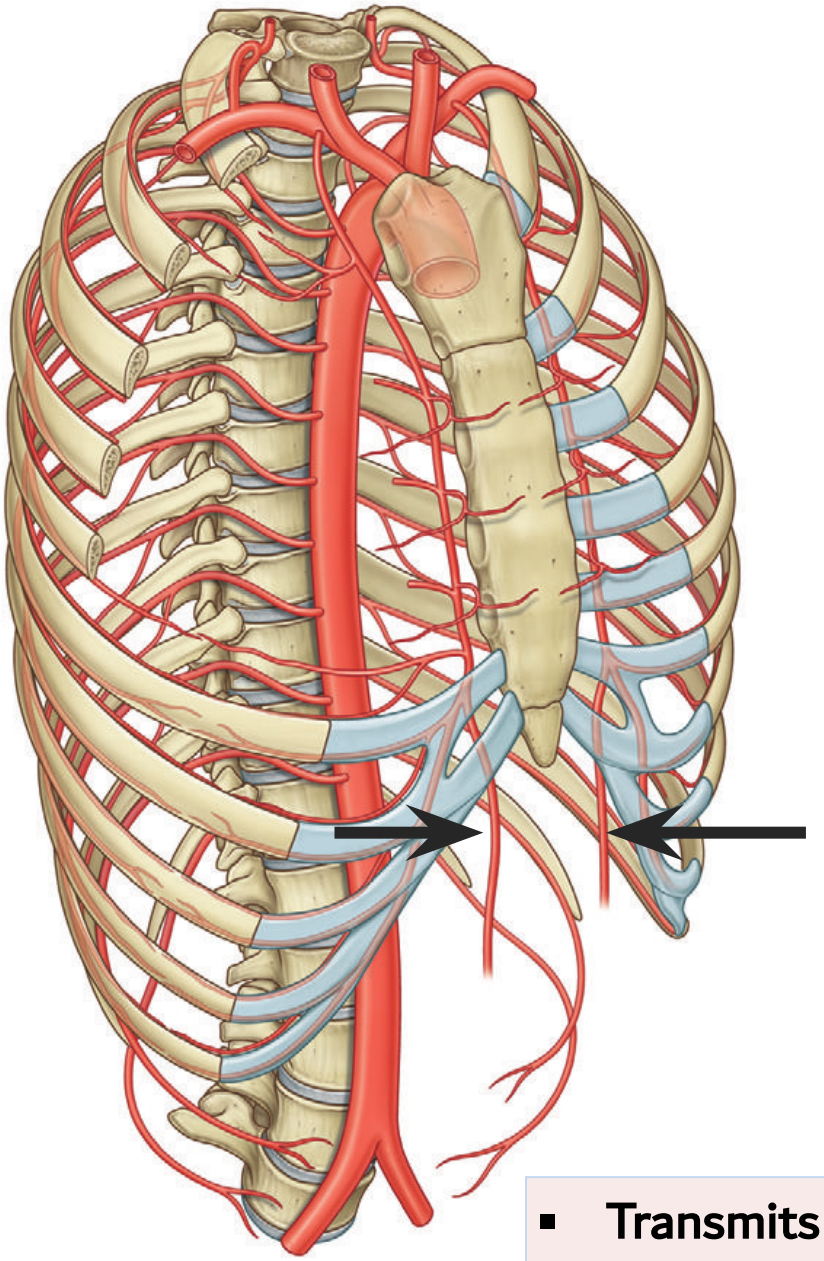


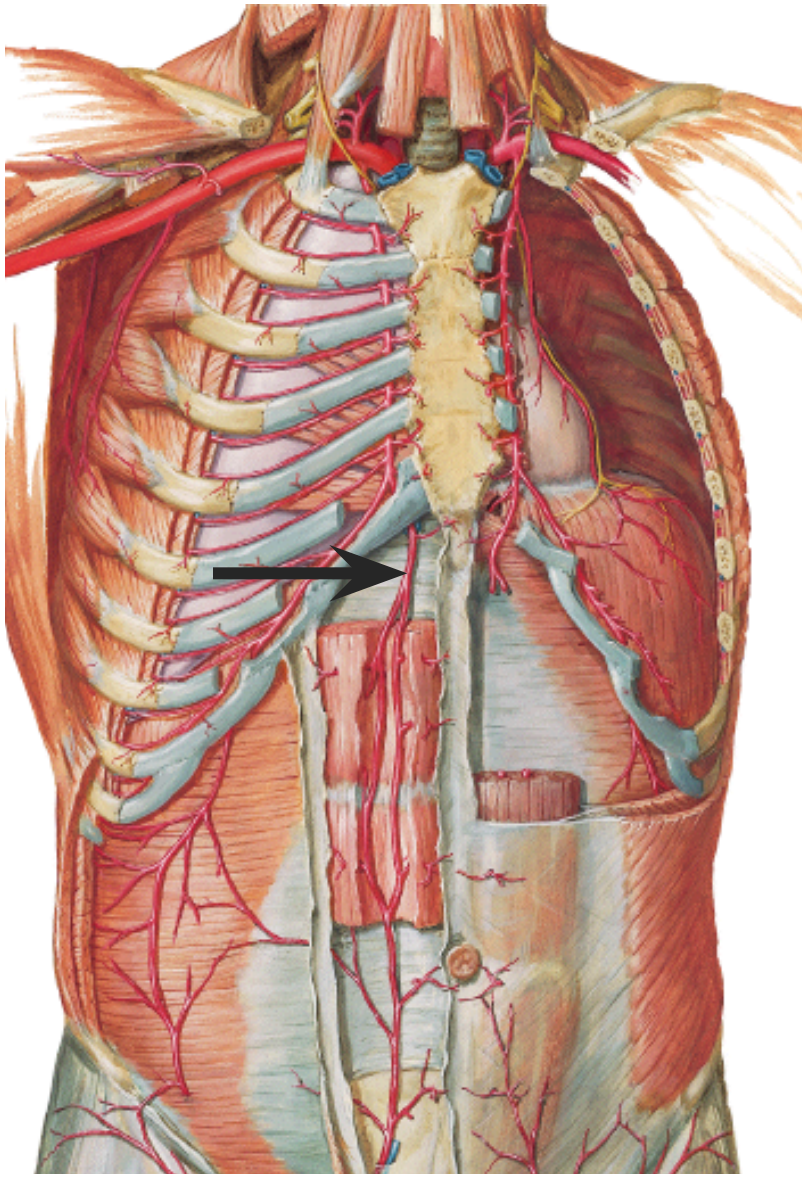


Lateral arcuate ligament (right & left):

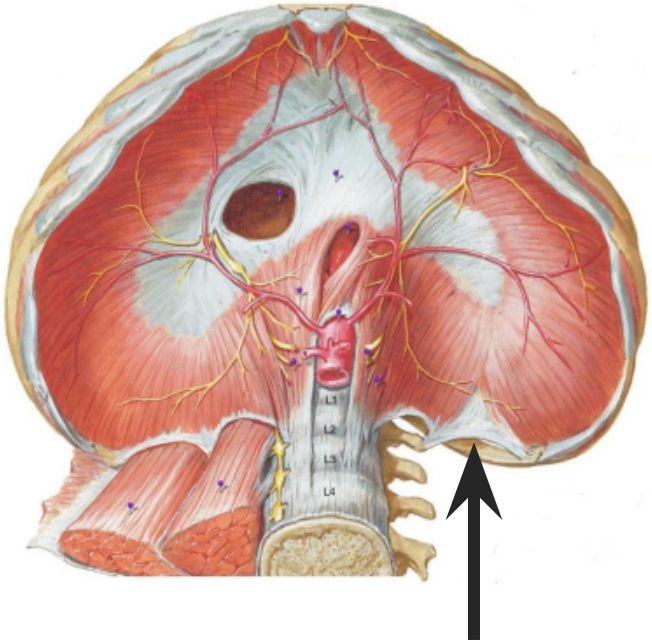
- Connects tip of the transverse process of L1 to the last rib.
- Arches over quadratus lumborum muscle.

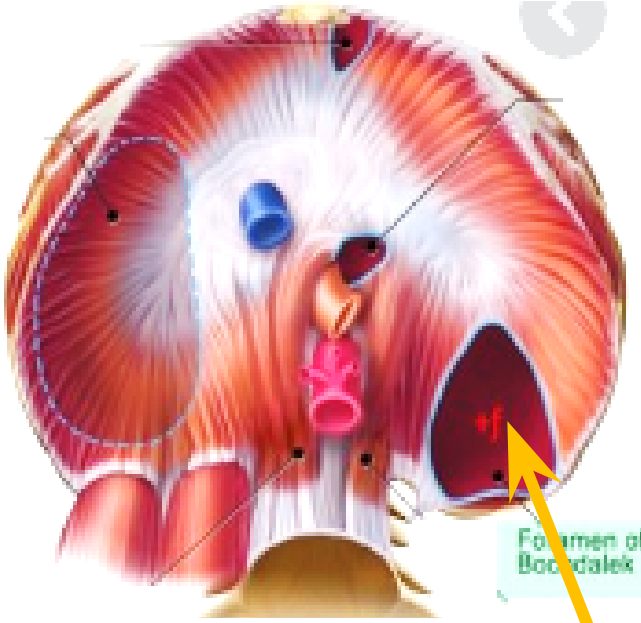

Foramen of Morgagni:
(bet. sternal & costal origins)
L1
L2
L3
L4
Foramen of Bochdalek
(Vertebro-costal triangle)

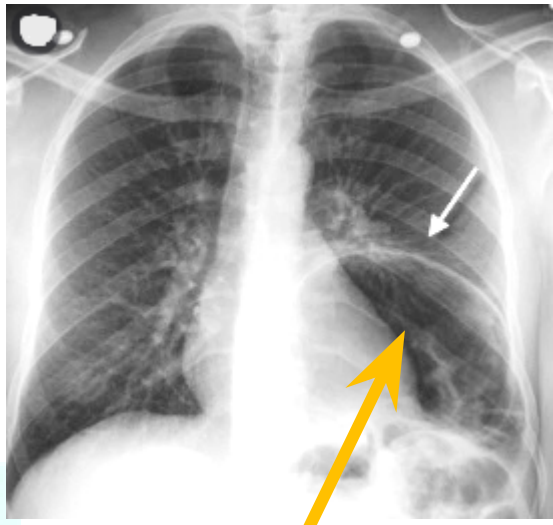




- Transmits superior epigastric vessels.
- Site of anterior (parasternal) diaphragmatic hernia.





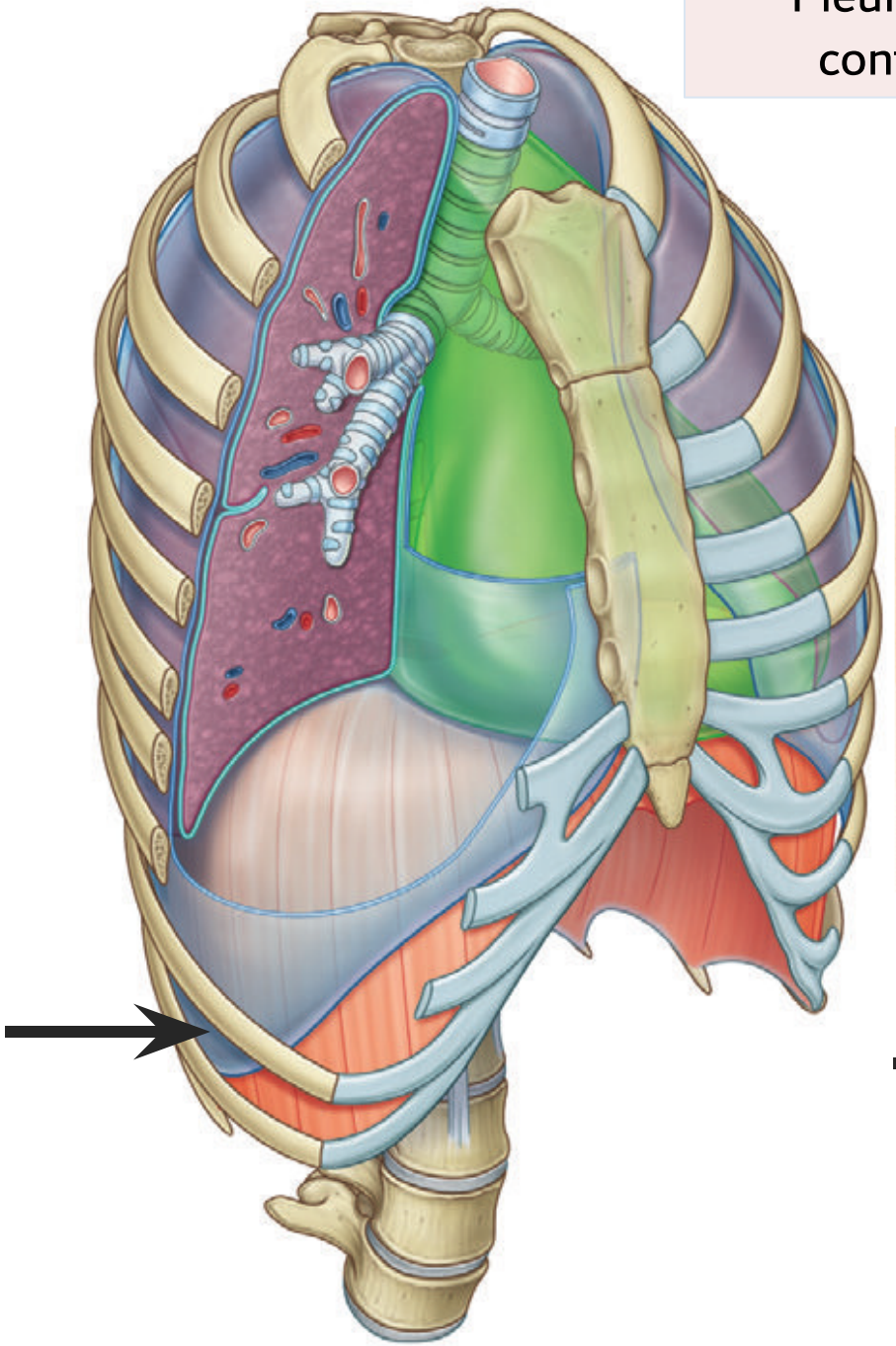


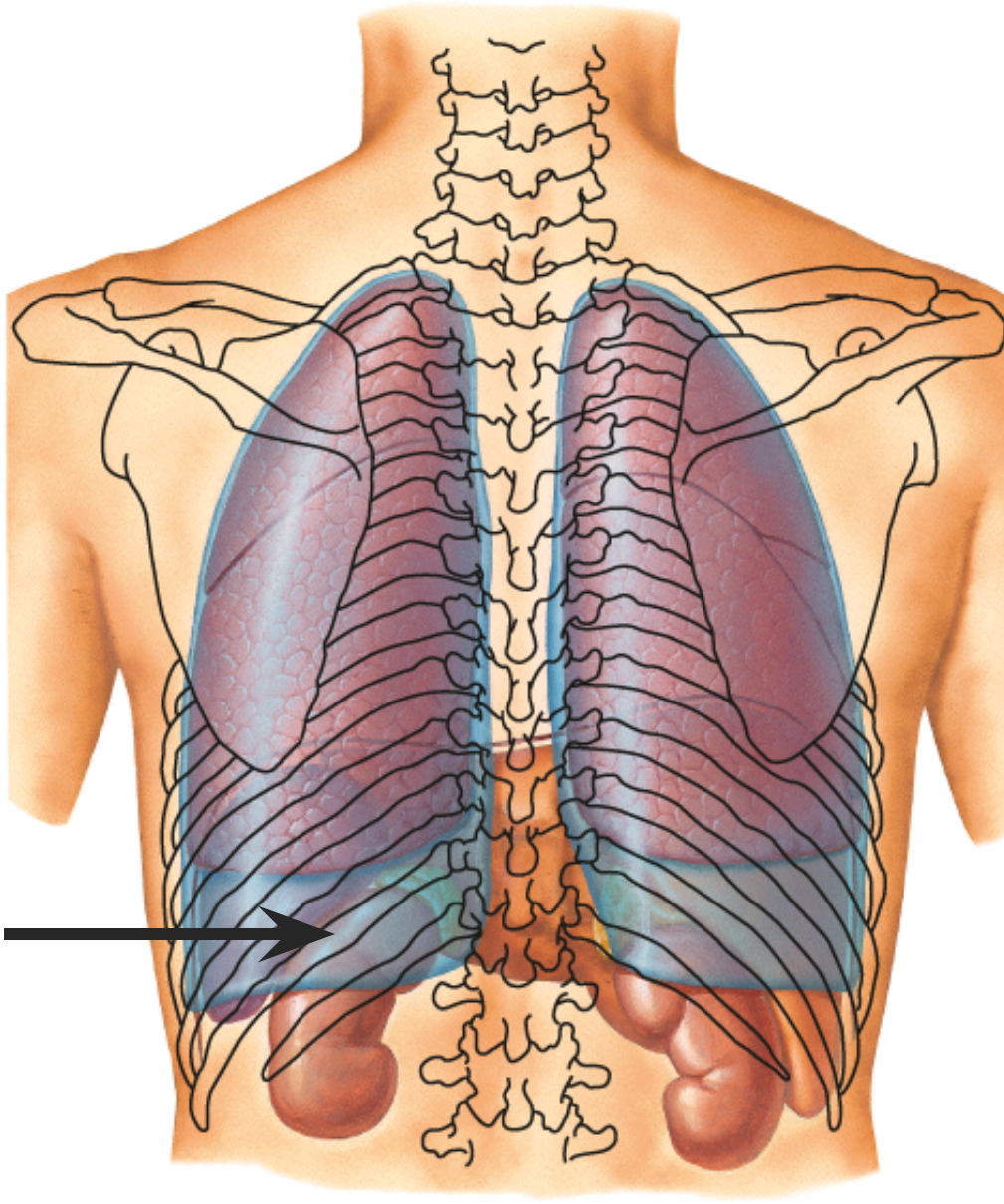
Bochdalek
Back

Hernia of Bochdalek

- Between costal & vertebral origins
- Site of posterior diaphragmatic hernia
- Mainly on the left side
- The pleura of costo-diaphragmatic recess comes in contact with posterior surface of the kidney **(Site of surgical injury).**

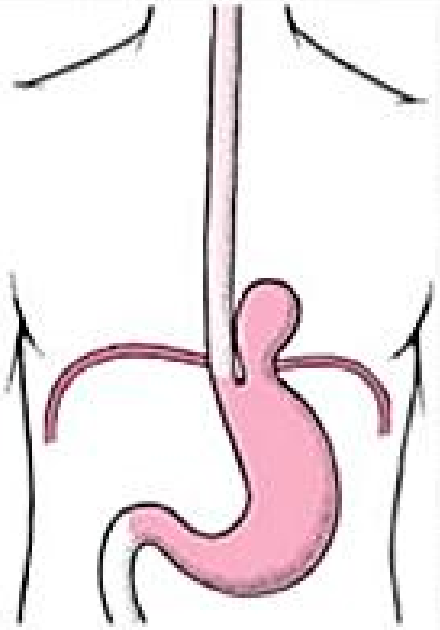
Pleura of costo-diaphragmatic recess comes in contact with posterior surface of the kidney



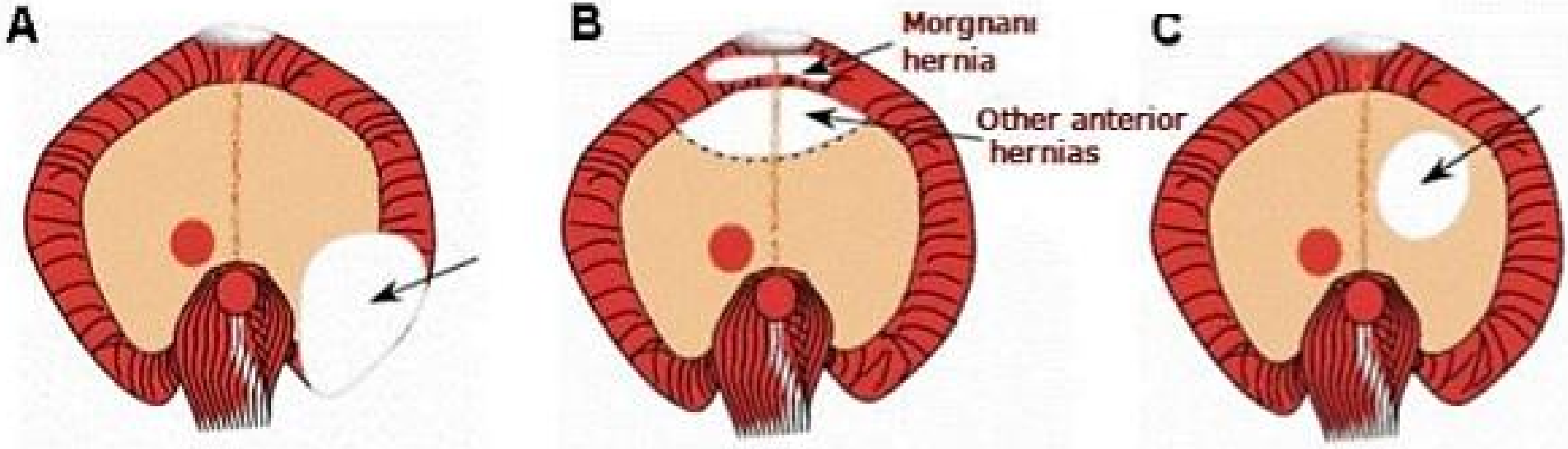


Congenital Hernia

a) Morgagni hernia or Retrosternal hernia
b) Bochdalek hernia or Posterolateral
c) Central hernia



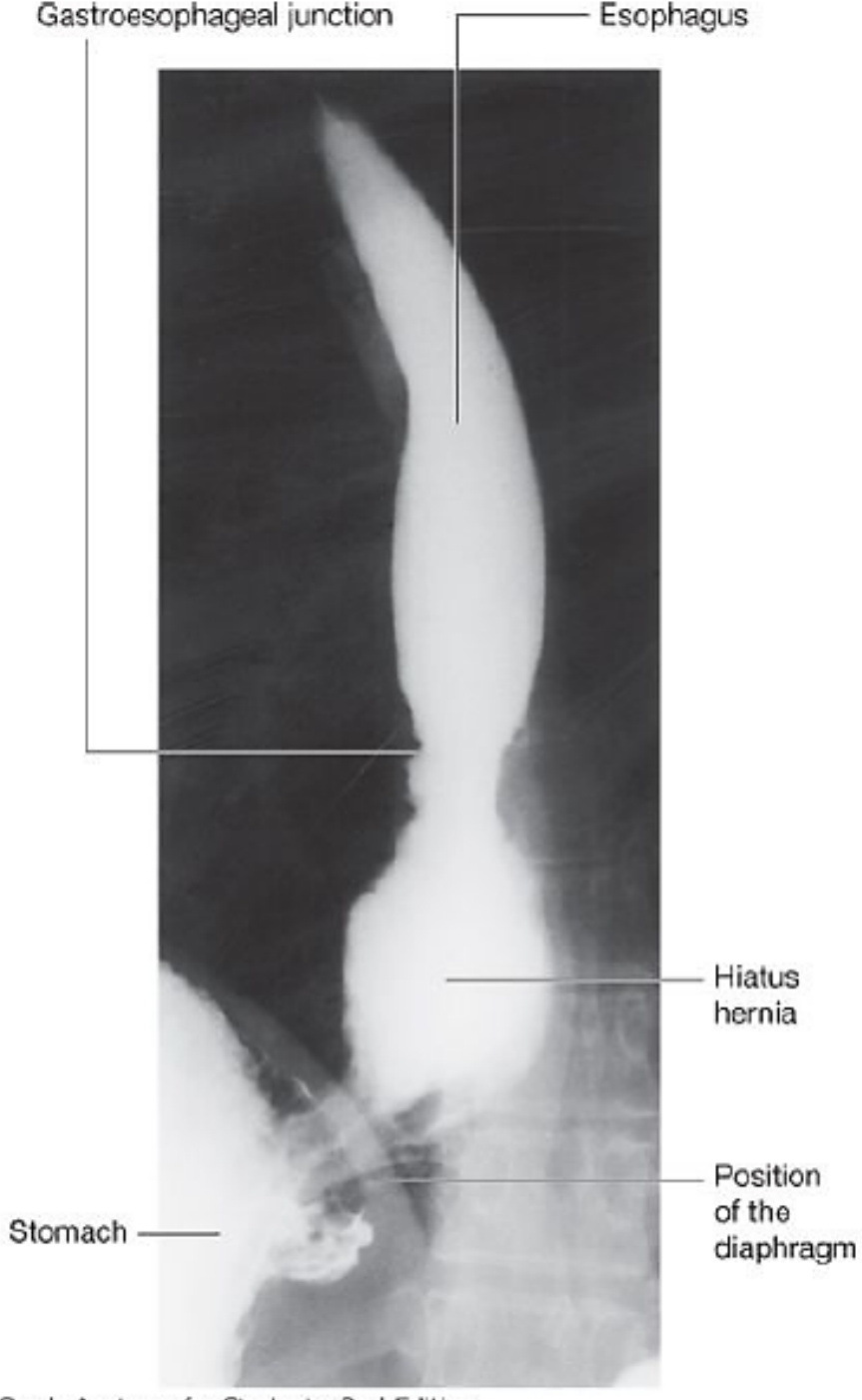
Paraesophageal Hiatus Hernia



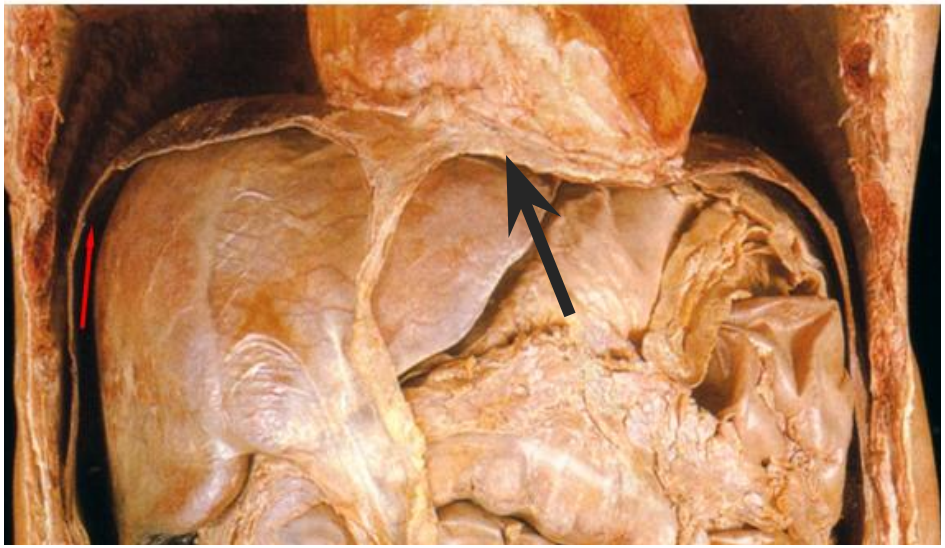
Bochdalek hernia

Morgnani hernia and other anterior hernias

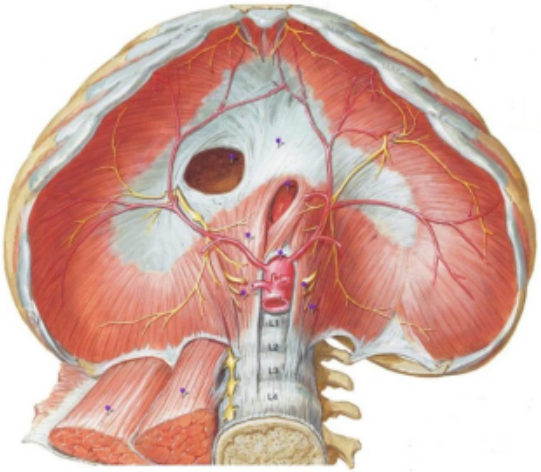
Central hernia

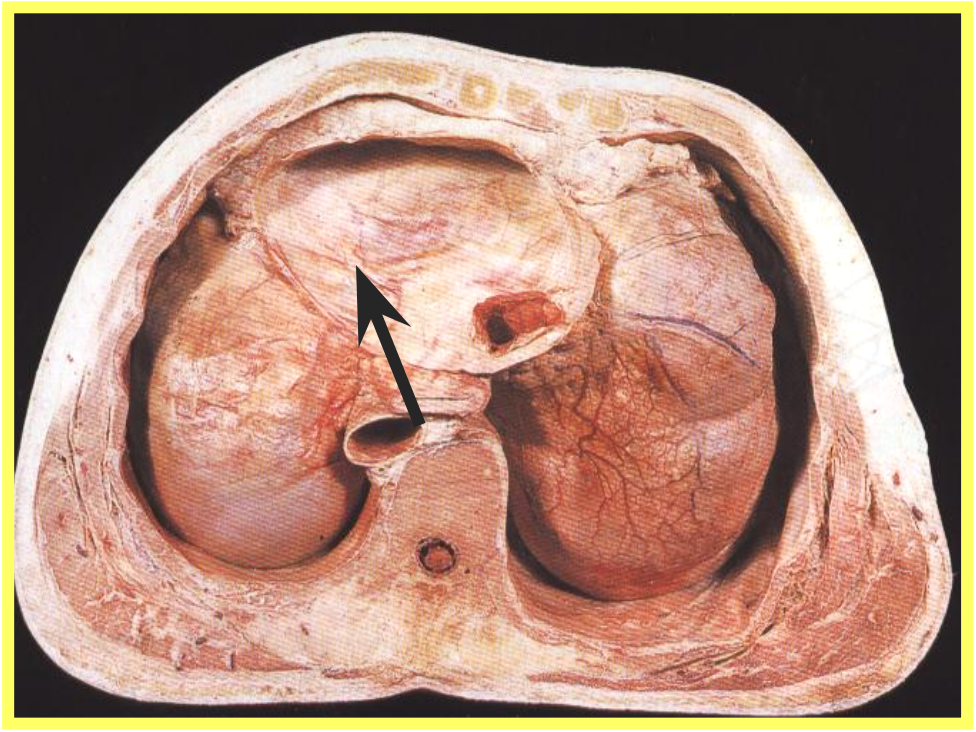


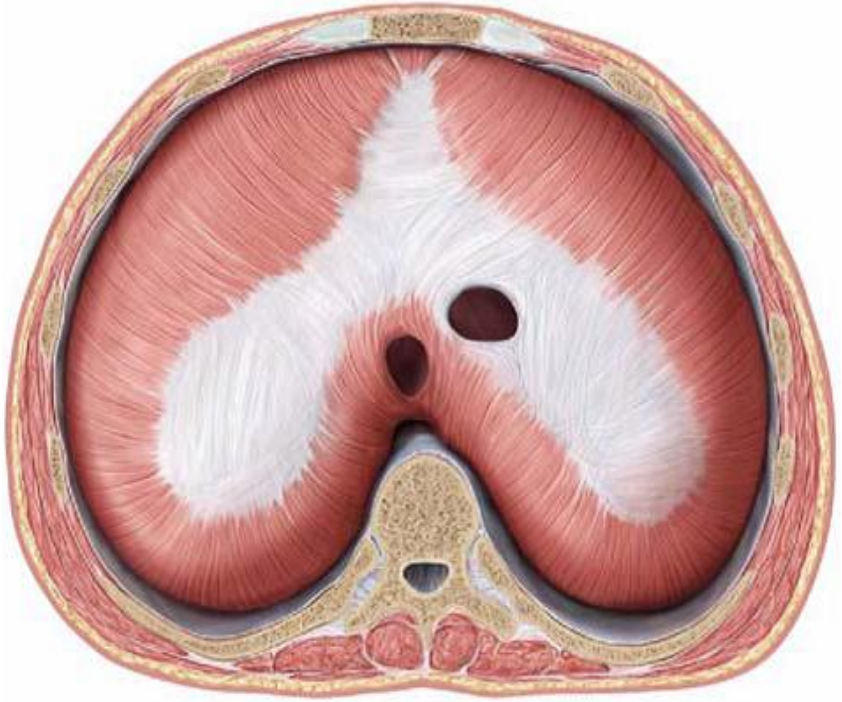
Drake: Gray's Anatomy for Students, 2nd Edition.



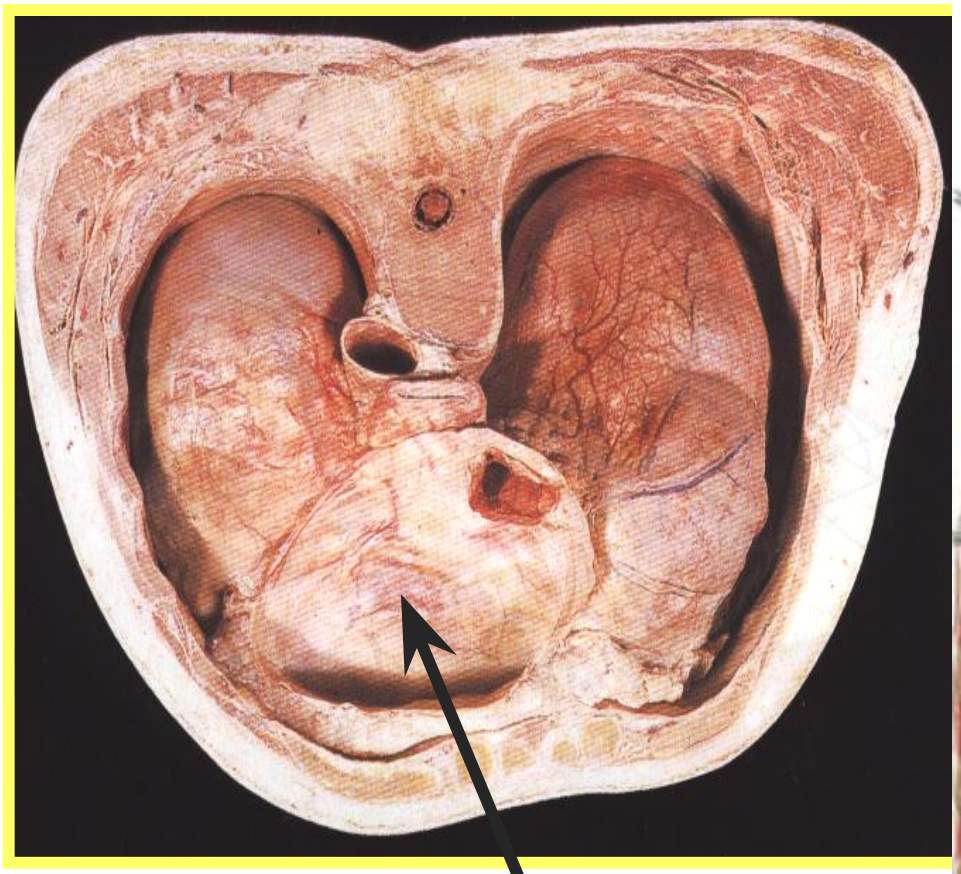


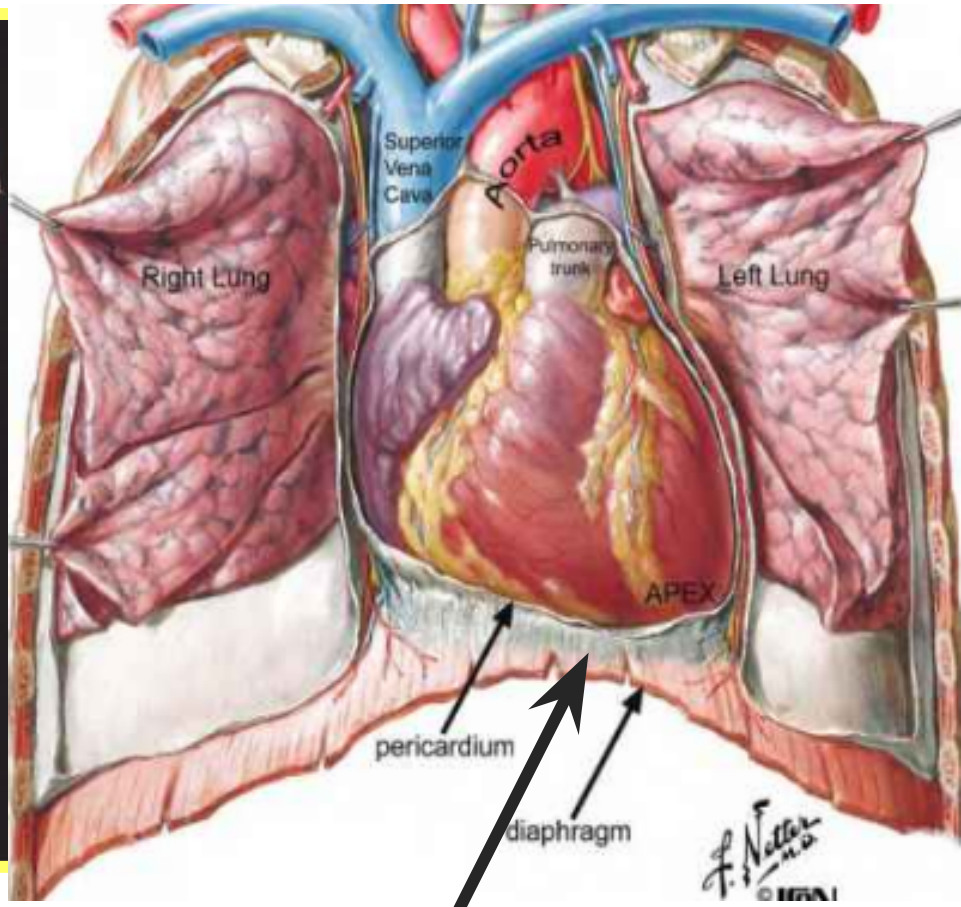




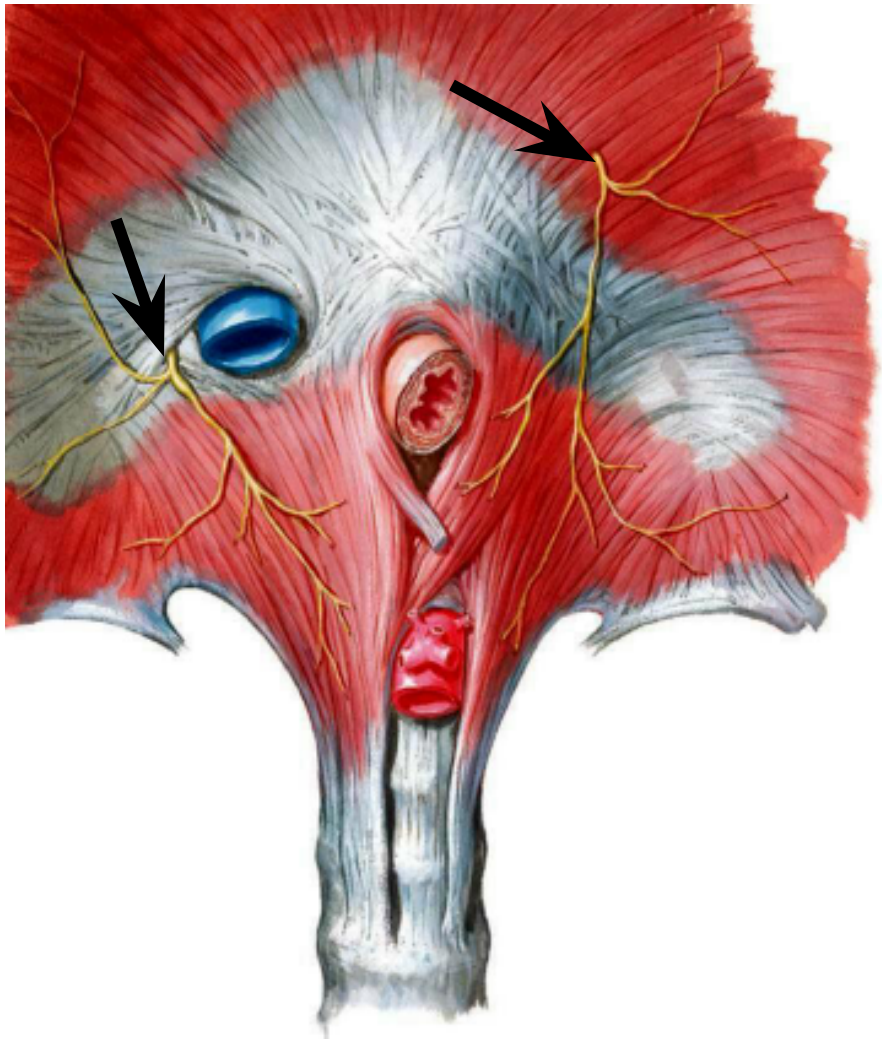


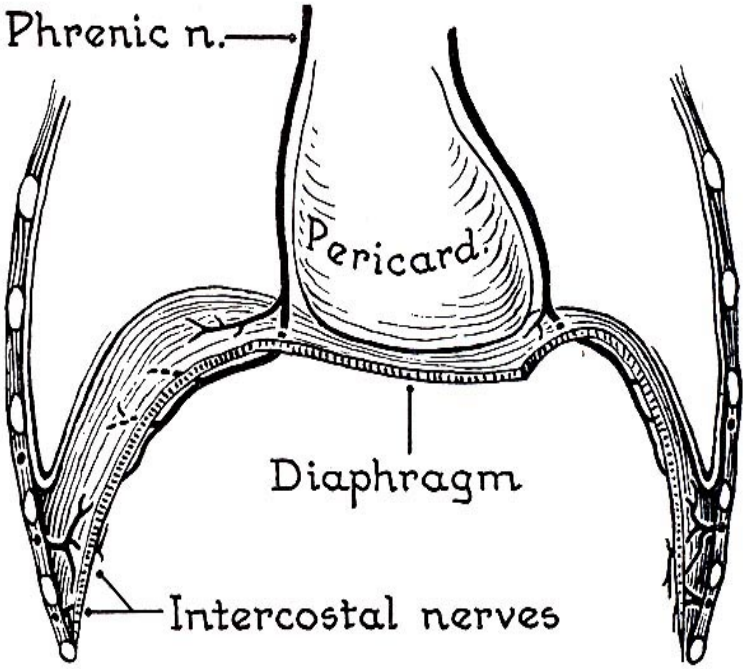
Insertion: No bony insertion----- Central Tendon----- Trifoliate---- 1 median and 2 lateral folia
Median lobe is related to the pericardium and heart.

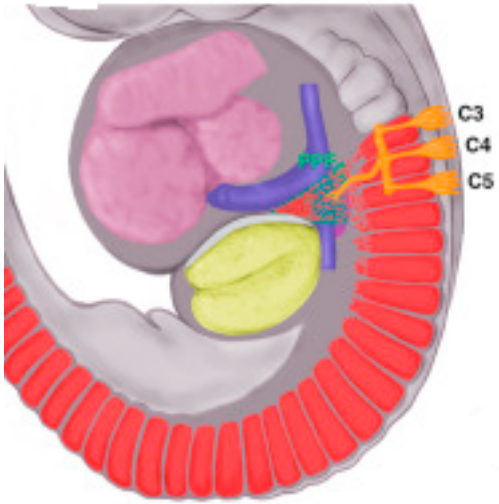




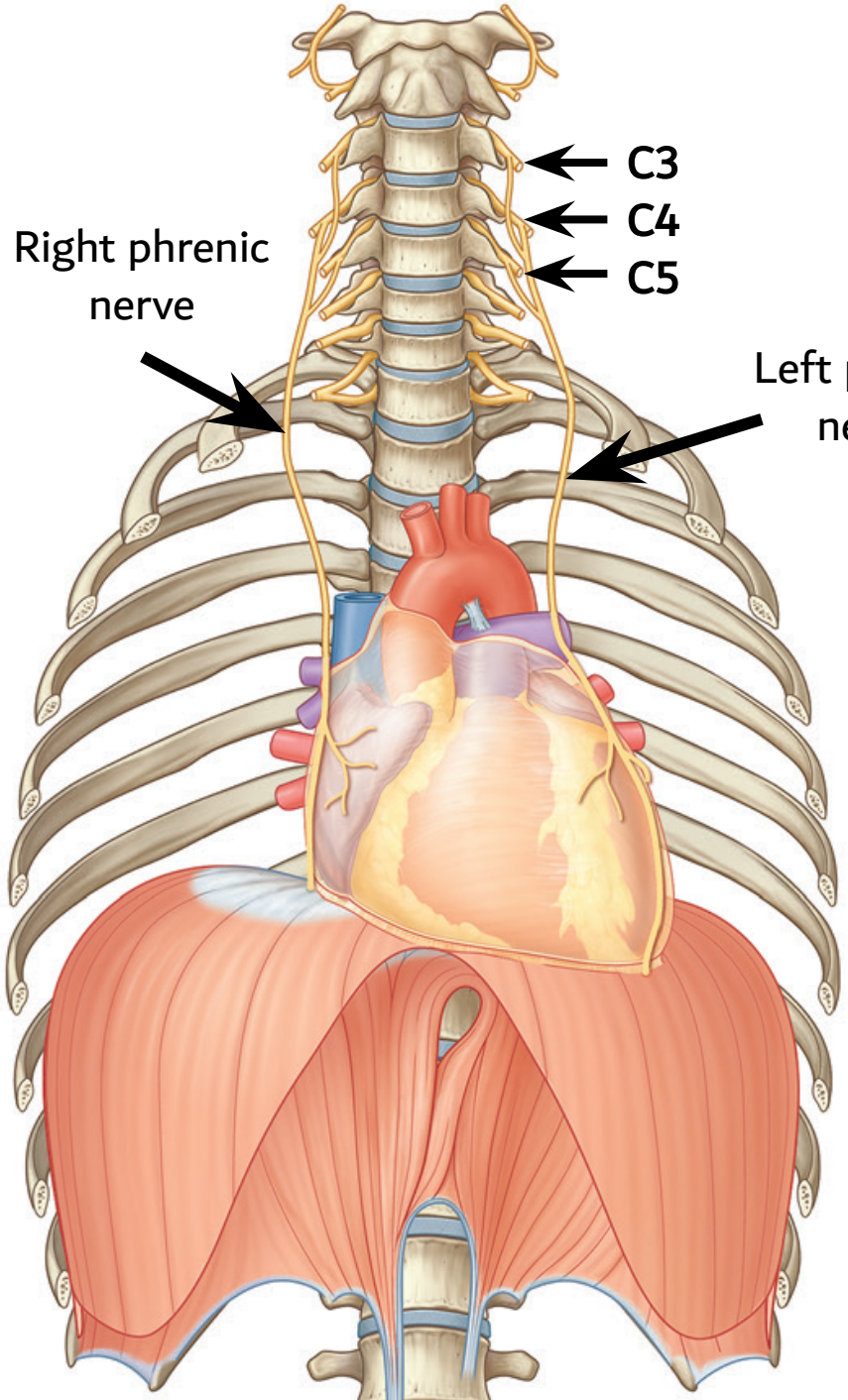
The median lobe is related to pericardium and heart.

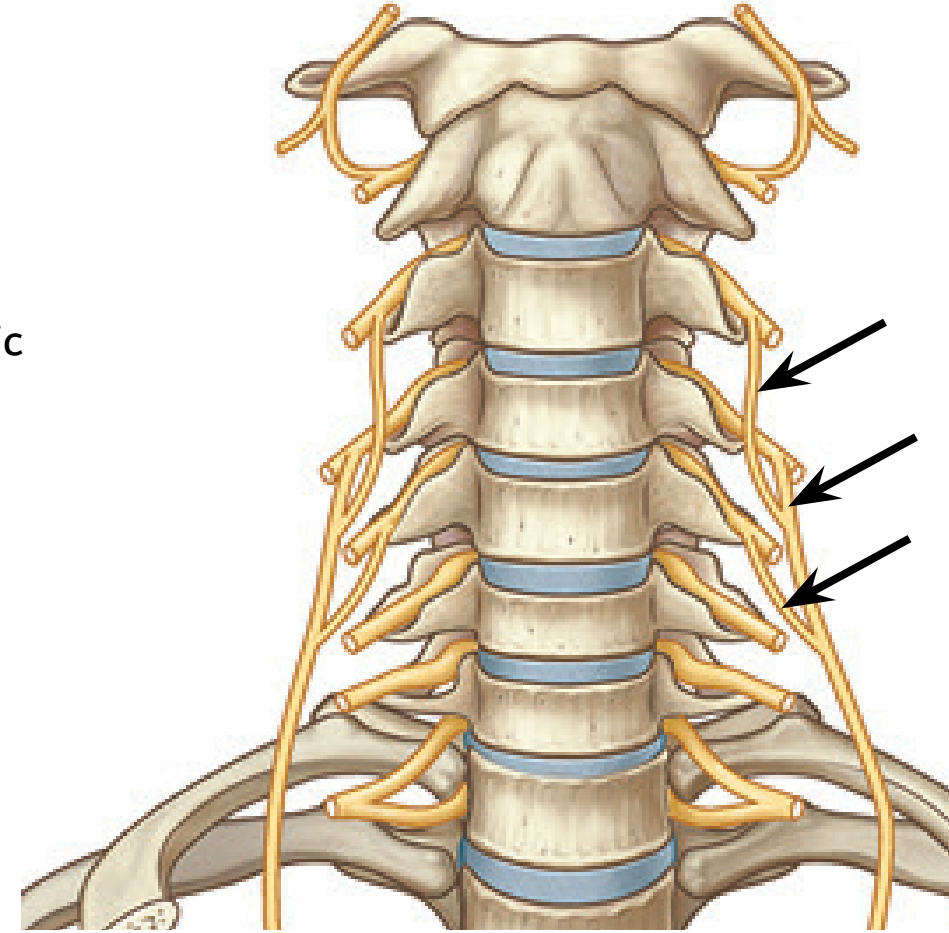




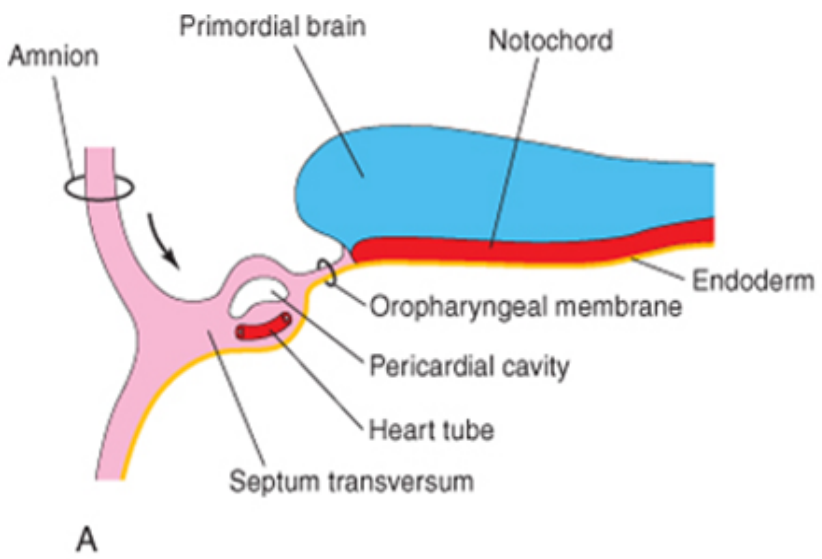


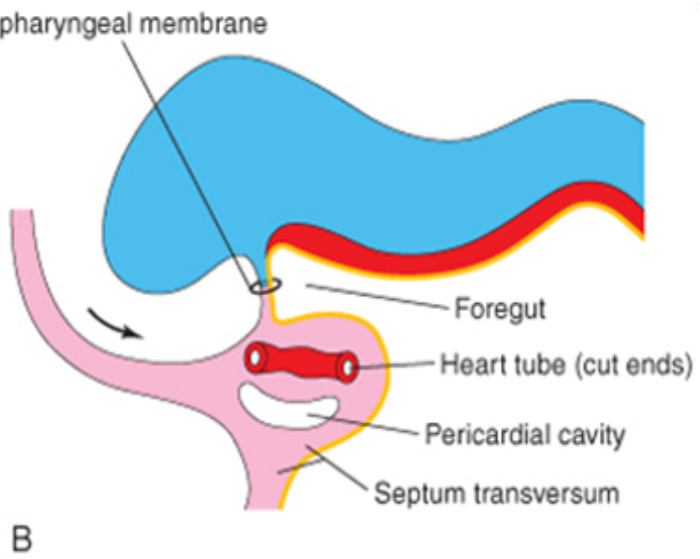
Nerve Supply: Phrenic Nerve ---- Root value????-----pass through------ Motor or sensory???
Undersurface ----- Folding
Sensory: lower 6 thoracic spinal nerves

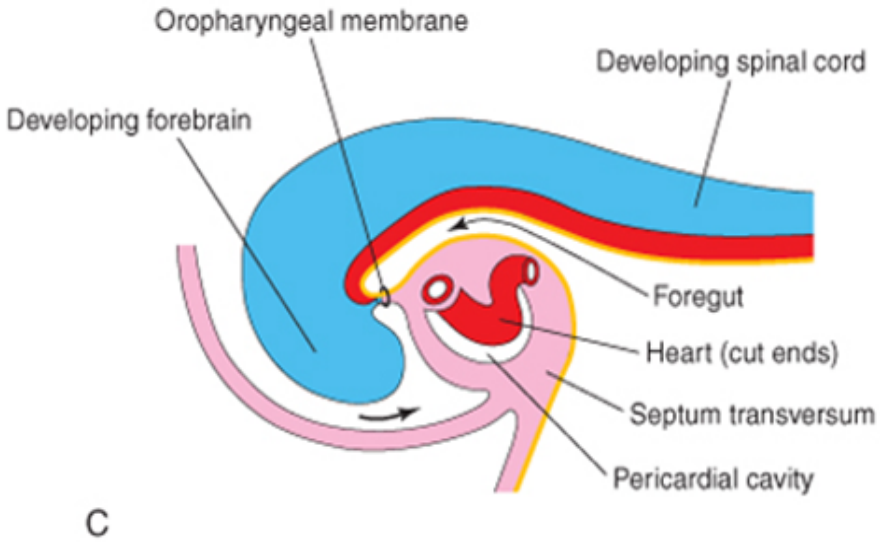


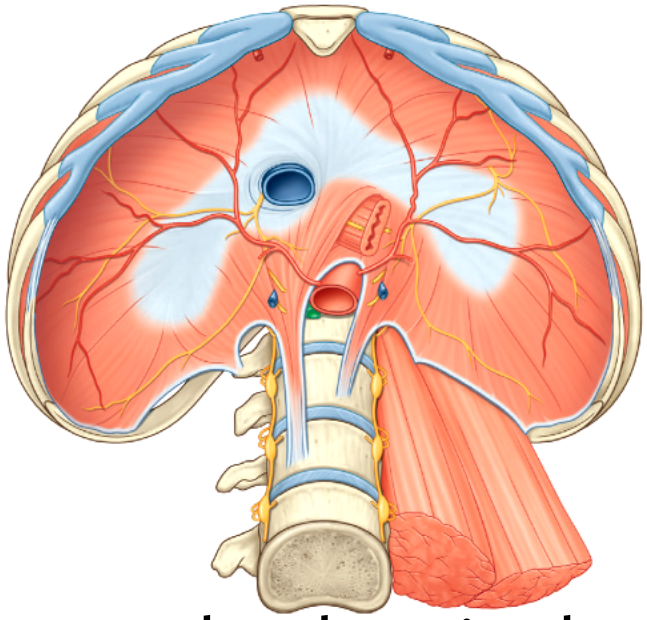


Ventral primary rami







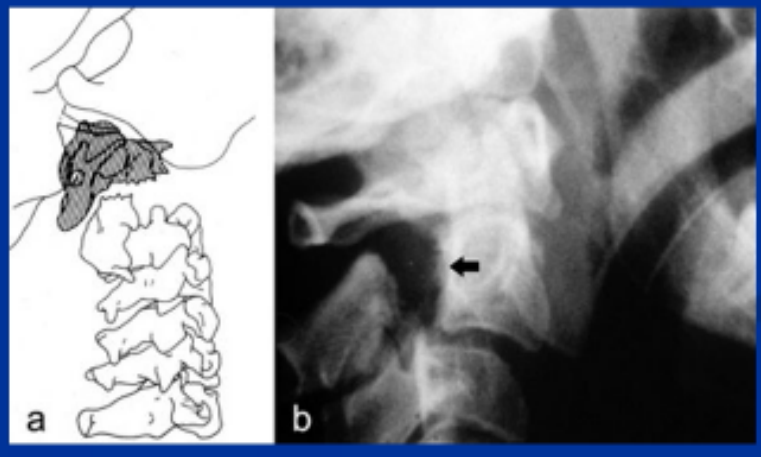


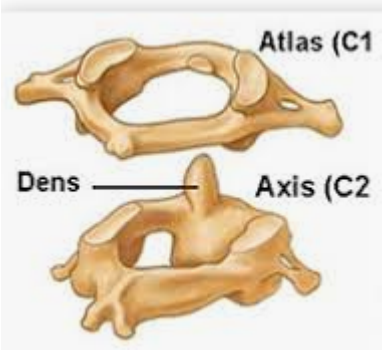
It arises in the neck because the diaphragm develops in the neck and then descends pulling the phrenic nerves with it.



Judicial Hanging

- Fracture through pedicle of C2 (axis) by hyperextension – subluxation of C1/C2 and/or C2/C3 leads to cord trauma and death

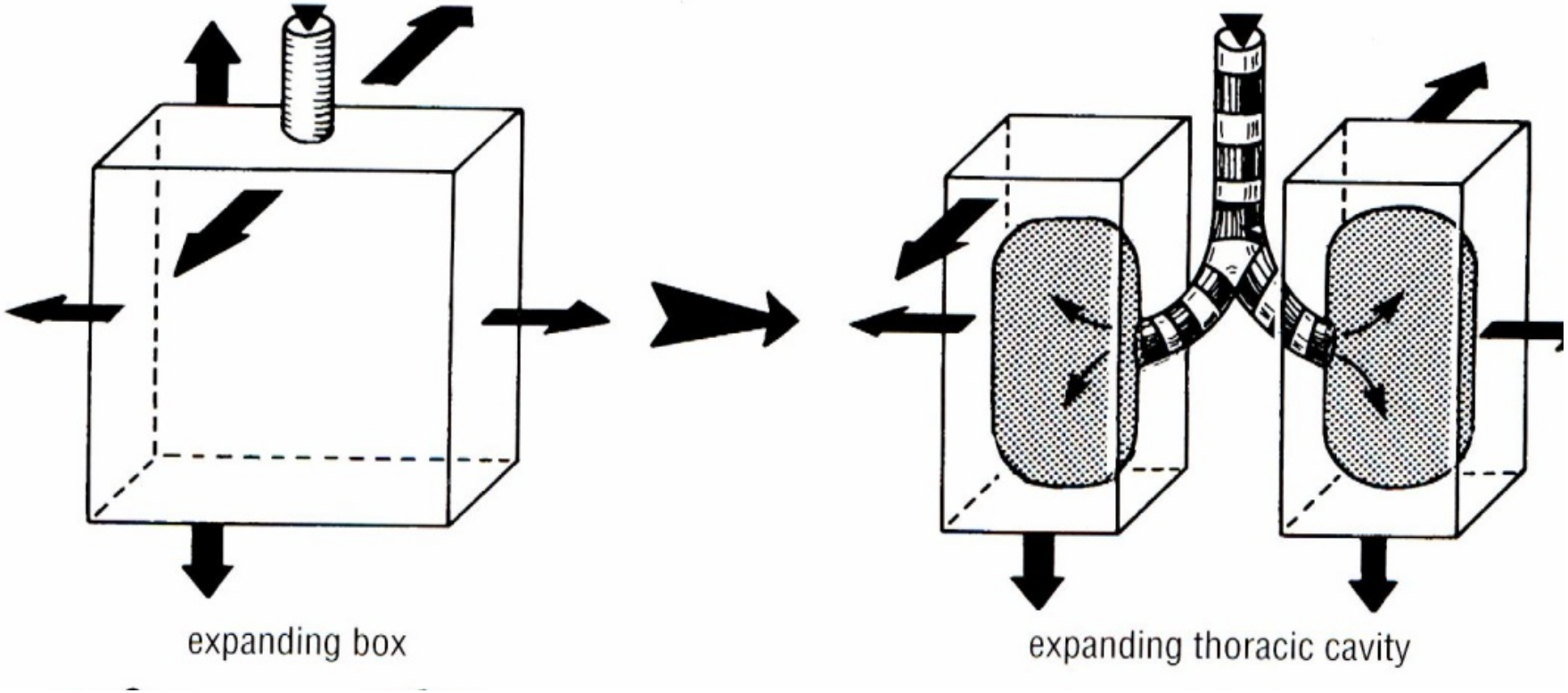




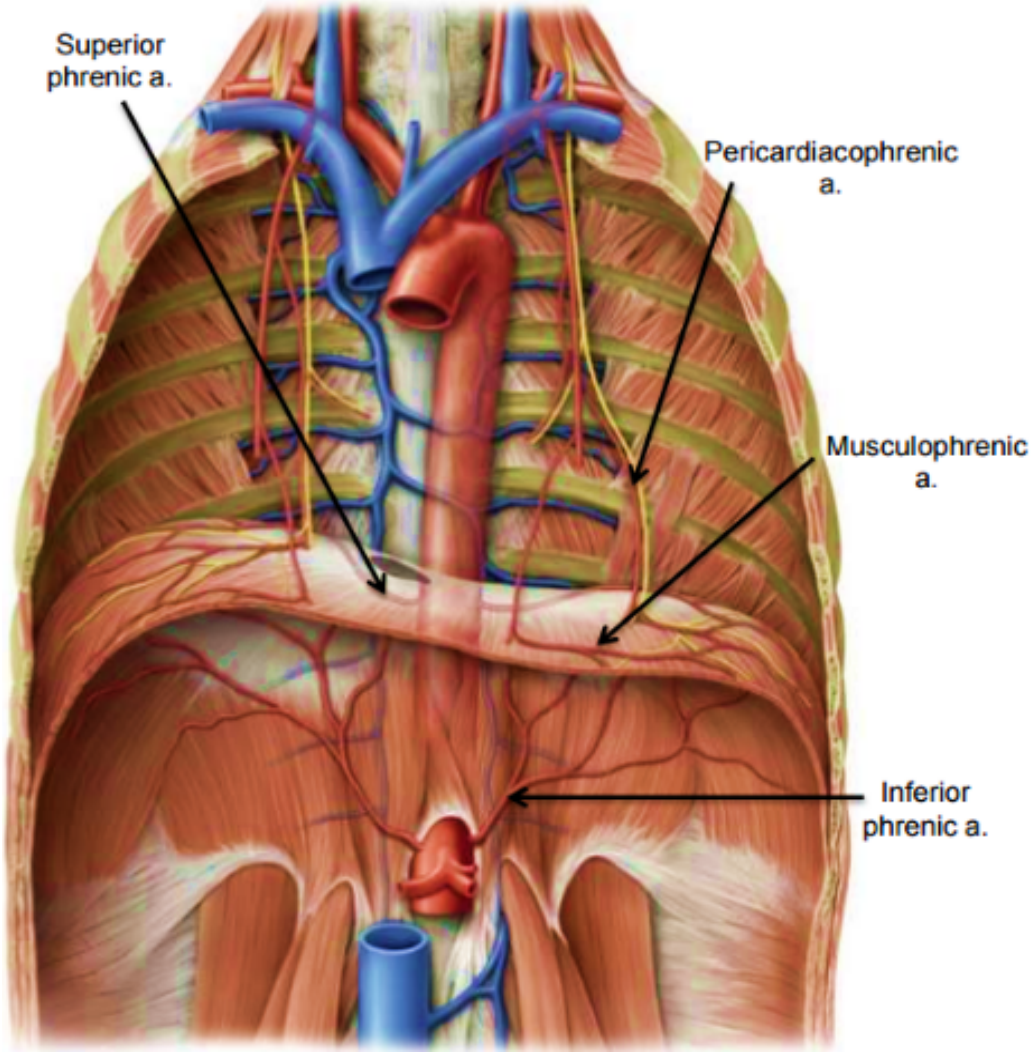
C three, four, five ---------- keep the man alive

- ***ACTION***: **The main muscle of Respiration**

1- Its contraction leads to its descent & increase in vertical diameter of the thoracic cavity.

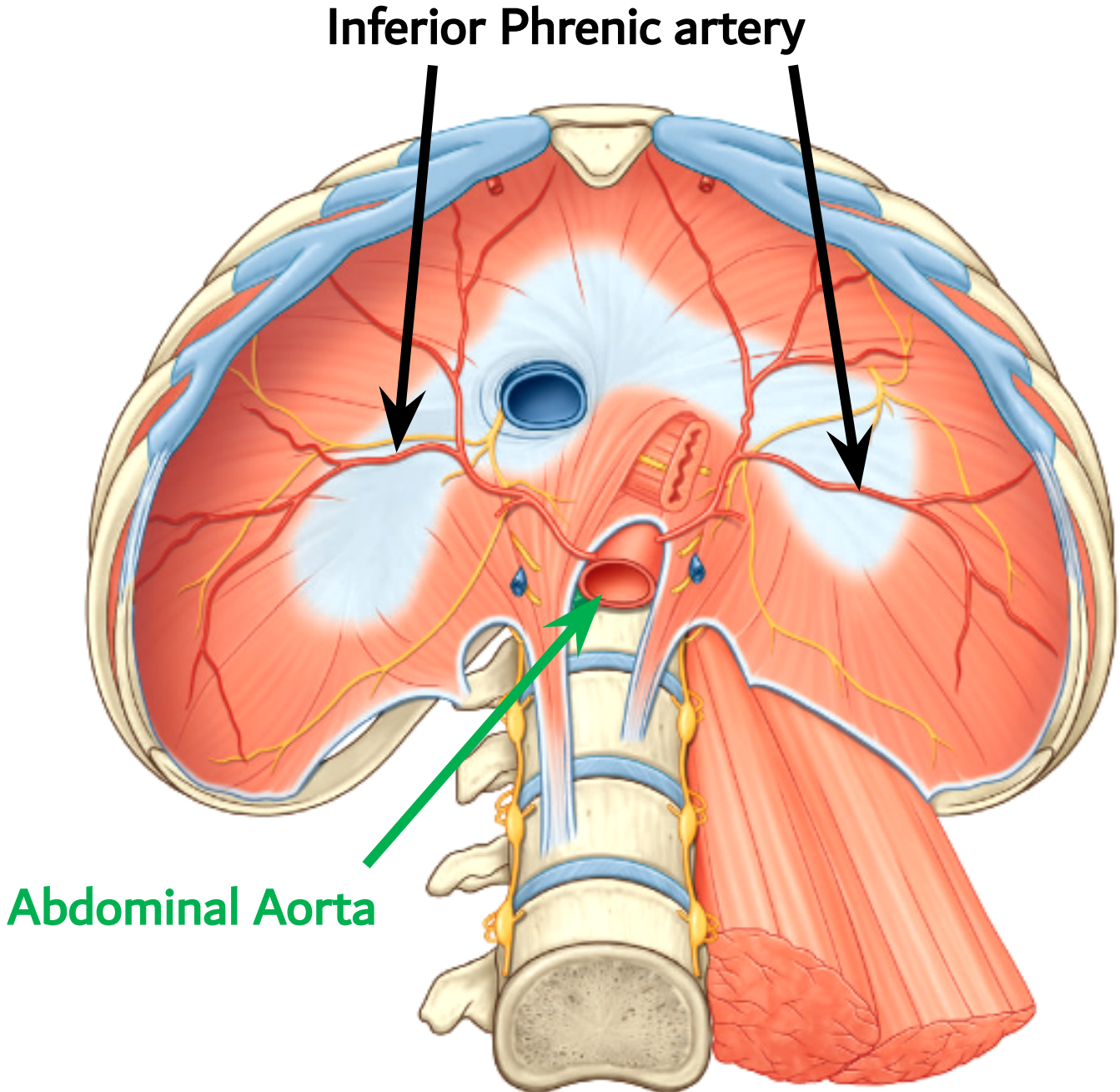


2- Increase the intra-abdominal pressure in different circumstances as; parturition, coughing, defecation and micturation

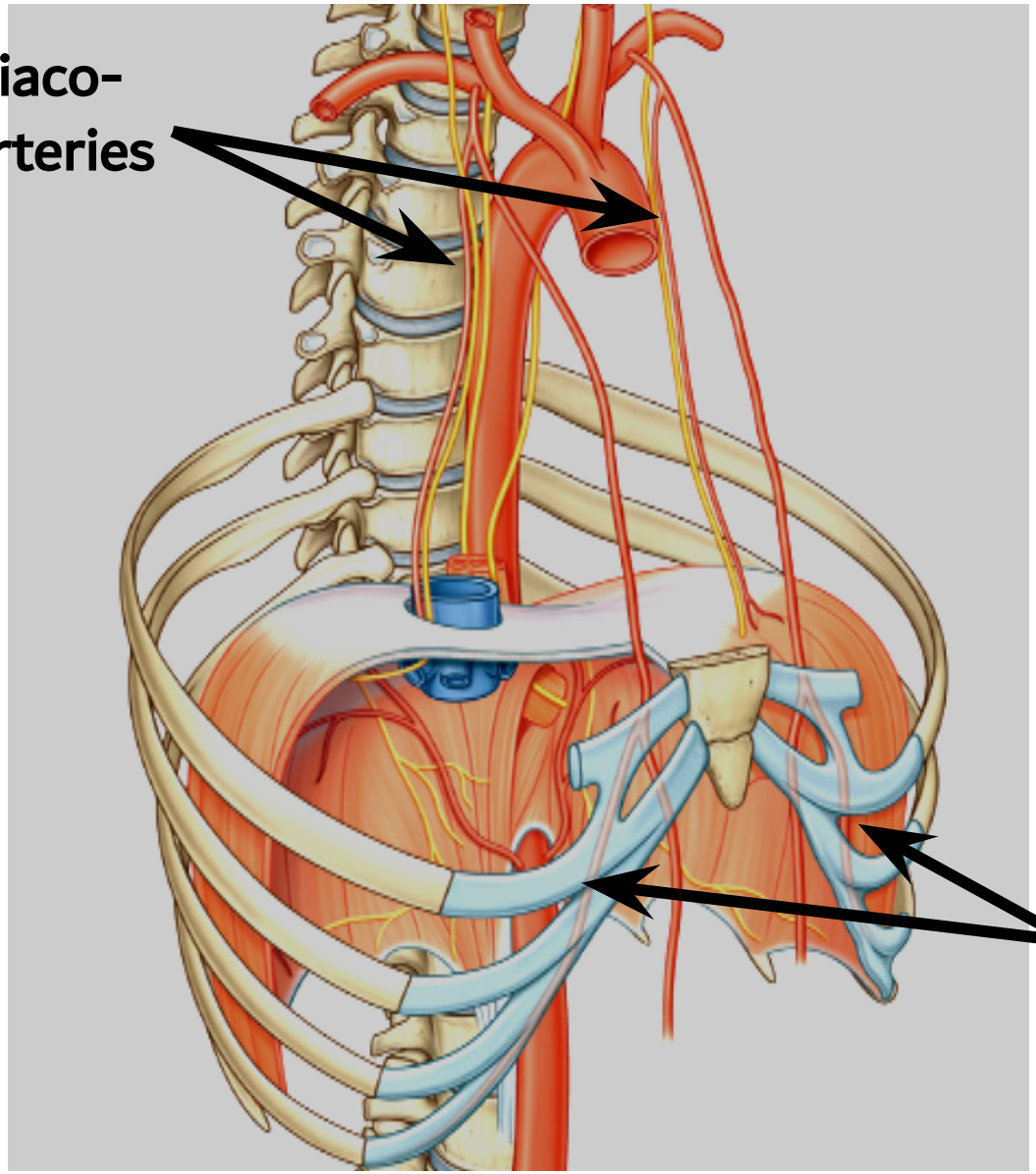


Arterial supply of the diaphragm:

- Superior Phrenic artery: from thoracic aorta.
- Lower intercostal arteries: from thoracic aorta.
- Inferior Phrenic artery: from abdominal aorta.
- Musculo-phrenic artery: from internal thoracic artery.
- Pericardio-phrenic artery: from internal thoracic artery.


Inferior Phrenic artery
Abdominal Aorta

Pericardiaco-
phrenic arteries



Musculophrenic-
phrenic

Thoracic surface

- Internal thoracic artery via:

1. Pericardiacophrenic arteries.
2. Musculophrenic arteries.

- Thoracic aorta via:

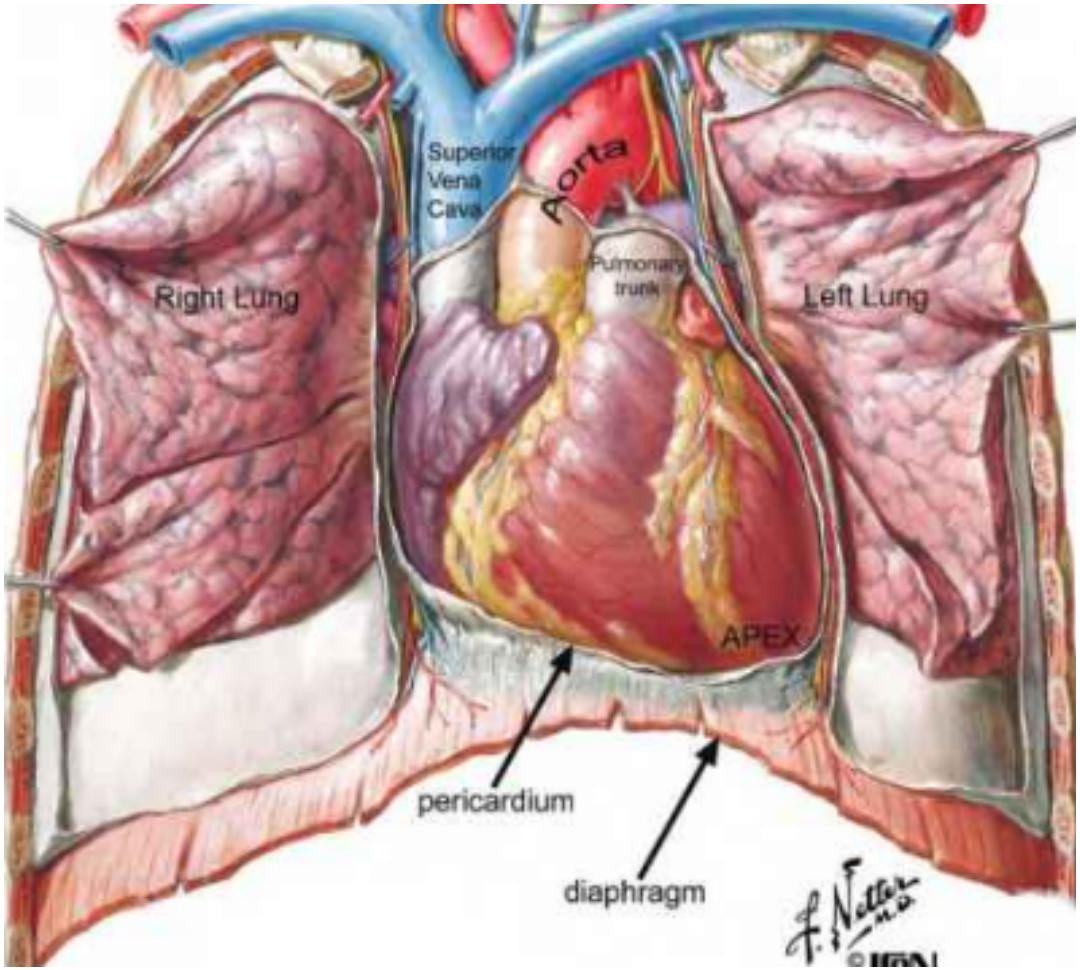
3. Superior phrenic arteries.

Abdominal surface

- Abdominal aorta via

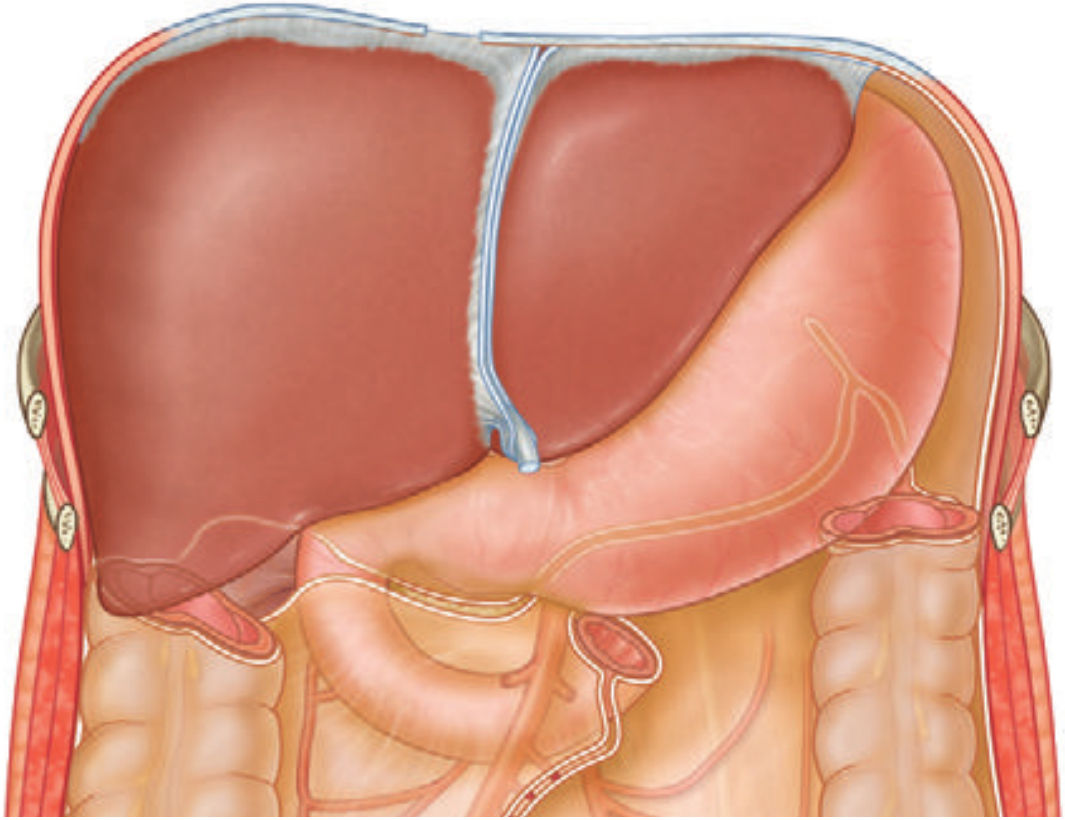
1. Inferior phrenic arteries

Relations of Superior surface



- Right copula is related to right pleura and lung.
- Left copula is related to left pleura and lung.
- Central tendon is related to base of heart and pericardium.

Relations of inferior surface



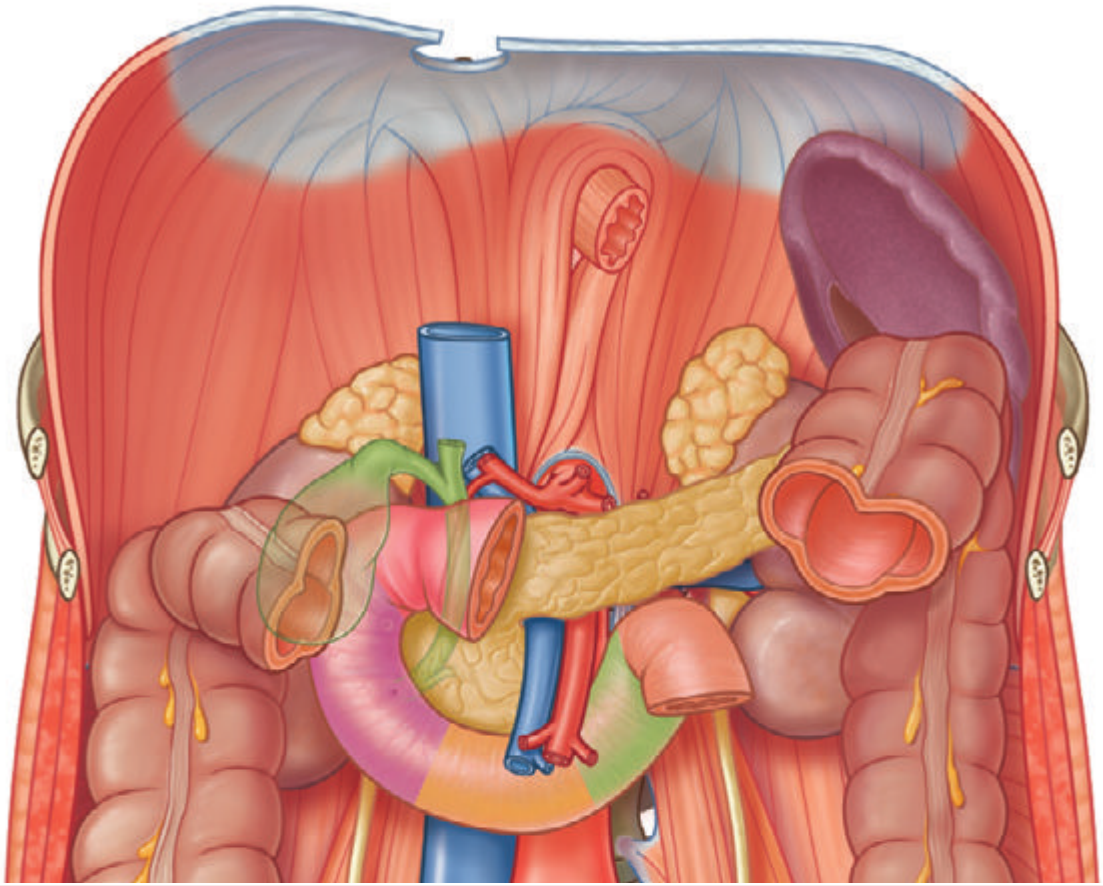
On the right:

- Right lobe of the liver.
- Right kidney and right suprarenal gland.

On the left:

- Left lobe of the liver.
- Left kidney and left suprarenal gland.
- Fundus of stomach and spleen.

Relations of inferior surface



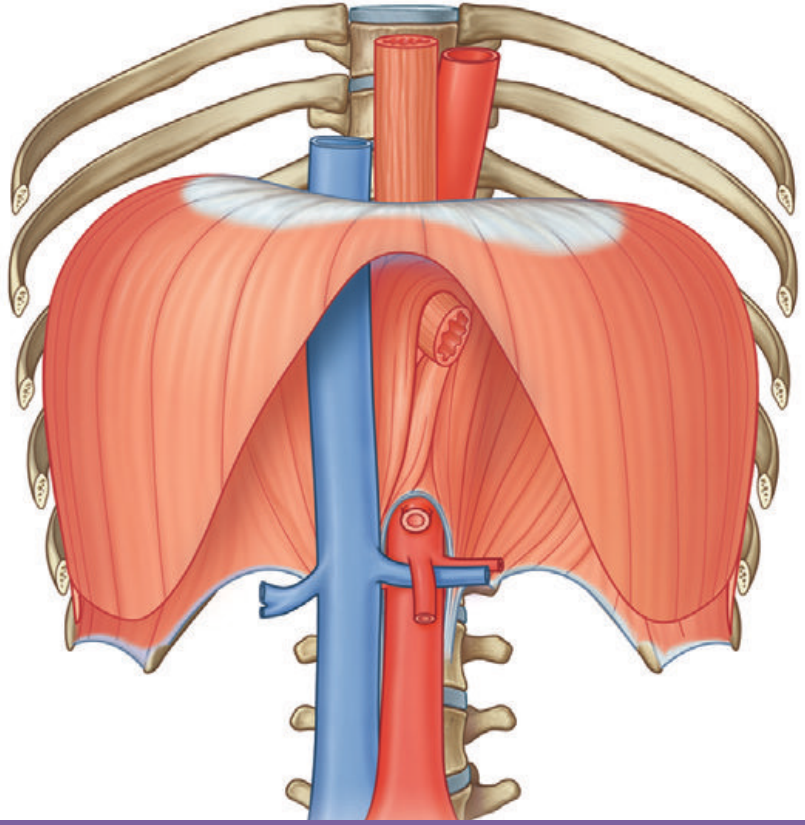
On the right:

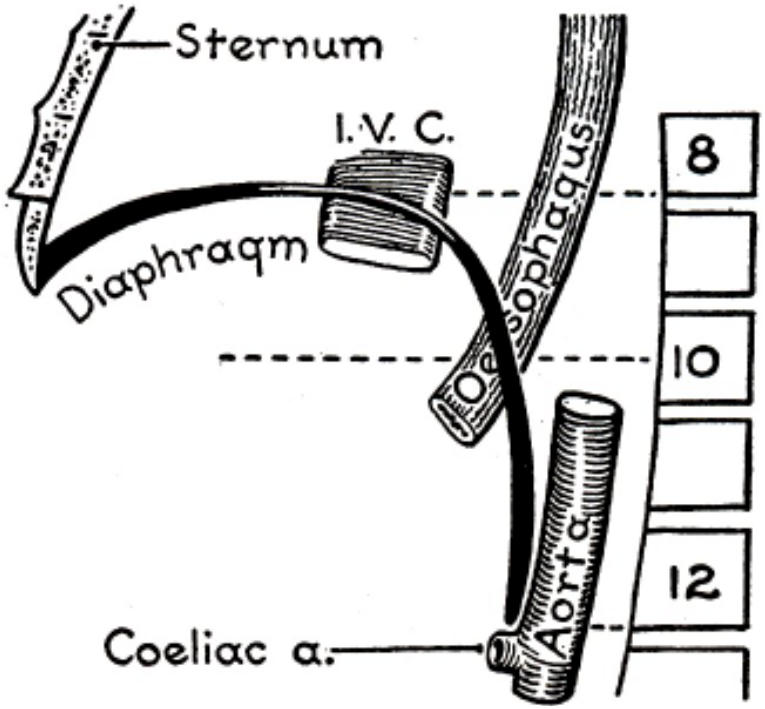
- Right lobe of the liver.
- Right kidney and right suprarenal gland.

On the left:

- Left lobe of the liver.
- Left kidney and left suprarenal gland.
- Fundus of stomach and spleen.

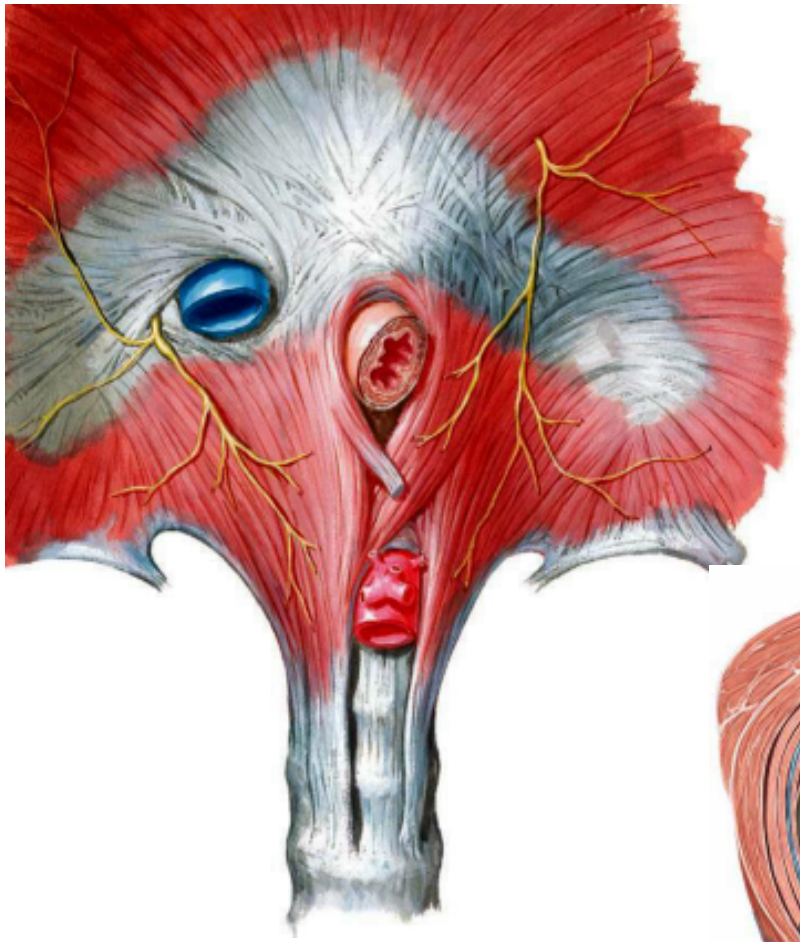
Major openings of diaphragm

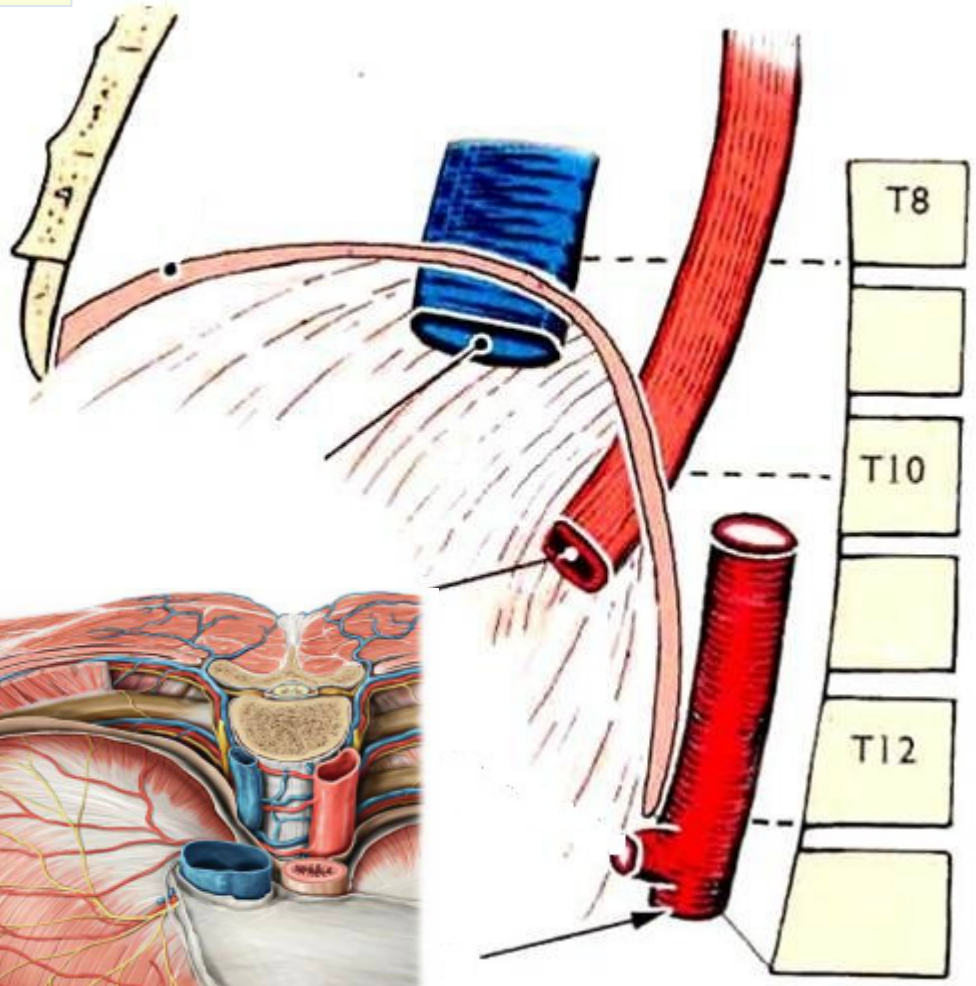


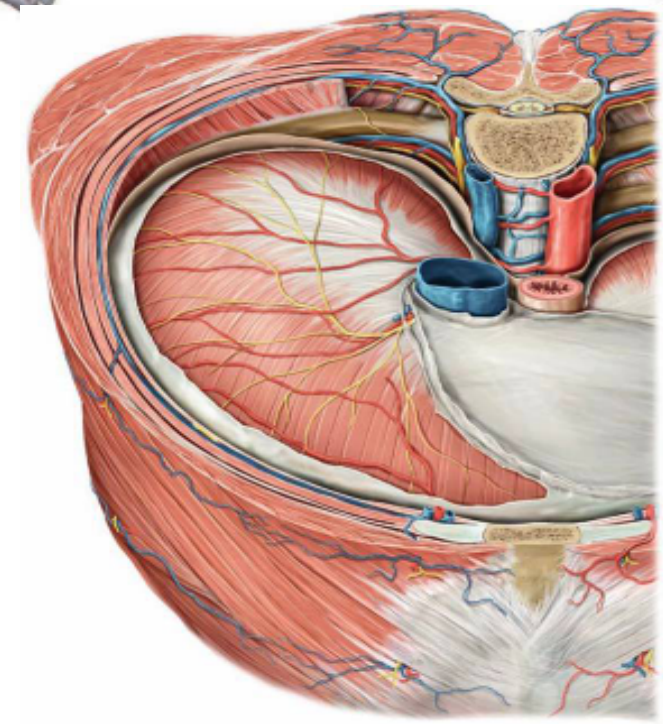


- *Voice*= *V*ena cava opening = T8
- *Of*= *O*esophageal opening= T10
- *America*= *A*ortic opening= T12

Levels

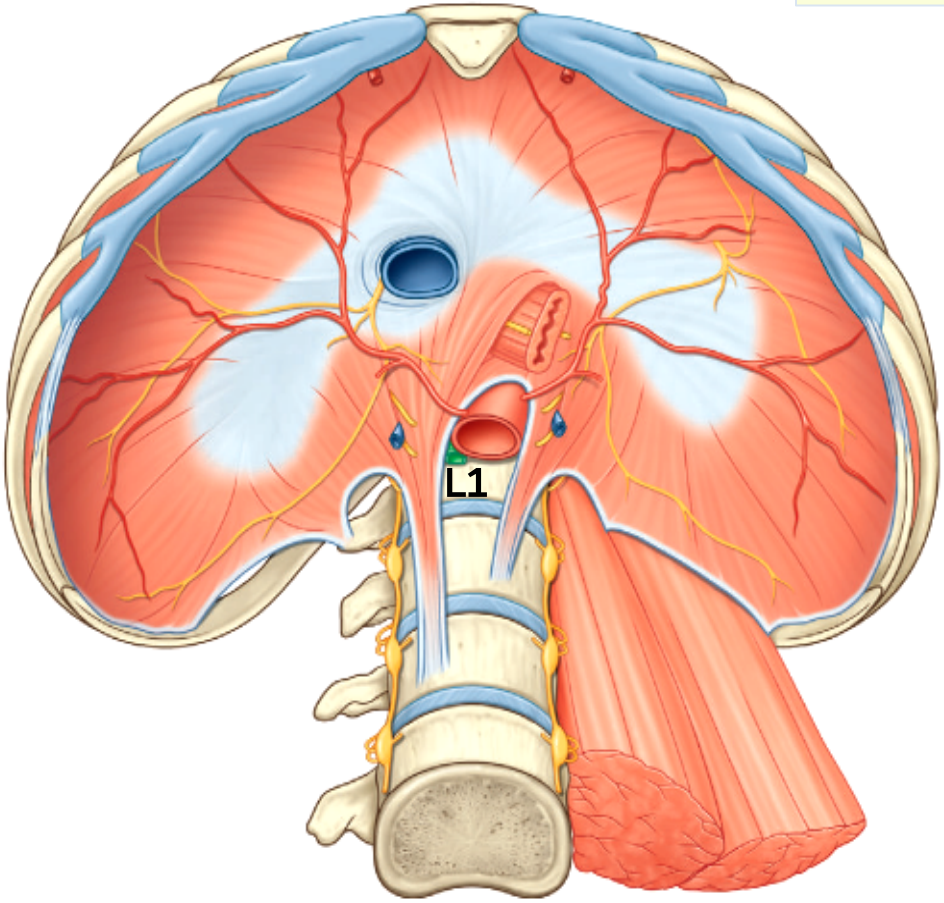


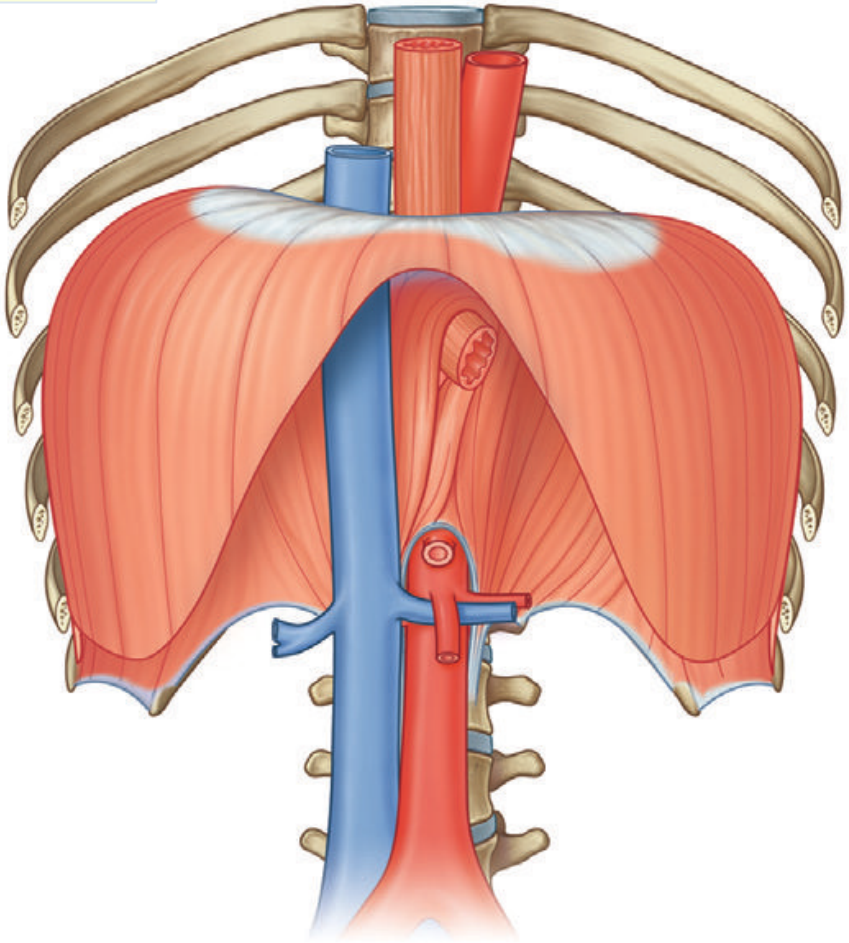




- I.V.C+ right Phrenic nerve
- Esophagus +??
- Aorta+ VAD

Position



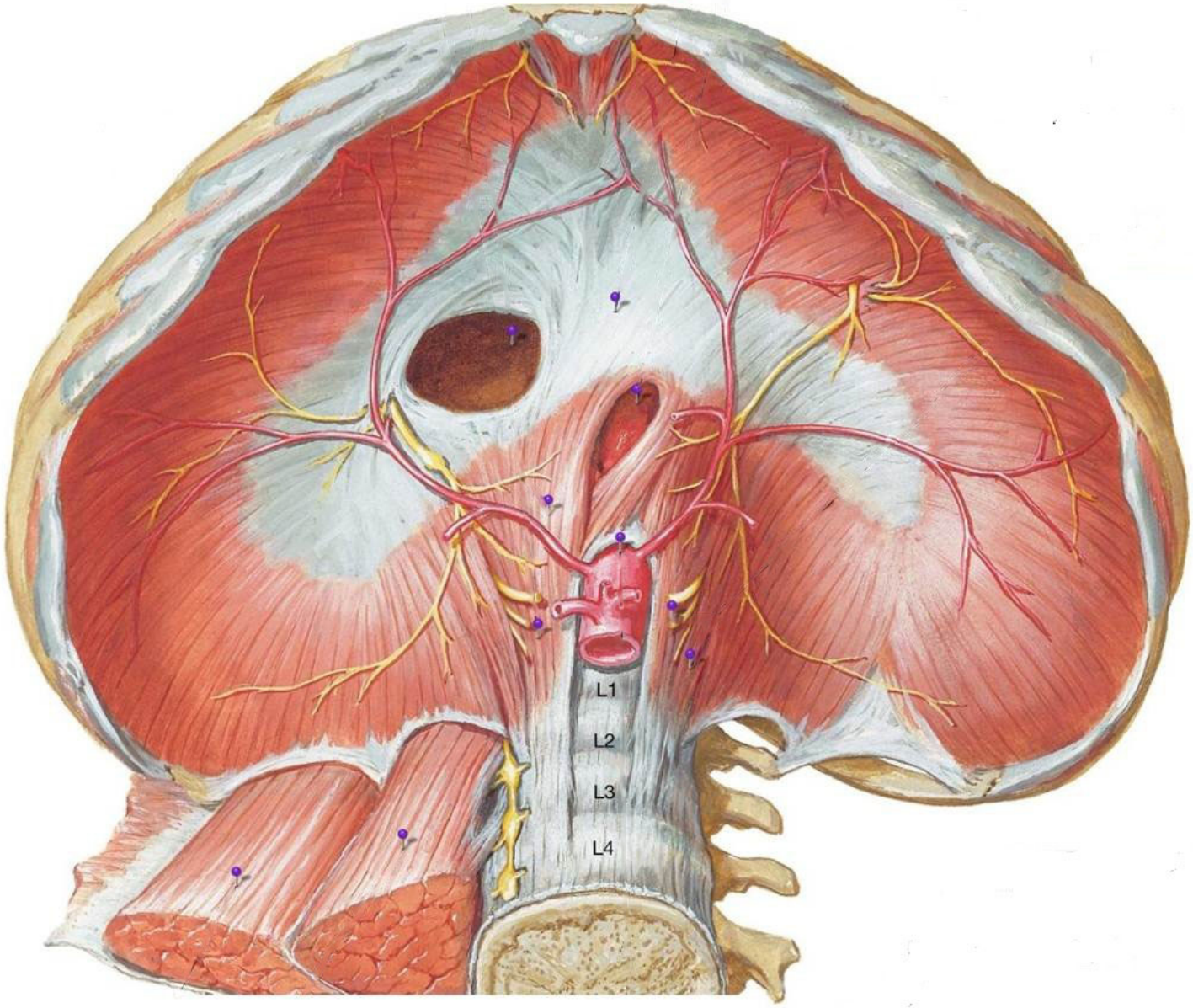


Why arcuate ligaments???

Vena cava opening= 1 inch to right of middle line, in central tendon.

Oesophageal opening= 1 inch to left of middle line & surrounded by fleshy fibres of right crus.

Aortic opening= In the middle line & behind median arcuate ligament.



Vena cava opening= 1 inch to right of middle line, in central tendon.

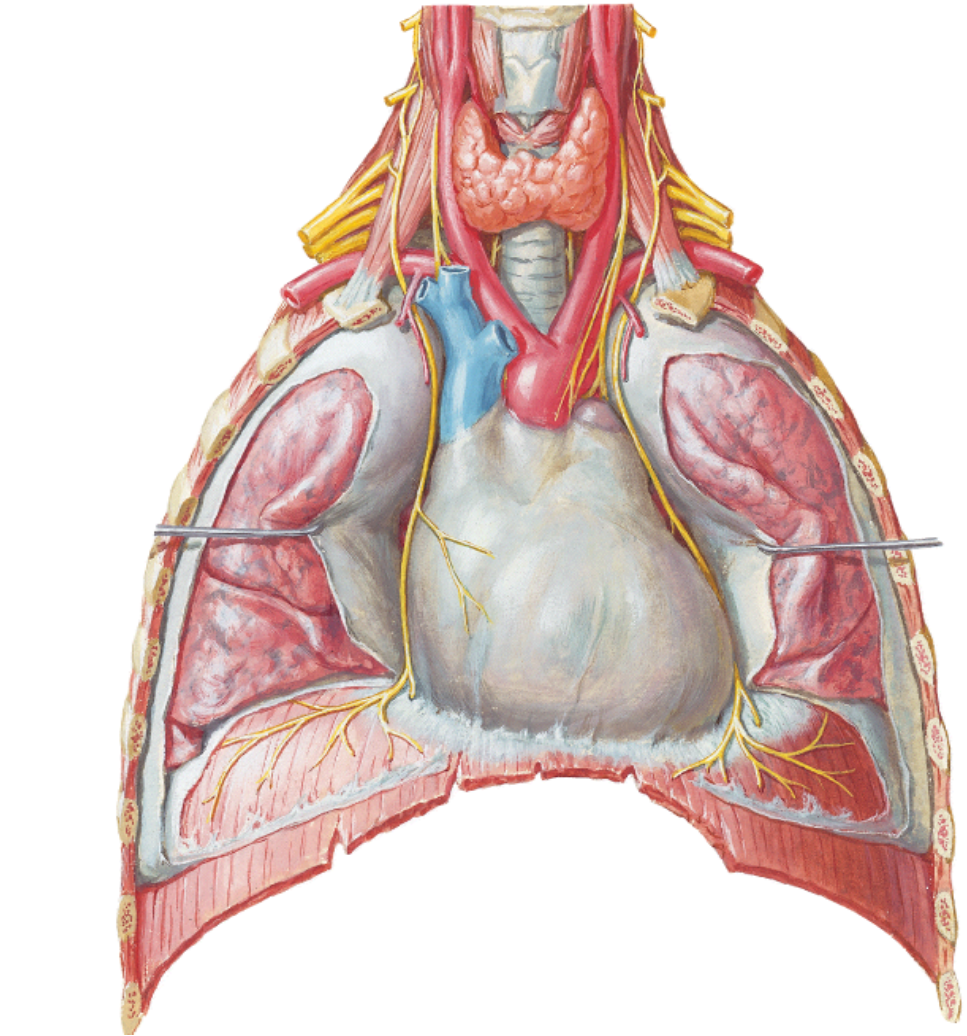
Oesophageal opening= 1 inch to left of middle line -surrounded by fleshy fibres of right crus.

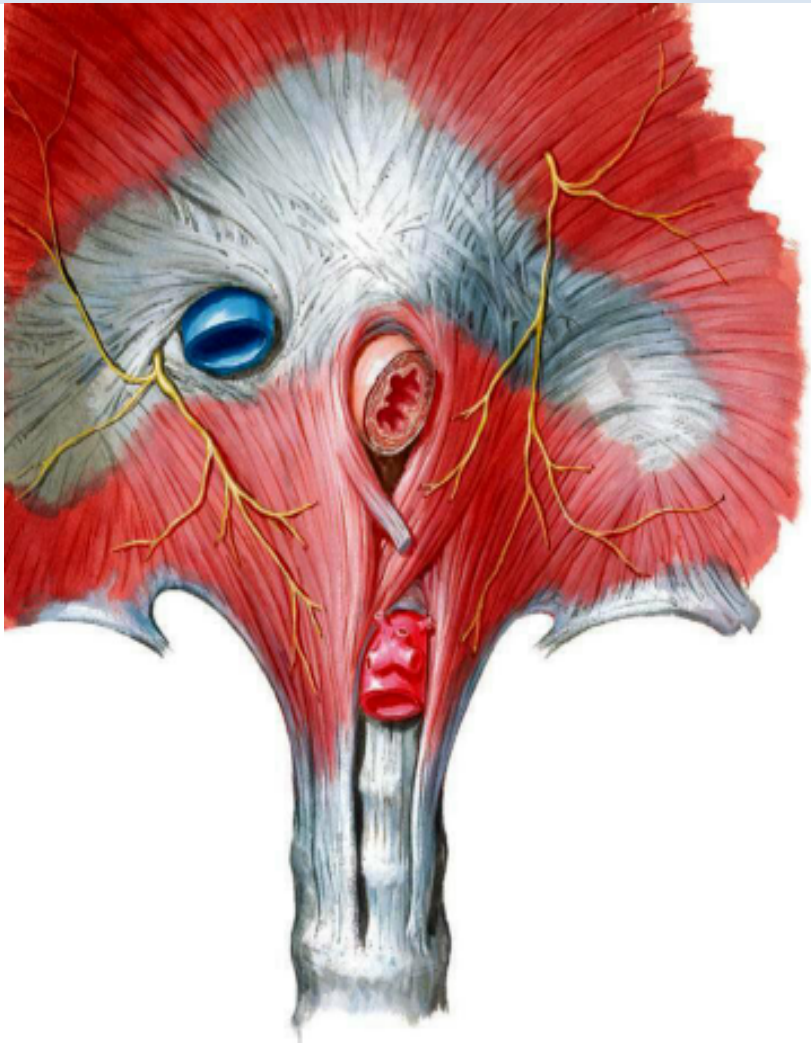
Aortic opening= In the middle line & behind median arcuate ligament.

3- Structures passing through

Vena cava opening

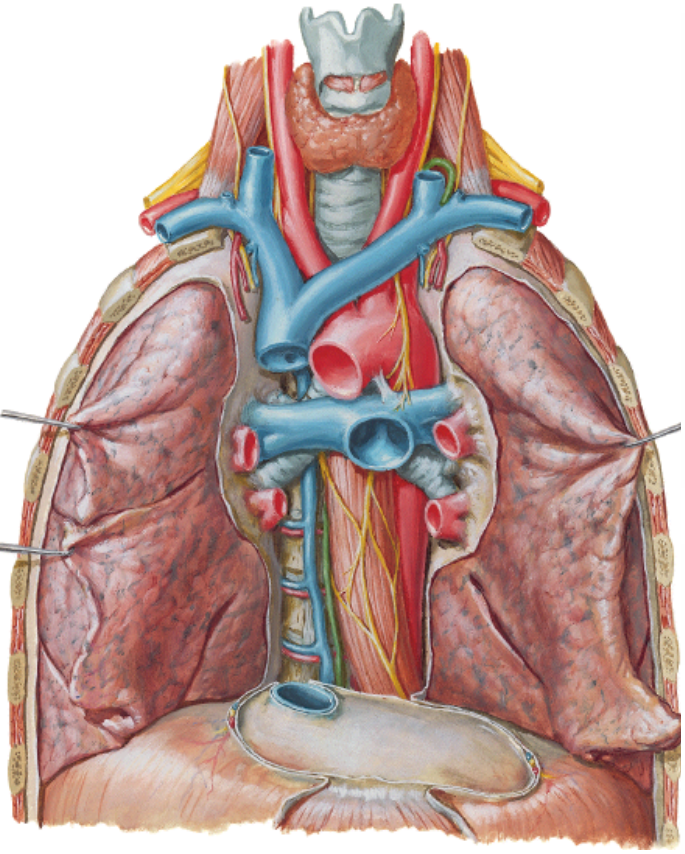
- I.V.C.
- Right Phrenic nerve
- Lymphatics.

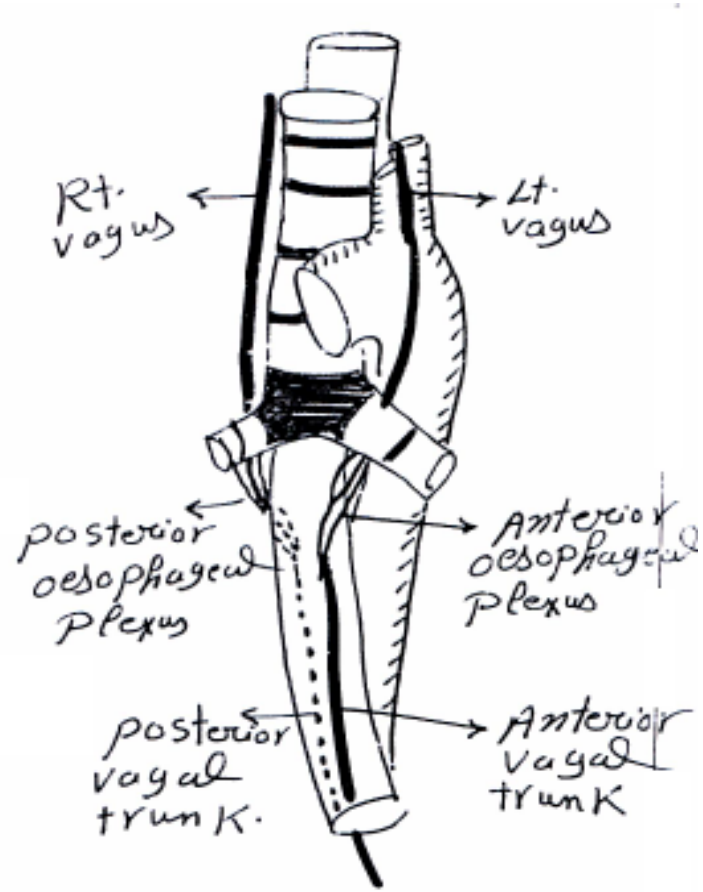


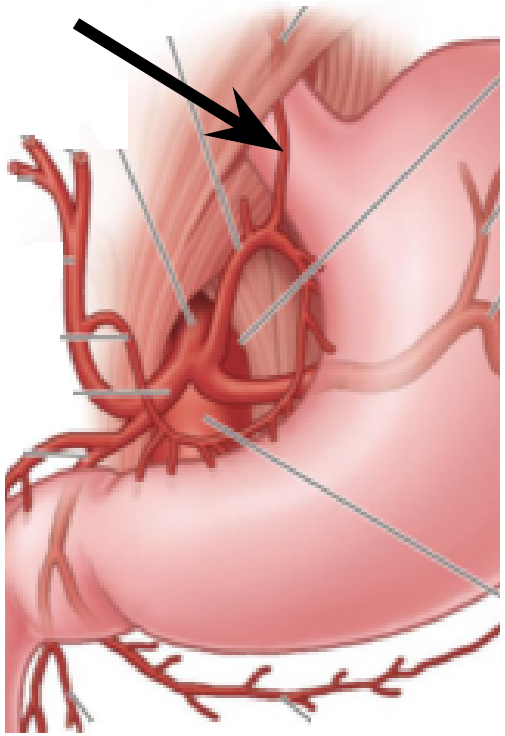


Oesophageal opening

- Oesophagus.
- Anterior & posterior vagal trunks.
- Oesophageal branches of left gastric vessels.

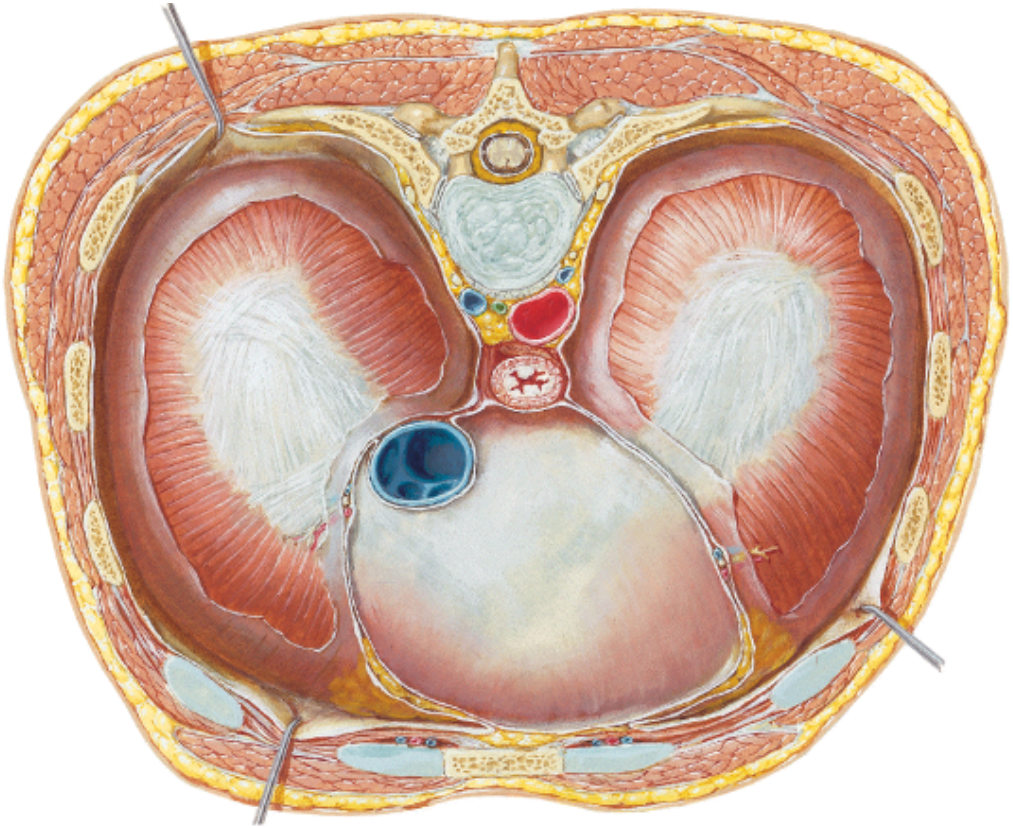


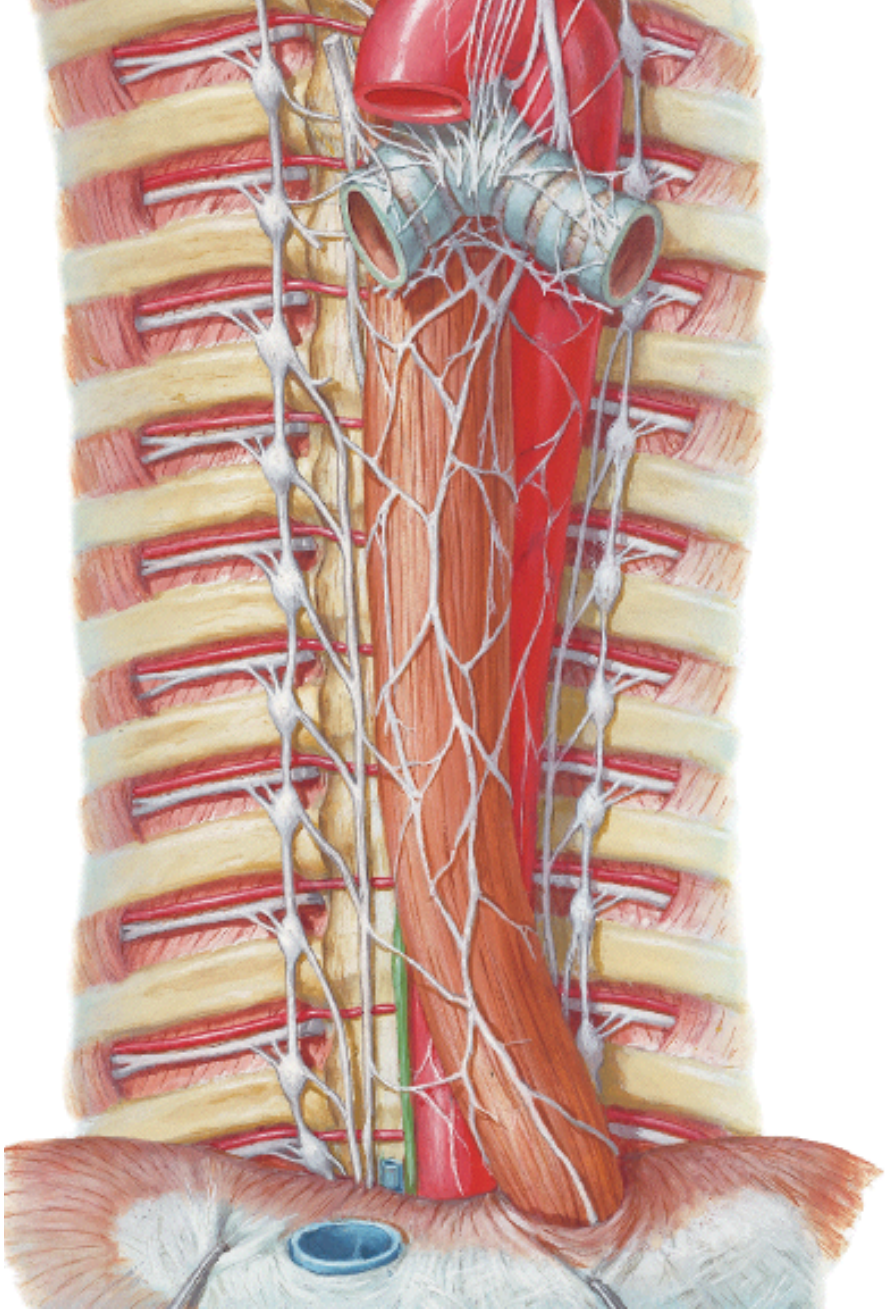


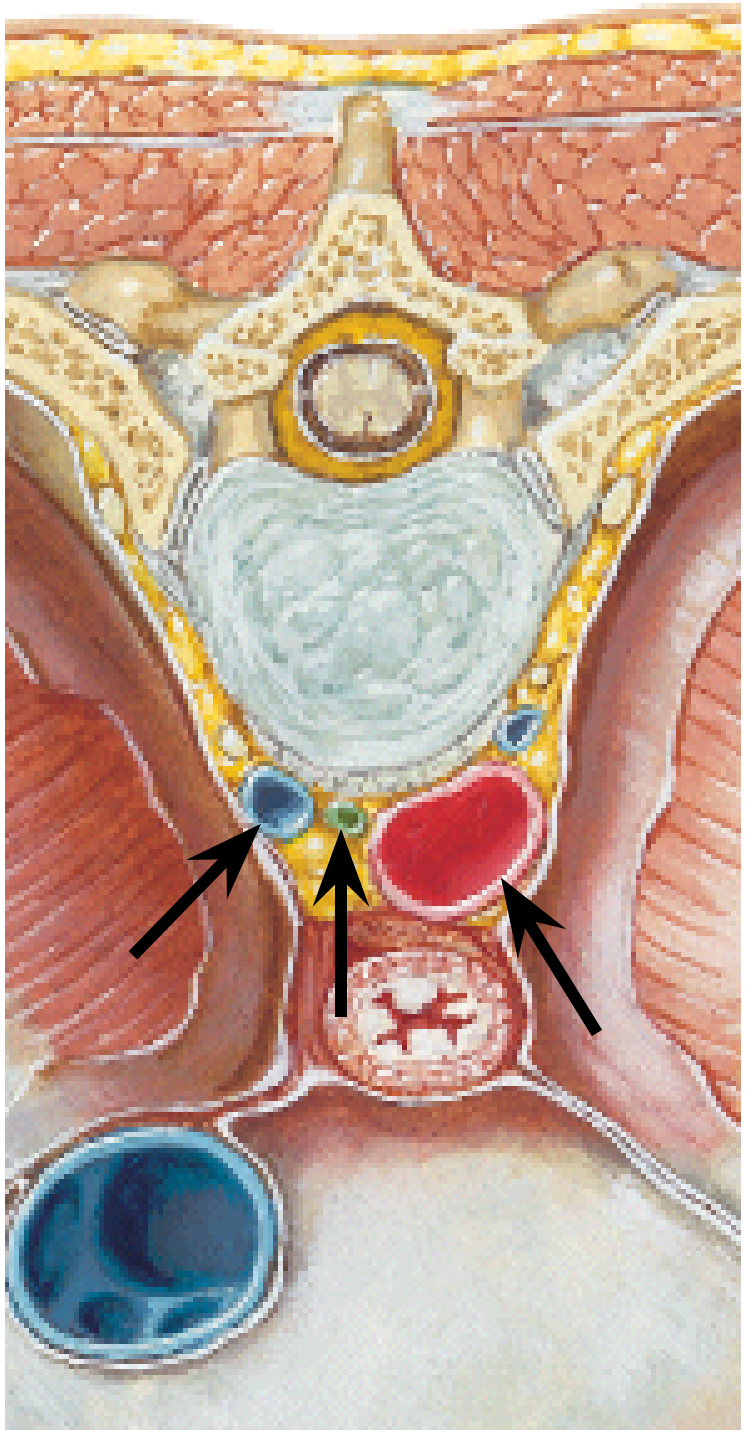


Aortic opening=

* Descending aorta.
* Azygos vein.
*Thoracic duct.

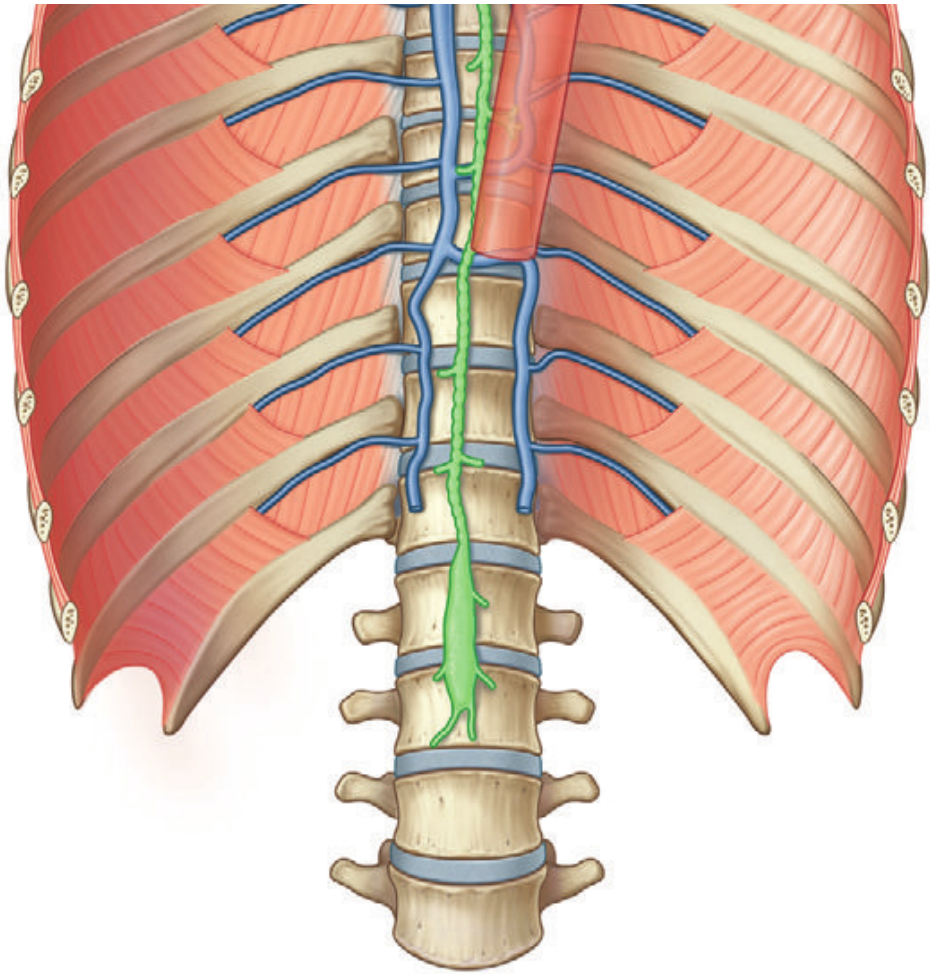






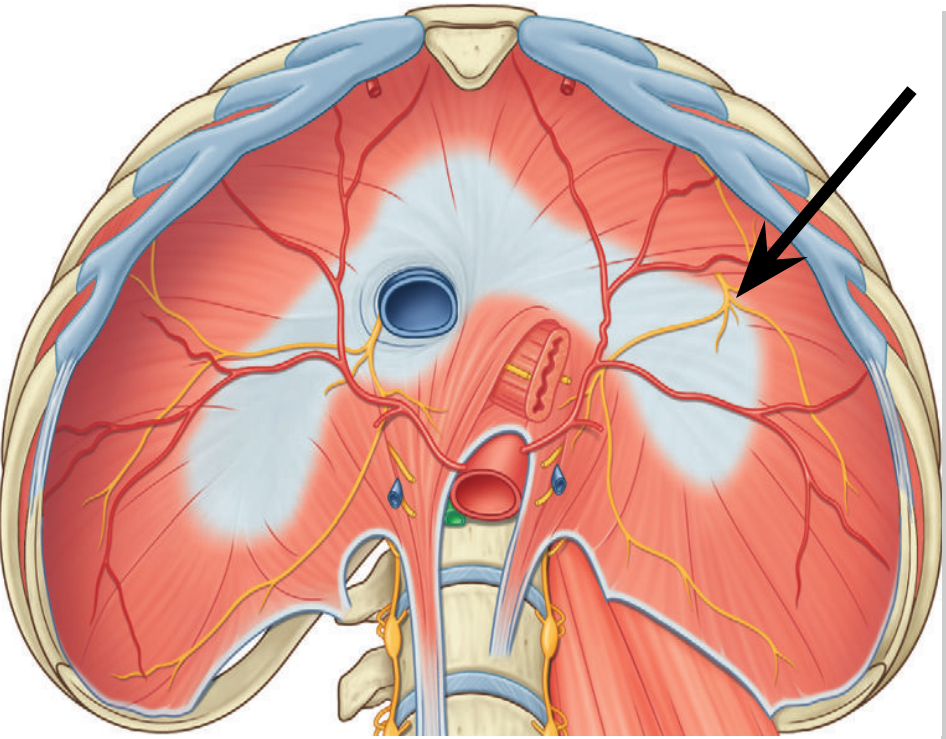
Aortic opening=

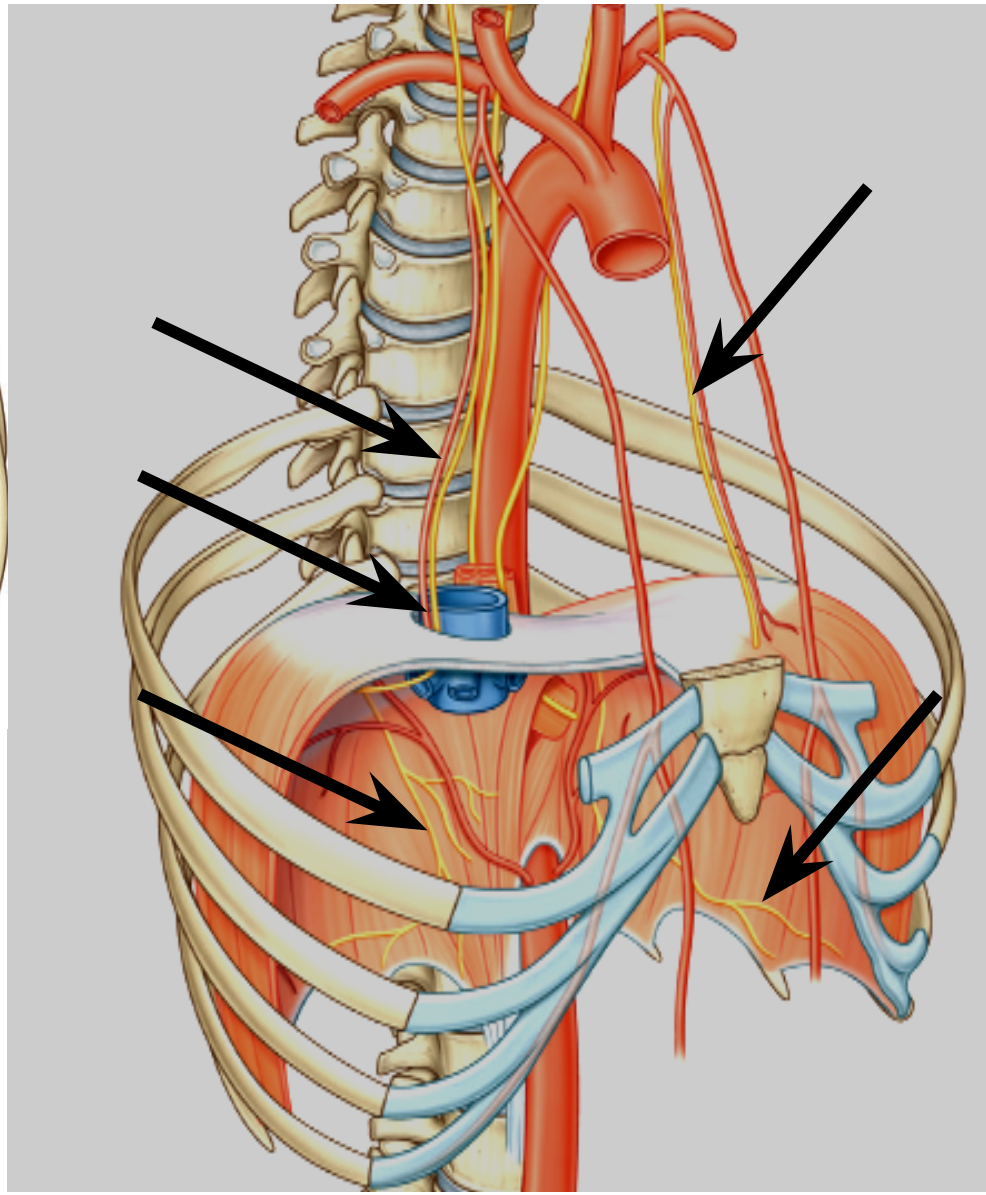
* Descending aorta.
* Azygos vein.
*Thoracic duct.



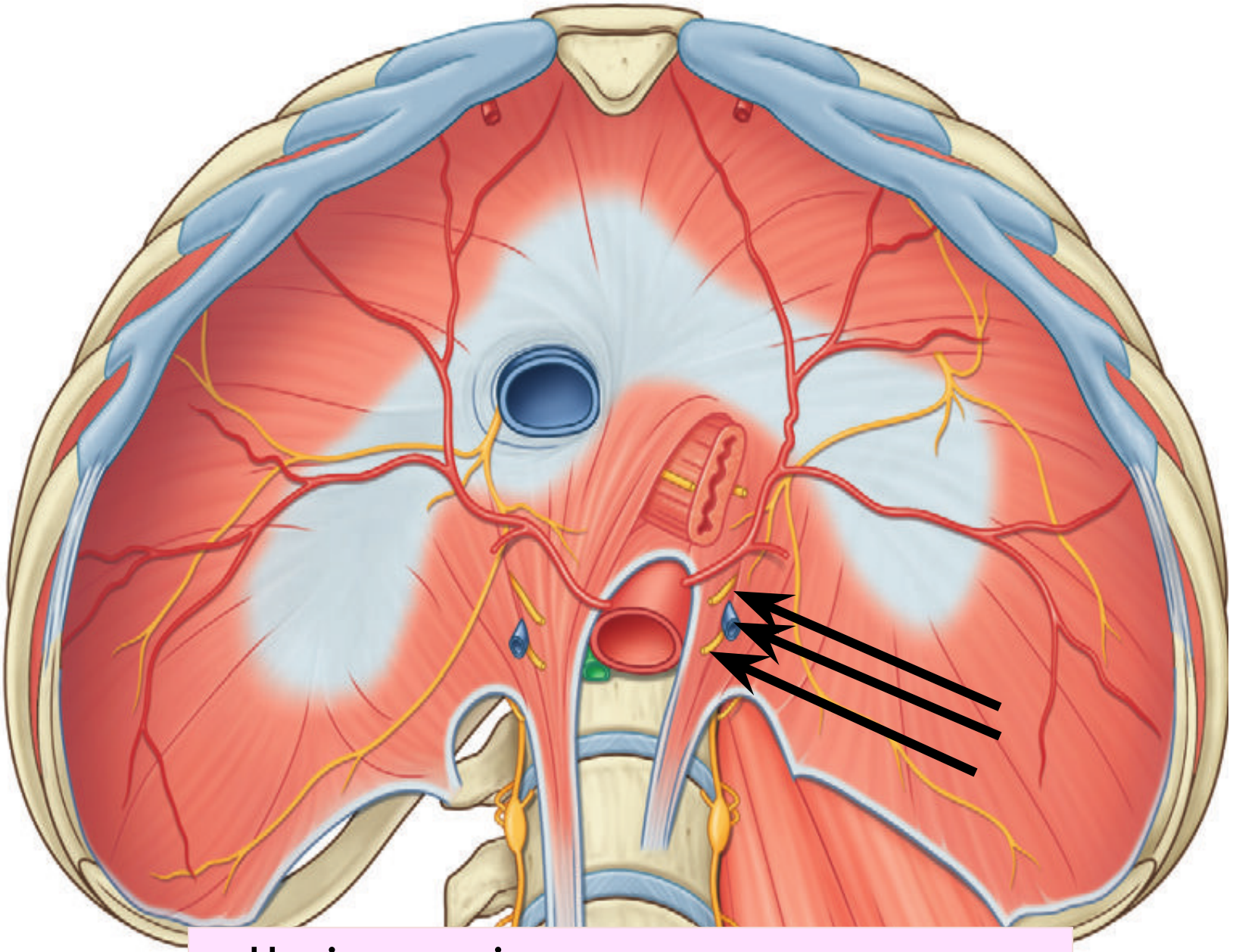
	Aortic Opening	Oesophageal Opening	I. V. C. Openig
1. Site:	T_{12} vertebra In the middle line. Behind median arcuate ligament	T_{10} vertebra I inch to left of middle line. In the right crus.	T_8 vertebra 1 inch to right of middle line. In the central tendon.
2. Structures inside:	Aorta to left Thoracic duct in between. Azygos vein to the right	Esophagus & 2 Vagi. Esophageal branches of left gastric vessels.	I.V.C, right Phrenic nerve & lymphaties.

Minor openings of diaphragm

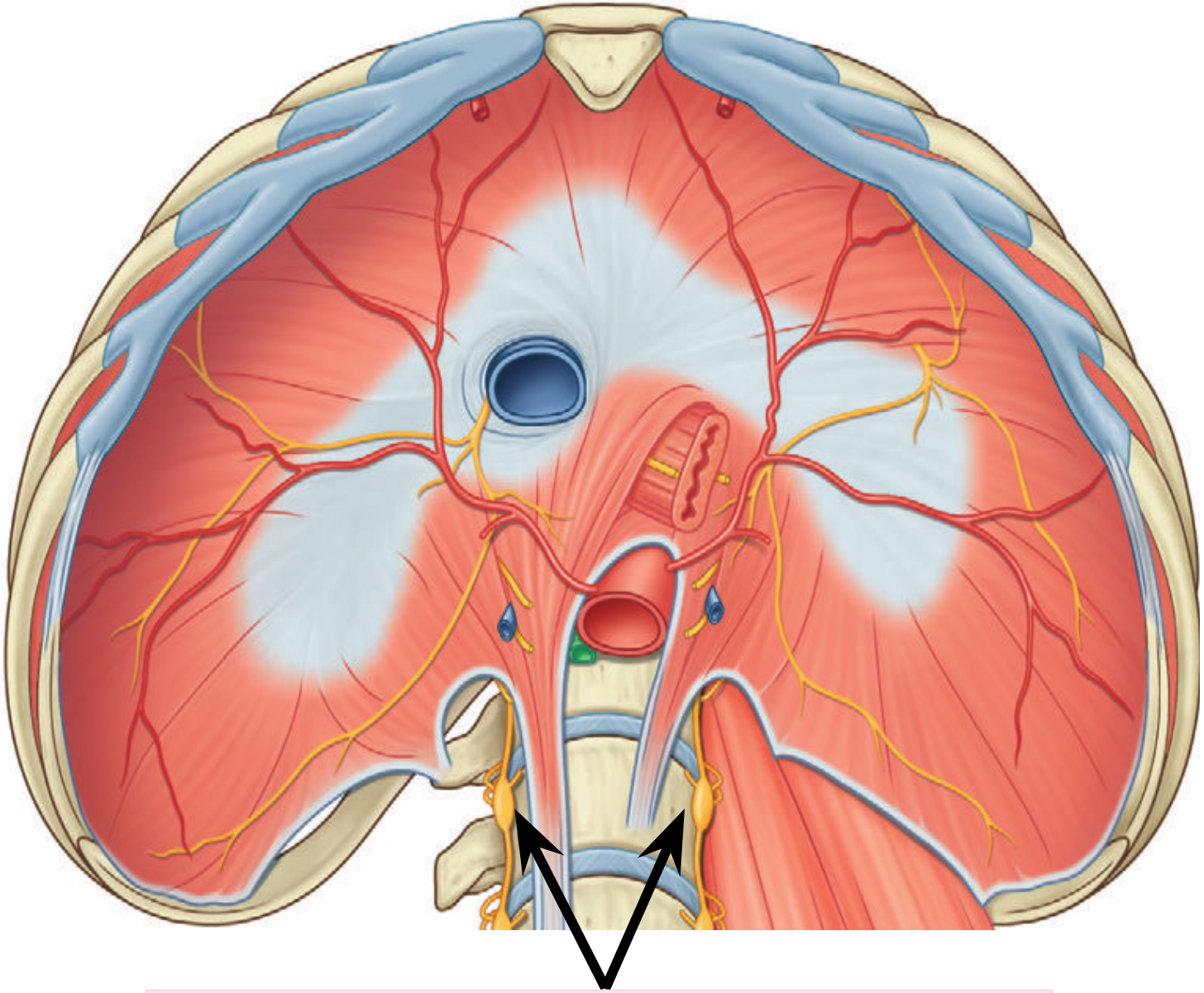




Left phrenic nerve pierces the left cupola.

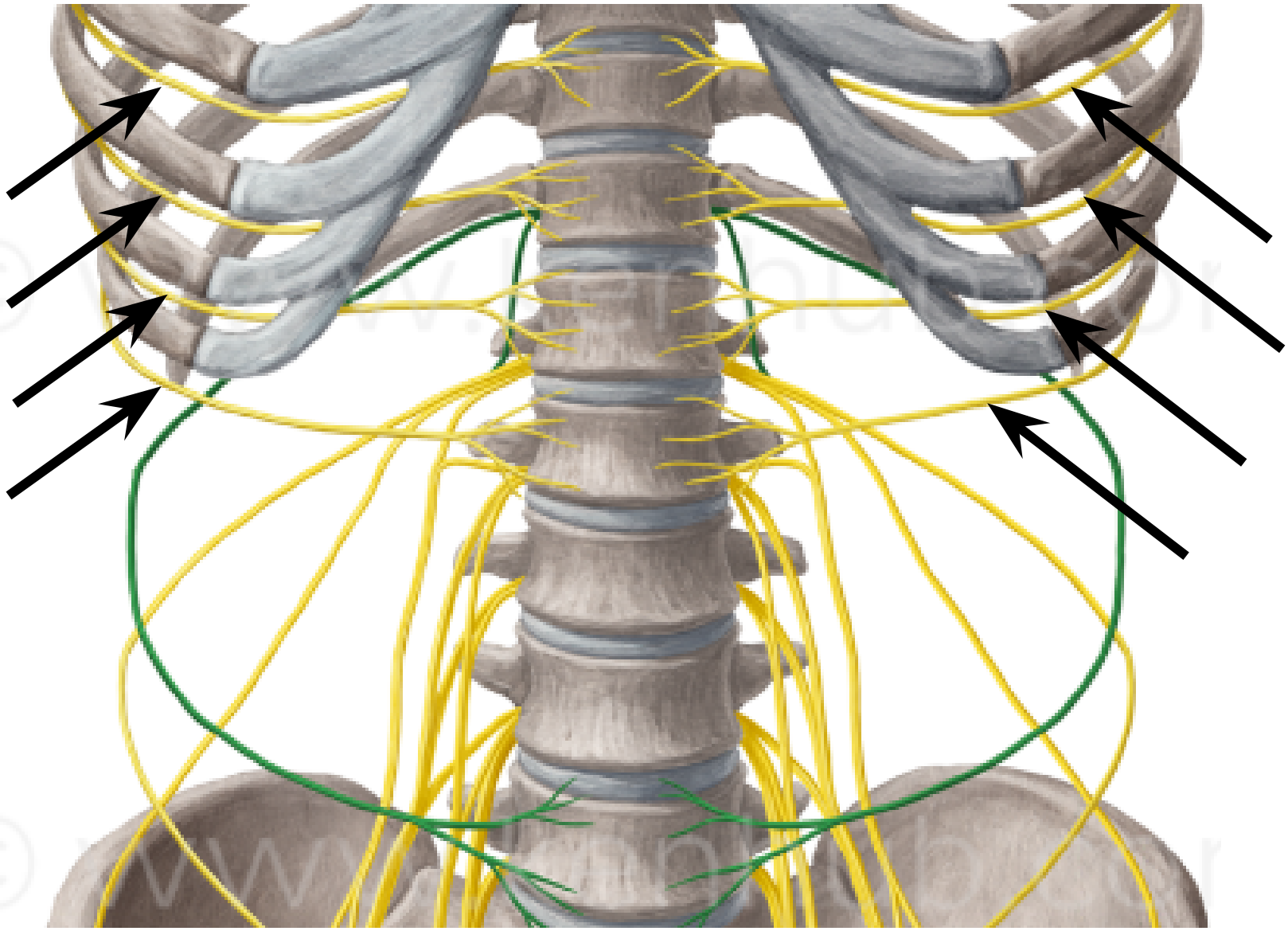


- Hemiazygos vein
- Greater and Lesser splanchnic nerves



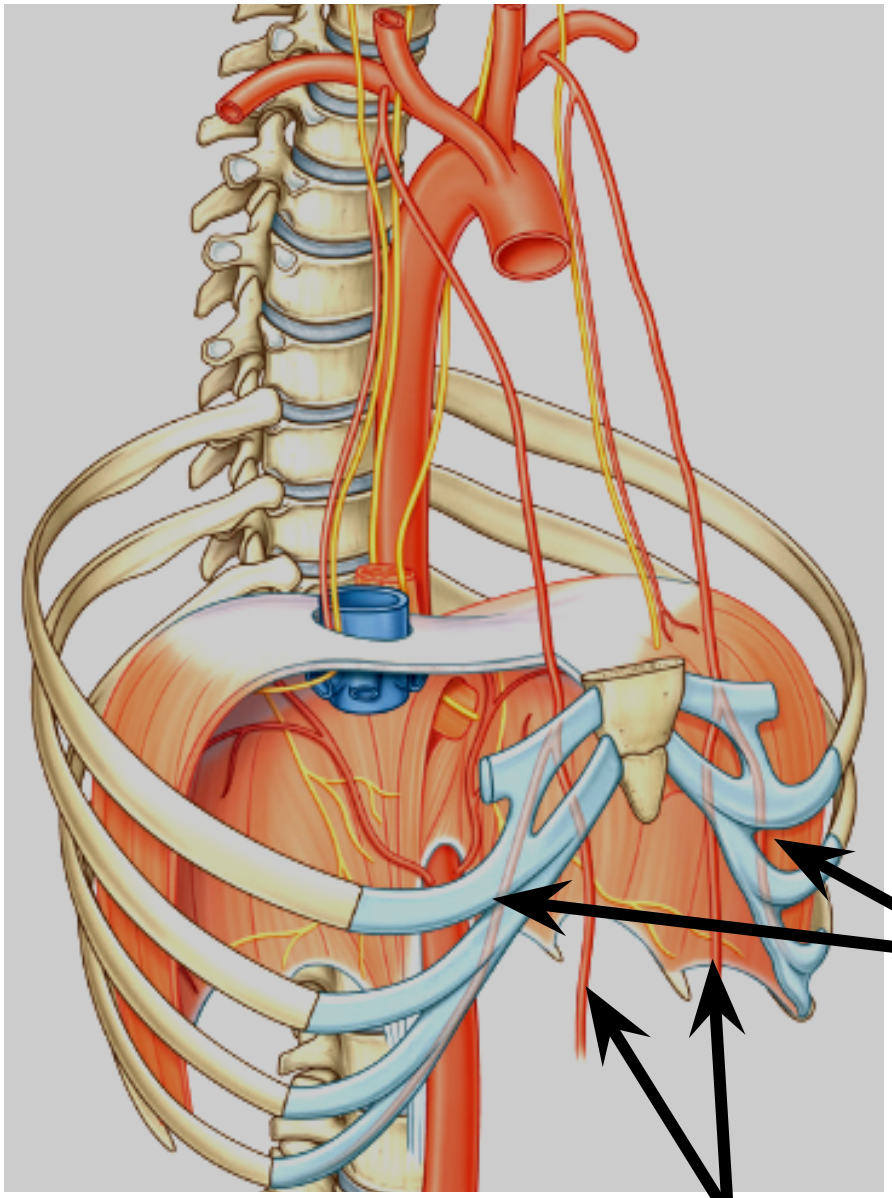
Sympathetic chain

Behind the medial arcuate ligament.



Lower 5 inter costal : between costal digitations of diaphragm.

Subcostal : behind lateral arcuate ligament.



Musculophrenic-phrenic

slips of origin of the diaphragm

Superior Epigastric

between sternal and costal origins

Minor openings of diaphragm

Between
slips of origin

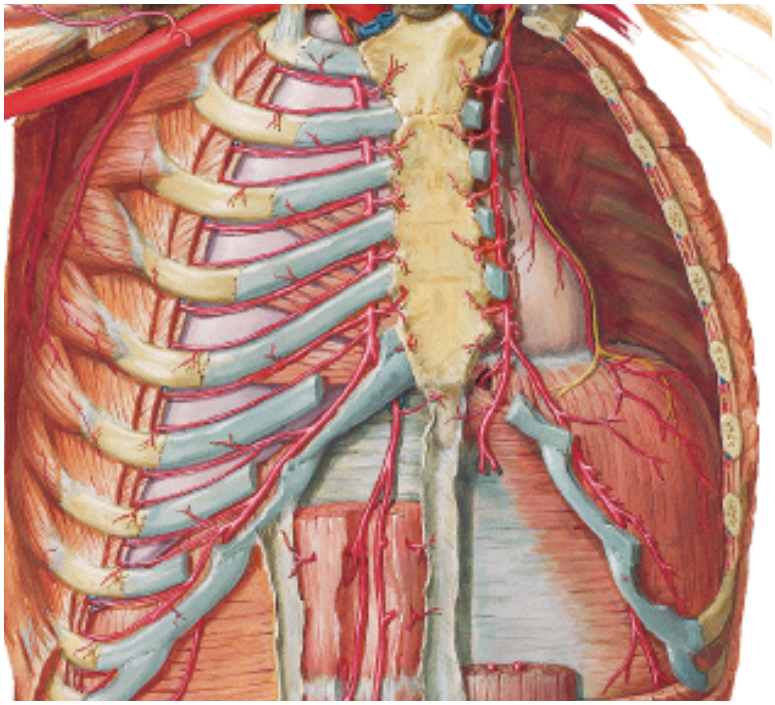
Between
costal digitations

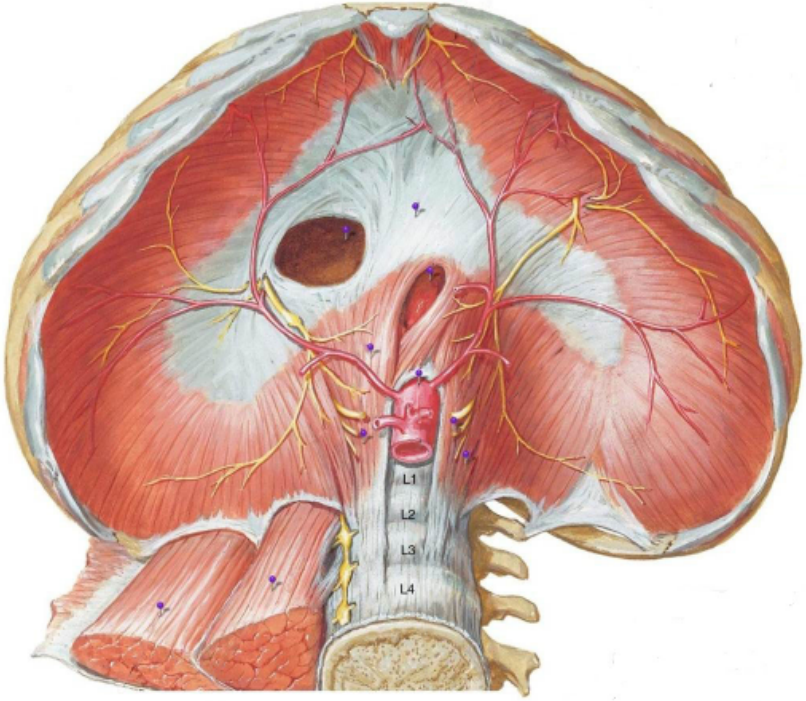
Behind
Lateral arcuate ligament

Behind
Medial arcuate ligament

Minute Openings
in the crura

LEFT PHRENIC NERVE





Minor openings of diaphragm

- **Musculo-phrenic art:** between slips of diaphragm origin at 7^{th}.&8^{th}. costal cartilages.
- **Superior epigastric artery:** between sternal and costal origins .

- **Lower 5 inter costal nerves & vessels:** between costal digitations of diaphragm.
- **Subcostal nerve** and **vessel:** behind lateral arcuate ligament

- **Inferior hemiazygos vein:** pierces left crus to enter the chest.
- **Greater and Lesser splanchnic nerves;** pierce the crus of the corresponding side.

- **Sympathetic chain:** Behind the medial arcuate ligament.

- **Left phrenic nerve** pierces the left cupola.

• Movements of respiration involve:

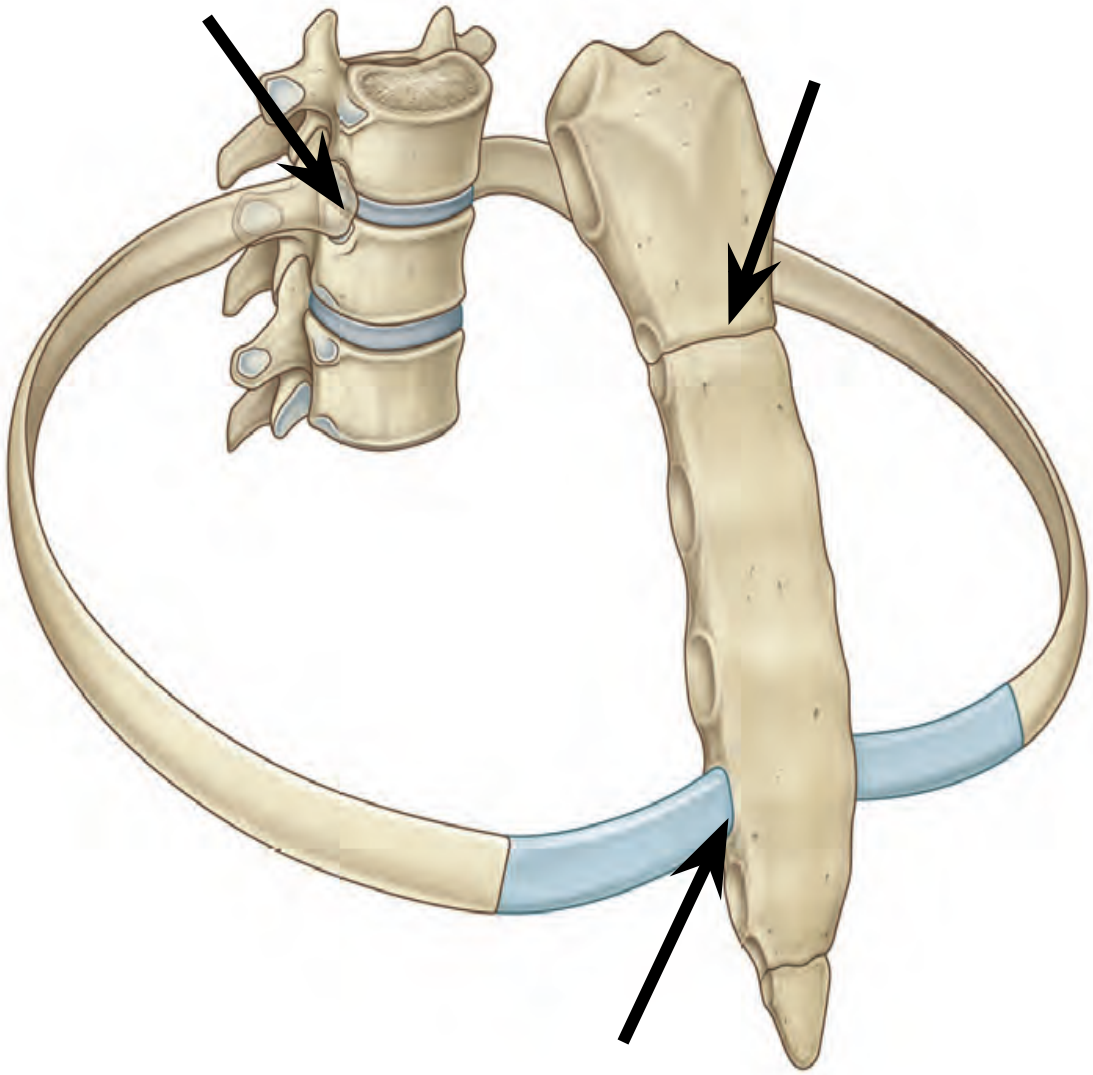
- **Muscles:** intercostals, diaphragm and accessory muscles.
- **Bones:** ribs and sternum.
- **Joints:** costovertebral, sternocostal and manubriosternal.

• Two phases:

Inspiration: active process------ contraction of muscles.
Expiration: passive process----- elastic recoil.

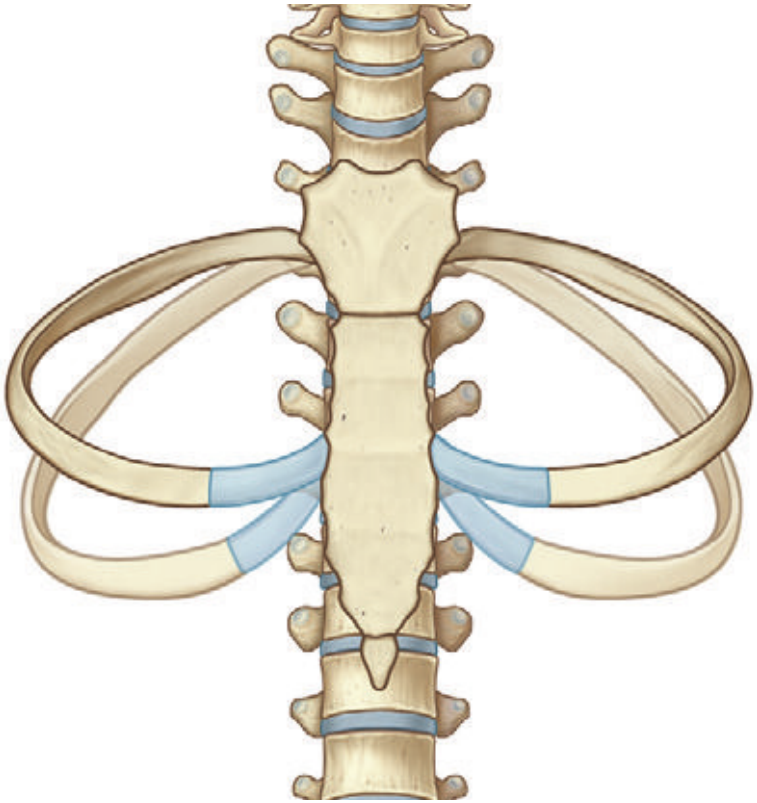
Changes in 3 diameters:

a- Anteroposterior diameter... by rib movements.
b- Transverse diameter ..... by rib movements.
c- Vertical diameter ..... by diaphragm.



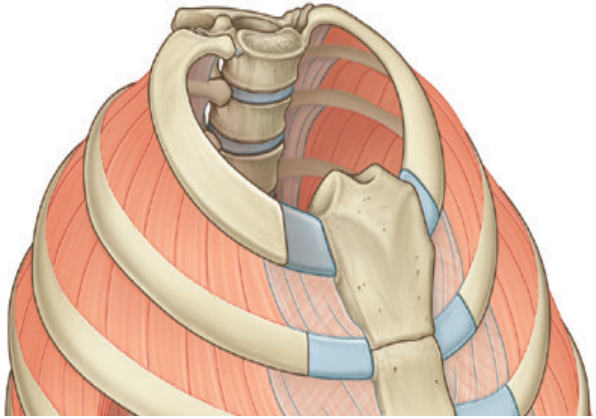
1-To increase the transverse diameter: (bucket handle movement)

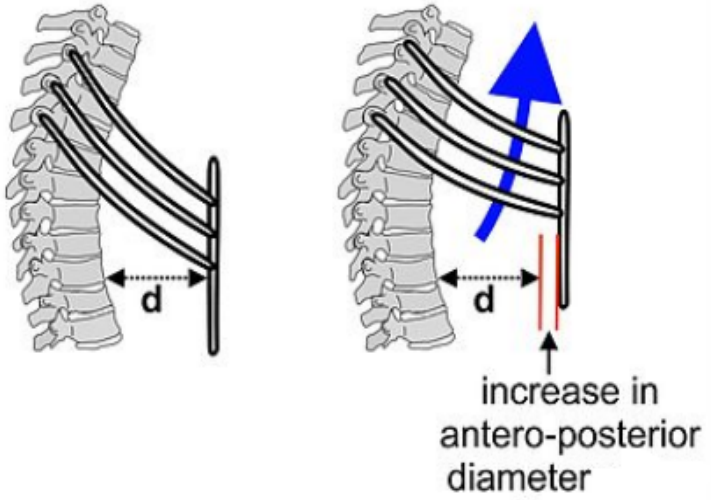


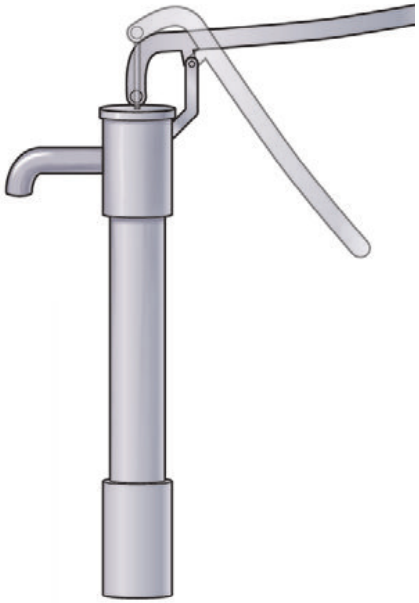


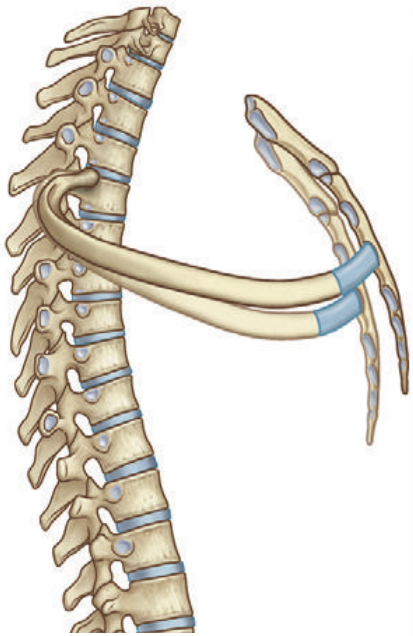
- At rest, costal arch hangs by side of chest; its middle part lies at a lower level than **2** ends.
- During inspiration, contraction of intercostal muscles causes ribs to **swing** up and out.
- Middle parts rise from sloping to horizontal position thus transverse diameter increases.
- Movement takes place around an anteroposterior axis between the 2 ends of costal arch.
- Apart from last **2** ribs (free anteriorly) all other are involved, especially from 8th to 10th.

2-To increase anteroposterior diameter: (pump handle movement)





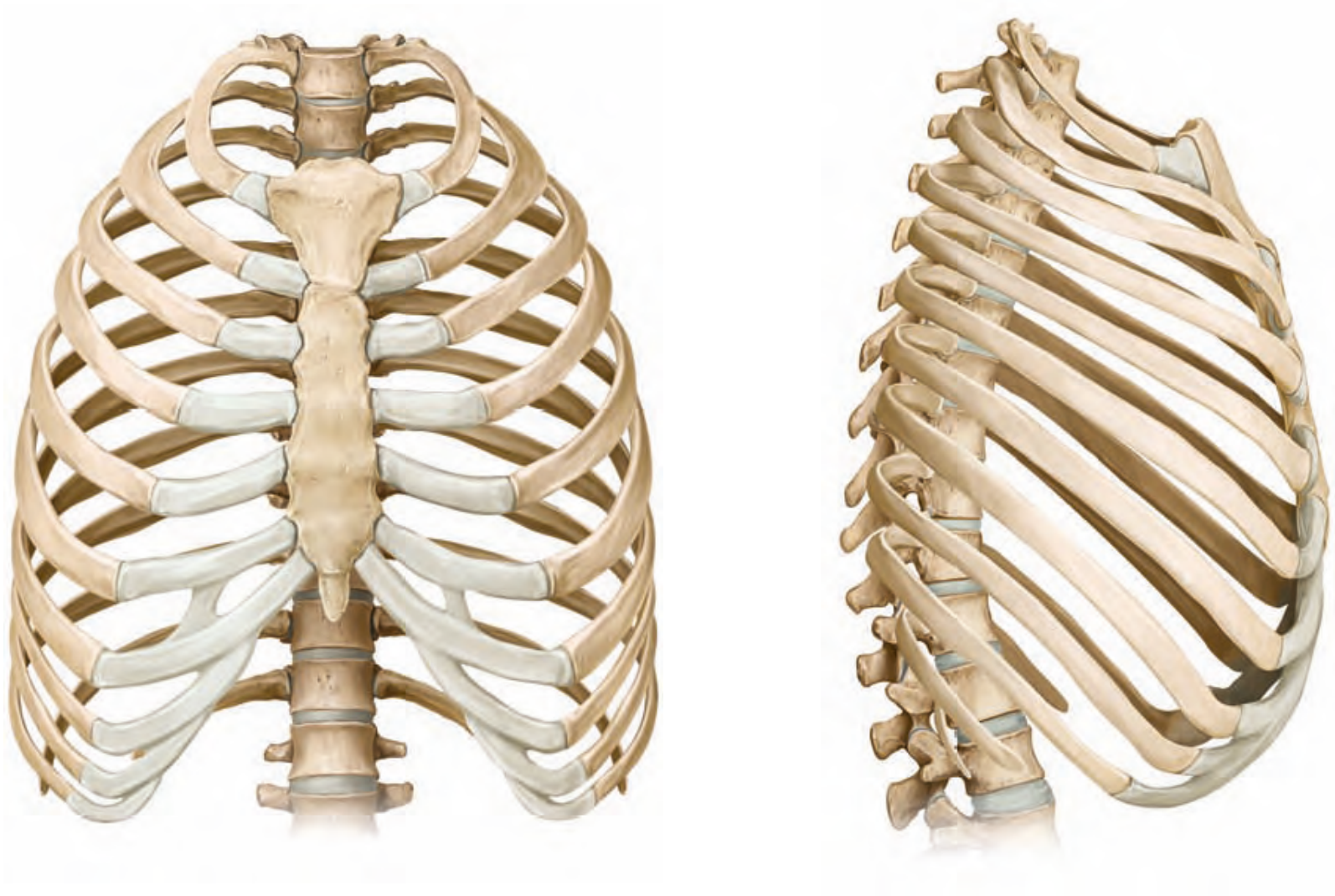






- Anterior (sternal) ends of ribs are lower level than their posterior (vertebral) ends.
- During inspiration, the intercostal muscles contract and shafts of ribs are elevated.
- thus, their anterior ends push sternum forwards and upwards, increasing A-P diameter.
- Movement occurs around a **transverse axis.**
- Manubrium remains fixed; the manubrio-sternal joint allows hinge-like movement of sternum.

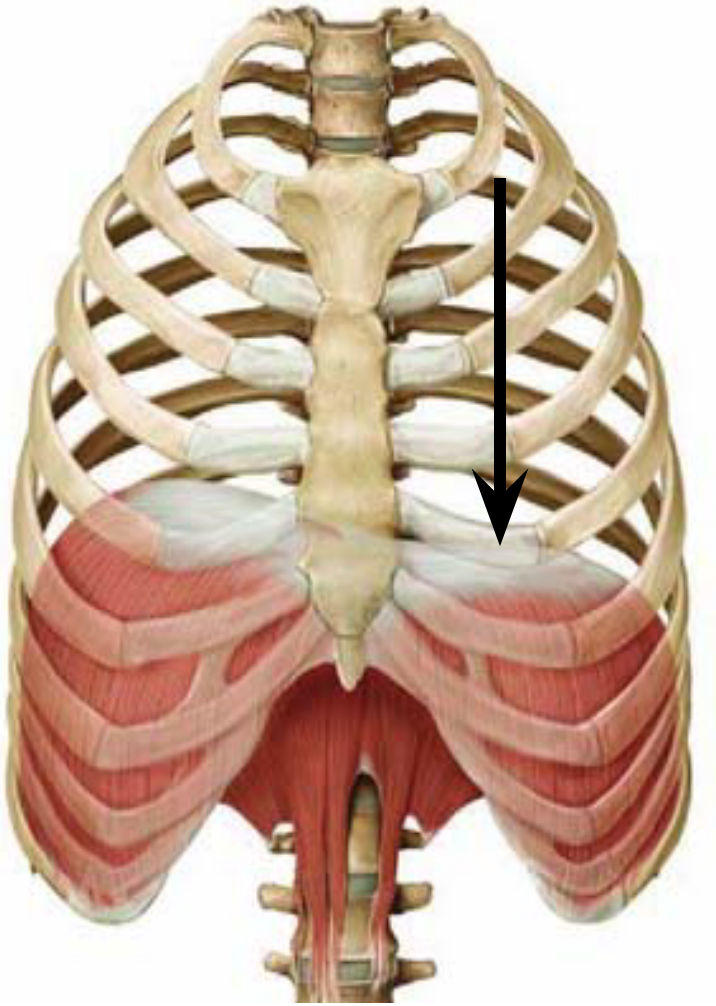
2-To increase anteroposterior diameter: (pump handle movement)

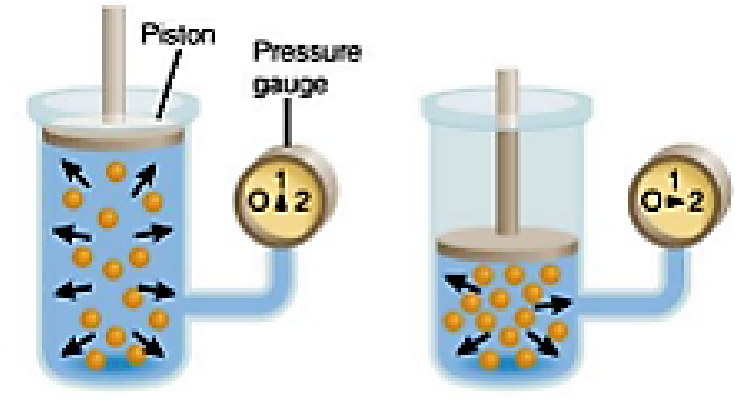


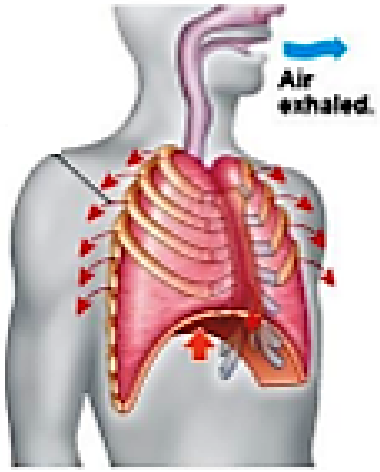
Only upper, true ribs **(2 to 7)** (vertebrosternal ribs) are involved.

(lower ribs have no direct articulation with sternum).

3- Movements of the diaphragm to increase vertical diameter:







- At rest, diaphragm is highly curved. During inspiration, it contracts and becomes shorter and less curved.
- The flattened diaphragm descends and vertical diameter of thorax increases **(piston-like downstroke).**
- As diaphragm descends, abdominal viscera are displaced downwards and anterior abdominal wall moves forwards to accommodate viscera.

1- Quiet inspiration

Intercostal muscles

1st rib and manubrium-----fixed. The last **two** ribs are immobile.

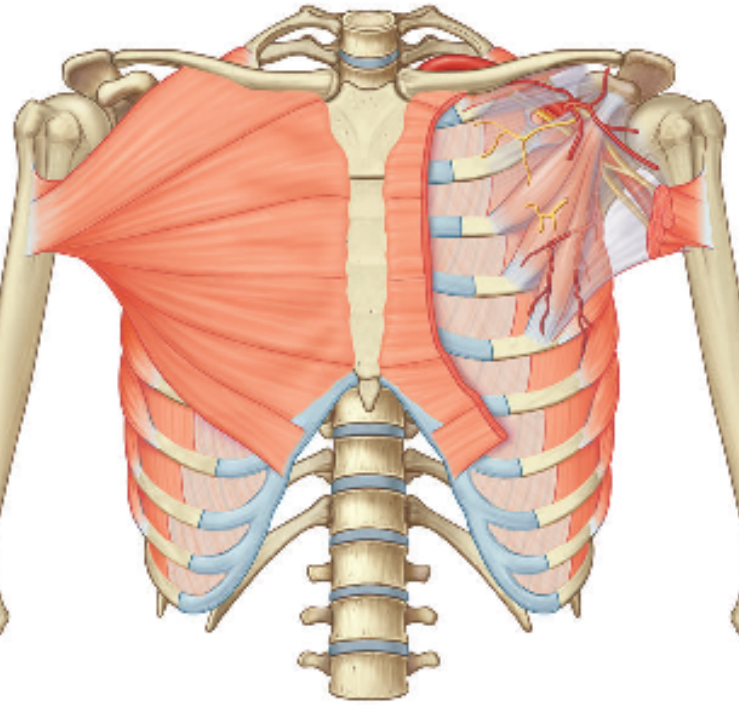
Upper ribs (2 -7)------increase anteroposterior diameter.

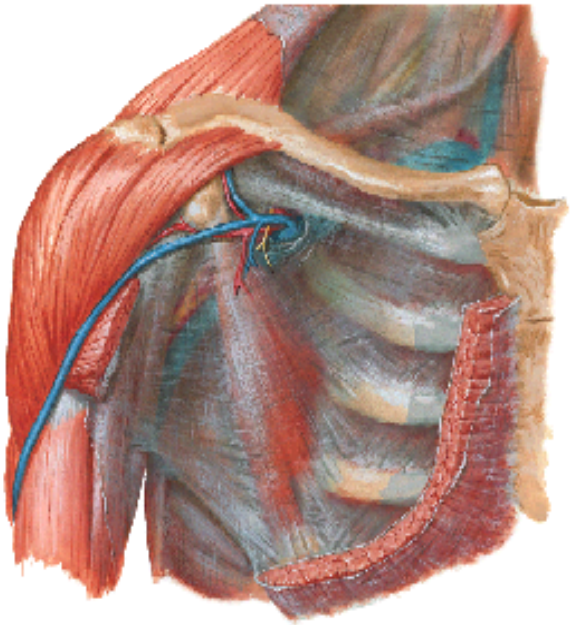
Lower ribs (8-10)-------increase transverse diameter (bucket-handle).

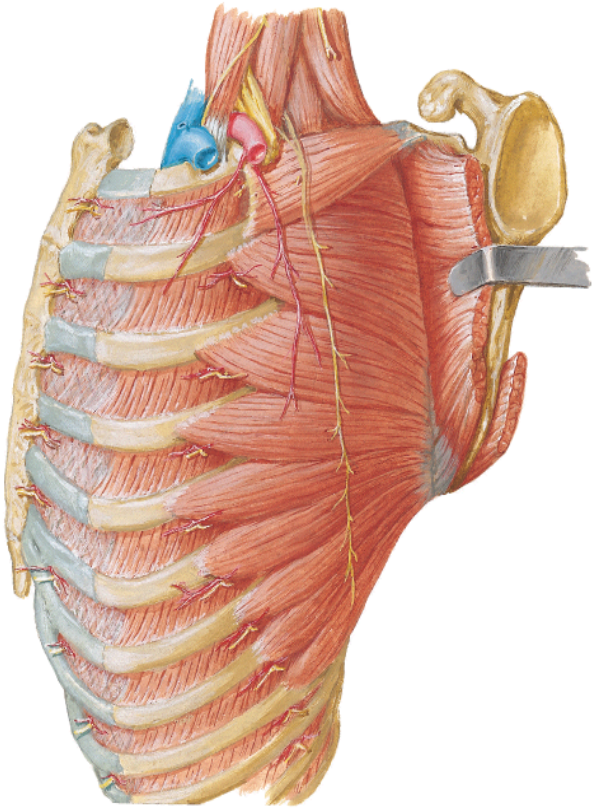
Diaphragm---------- increases vertical diameter.

2- Forced inspiration

Axial muscles







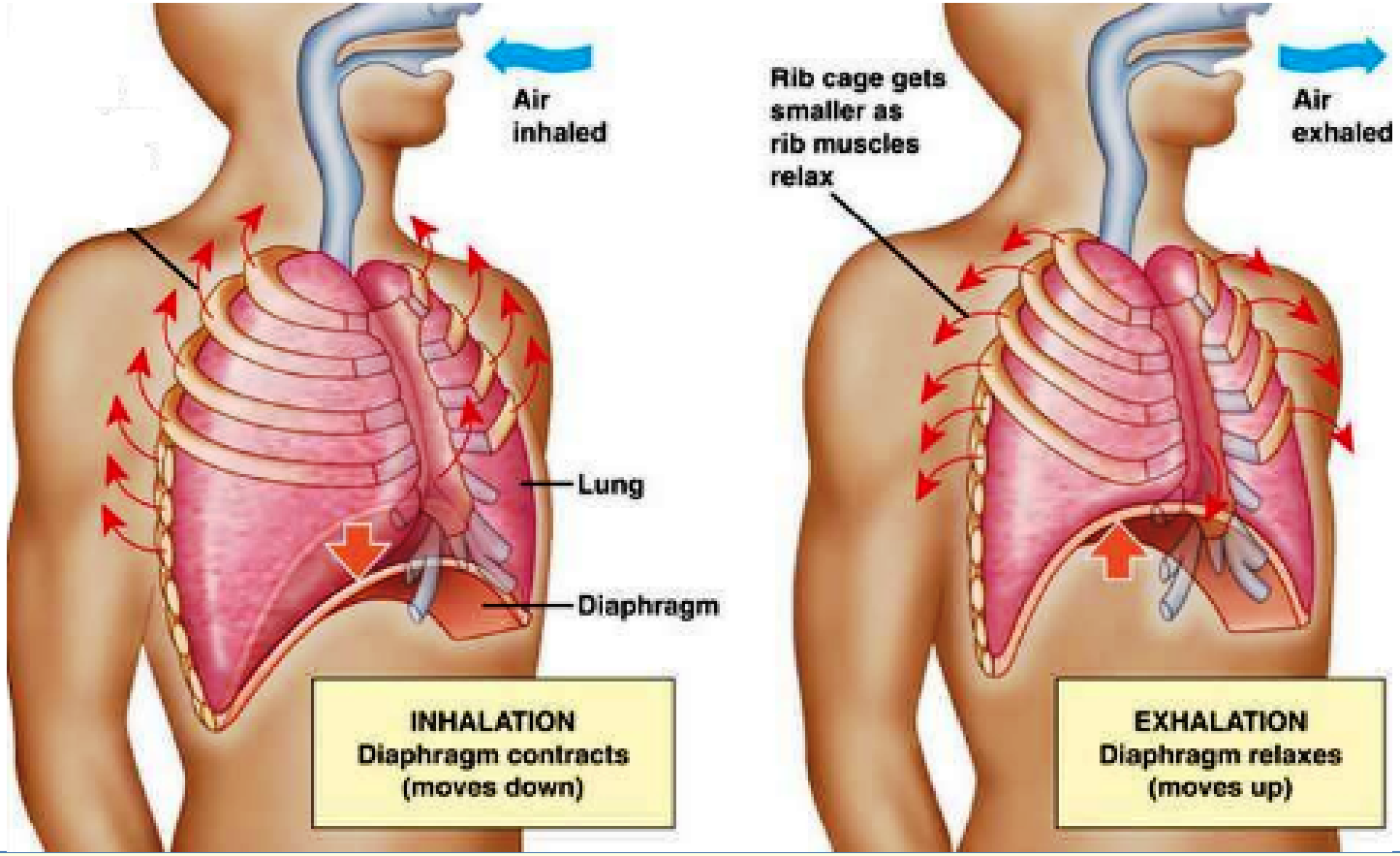
Pectoralis major --------raises sternum and upper **6** costal cartilages.

Pectoralis minor --------elevates 3rd, 4th and 5th ribs.

Serratus anterior ---------pulls on upper **8** ribs.

1- Quiet expiration

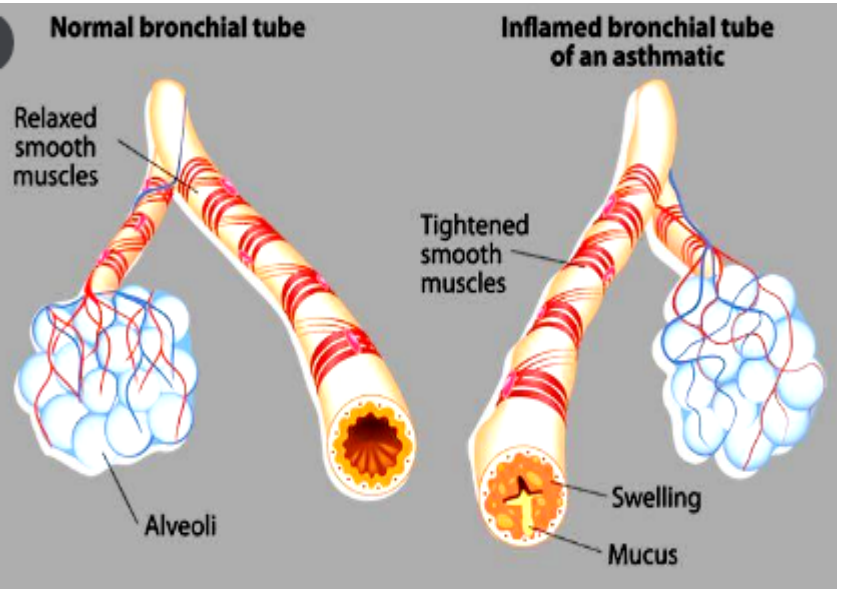
Passive process------Elastic recoil

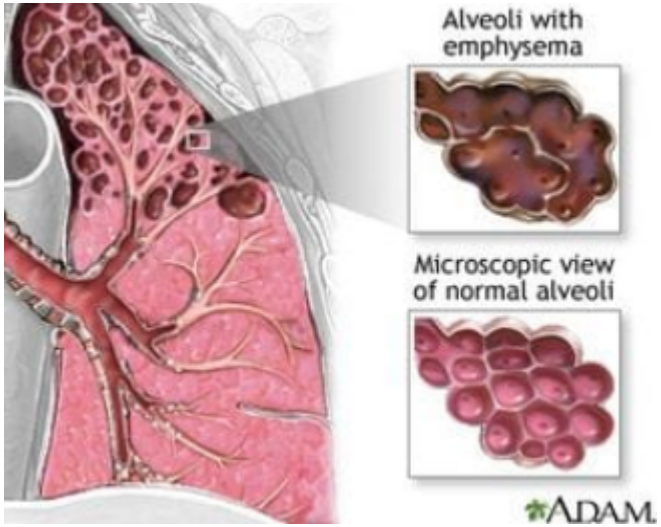


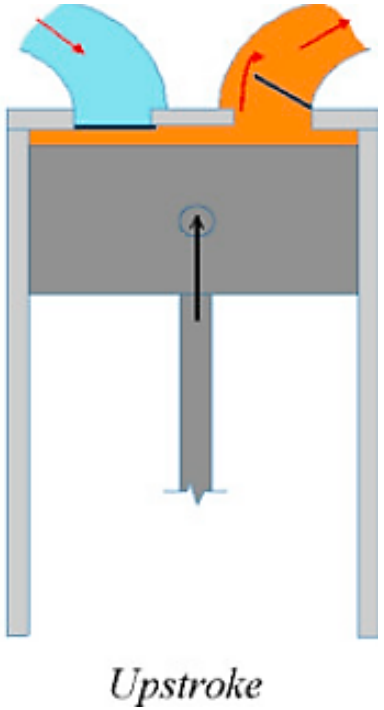
- Elastic recoil of the stretched **lung tissue.**
- Elastic recoil of the twisted **costal cartilages.**
- Muscle tone of **anterior abdominal wall** pushes viscera backwards which push diaphragm upwards.

2- Forced expiration= Laboured expiration

Active process



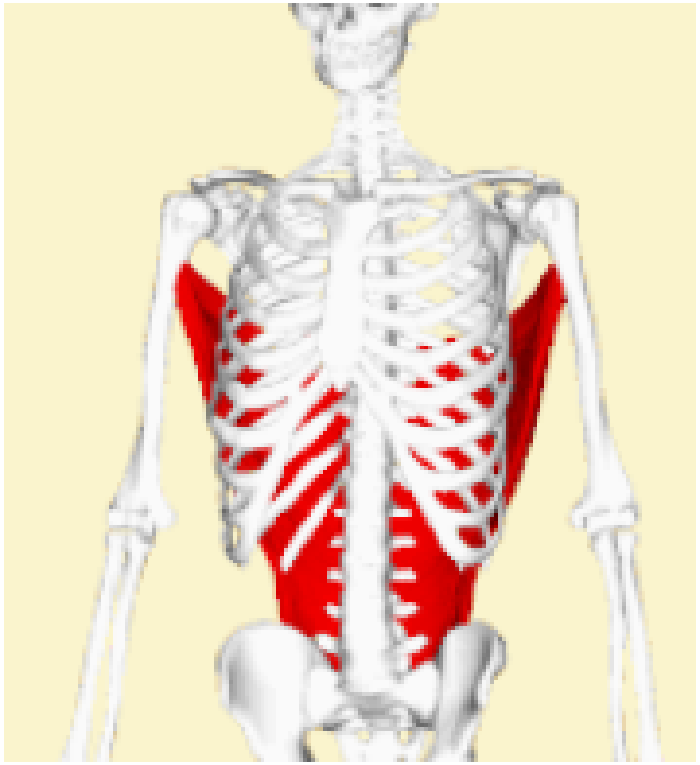


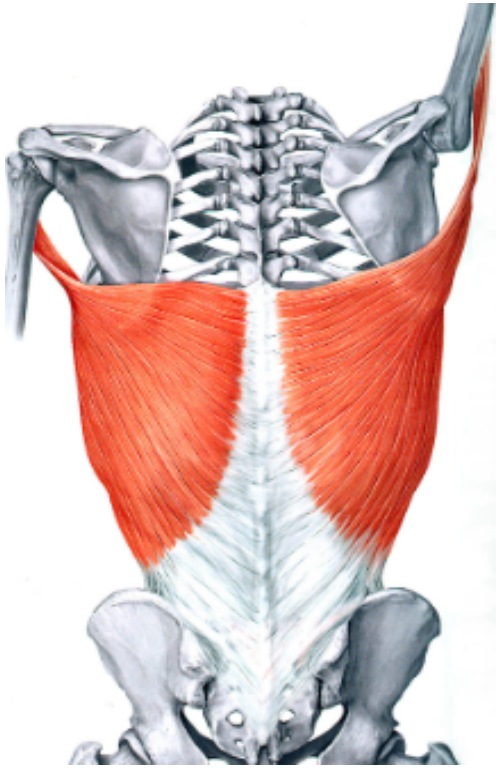


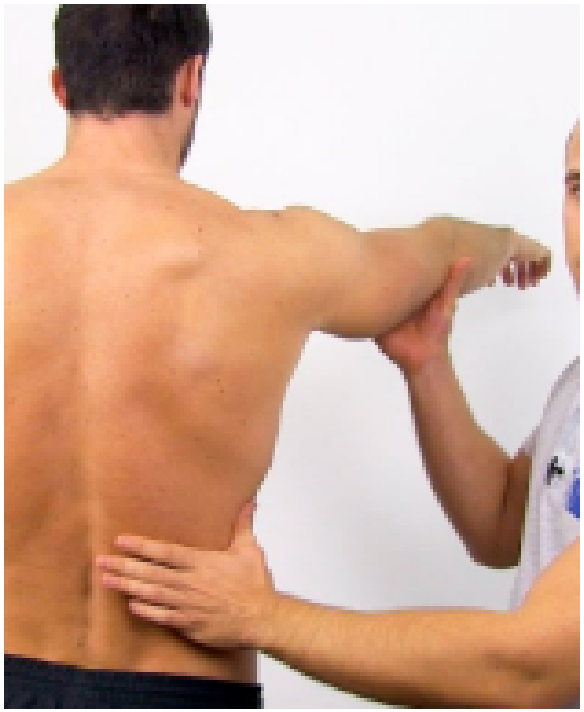
- Lungs loose elasticity(**emphysema**) or narrow respiratory passages (**asthma**).
- Abdominal muscles contract increasing intra-abdominal pressure and forcing diaphragm further upwards **(piston-like upstroke).**

2- Forced expiration= Laboured expiration

Active process







- The latissimus dorsi muscle contracts strongly compressing lower ribs.
- Used in **coughing** and **sneezing**.
- Asking a person to cough while placing a hand on the lower part of the side of his chest is used to test the integrity of his latissimus dorsi.

Types of Respiration

- Respiration could be mainly thoracic, mainly abdominal or mixed abdomino-thoracic.
- **At birth:** respiration is mainly **abdominal** (by upward and downward piston-like action of diaphragm).
- By the **7th year**, the ribs are oblique and respiration becomes **abdomino-thoracic**.
- Respiration in males is mainly abdominal-

in **females** mainly **thoracic** (abdominal cavity may get over occupied with a pregnancy.

وَقُلِ الْحَمْدُ لِلَّهِ