Thorax: Chest wall, mediastinum, thoracic apertures, respiratory mechanics

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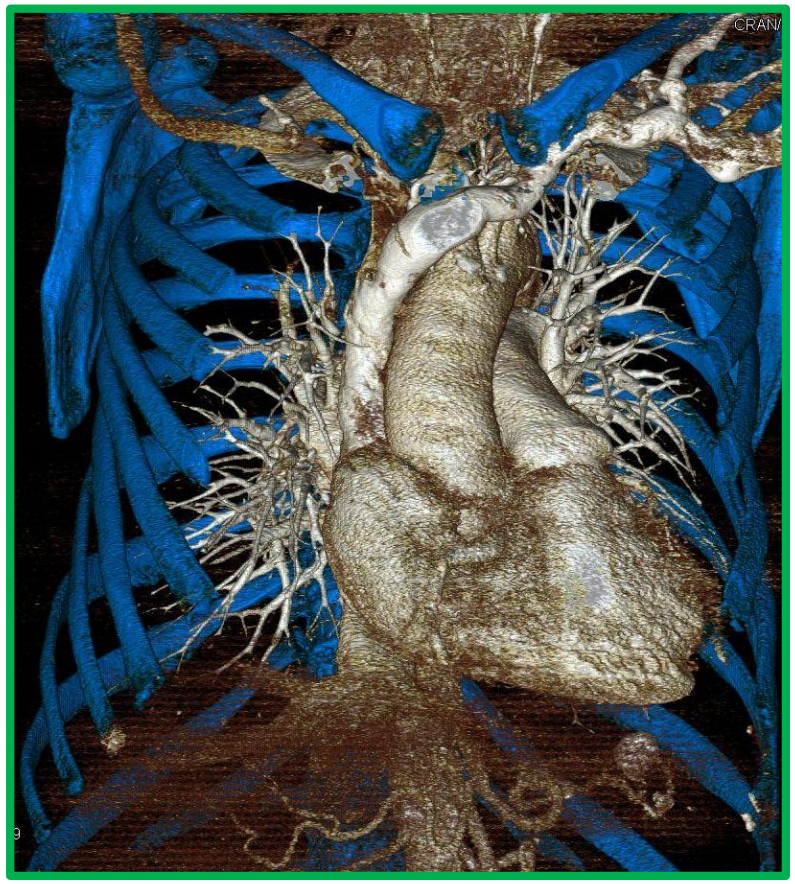
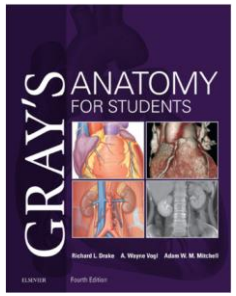
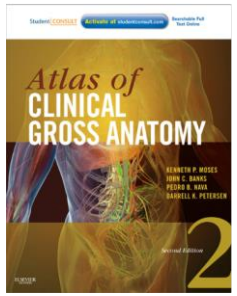
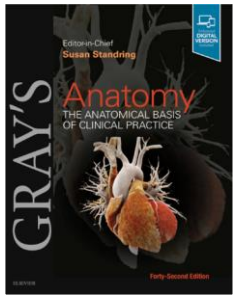
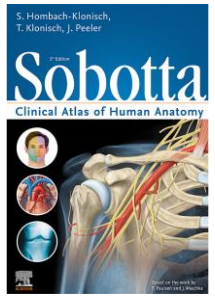










LÉKAŘSKÁ FAKULTA V PLZNI
Univerzita Karlova

Univerzita Karlova

Introduction, ie. What is this good for?!

Dear students, colleagues,

This study material is a supporting aid to our anatomy practicals, its goal is to understand and consolidate the discussed matter, clinical implications including. Knowledge practice is based on supplementary questions and tasks, you can check your answers on the next slide/s.

I wish you good luck and joy from new knowledge,

Lada Eberlova

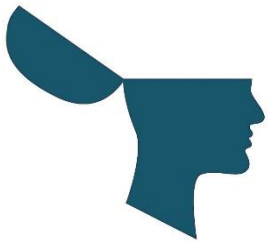
The following pictograms will accompany you:

 to recall or remember

 clinical notes

 to be completed

Recommendation: Find the most effective way of learning that works for you. **S**tudy regularly, most often every day, and **d**iscuss the matter with your mates. Do not be afraid to **a**sk so that SDA is not SAD when the time comes...



Learning goals

i.e. What do you FINALLY need to know?

- Knowledge demands for the spot test/s
- **Knowledge requests for the final exam (oral!)**

RESPIRATORY SYSTEM

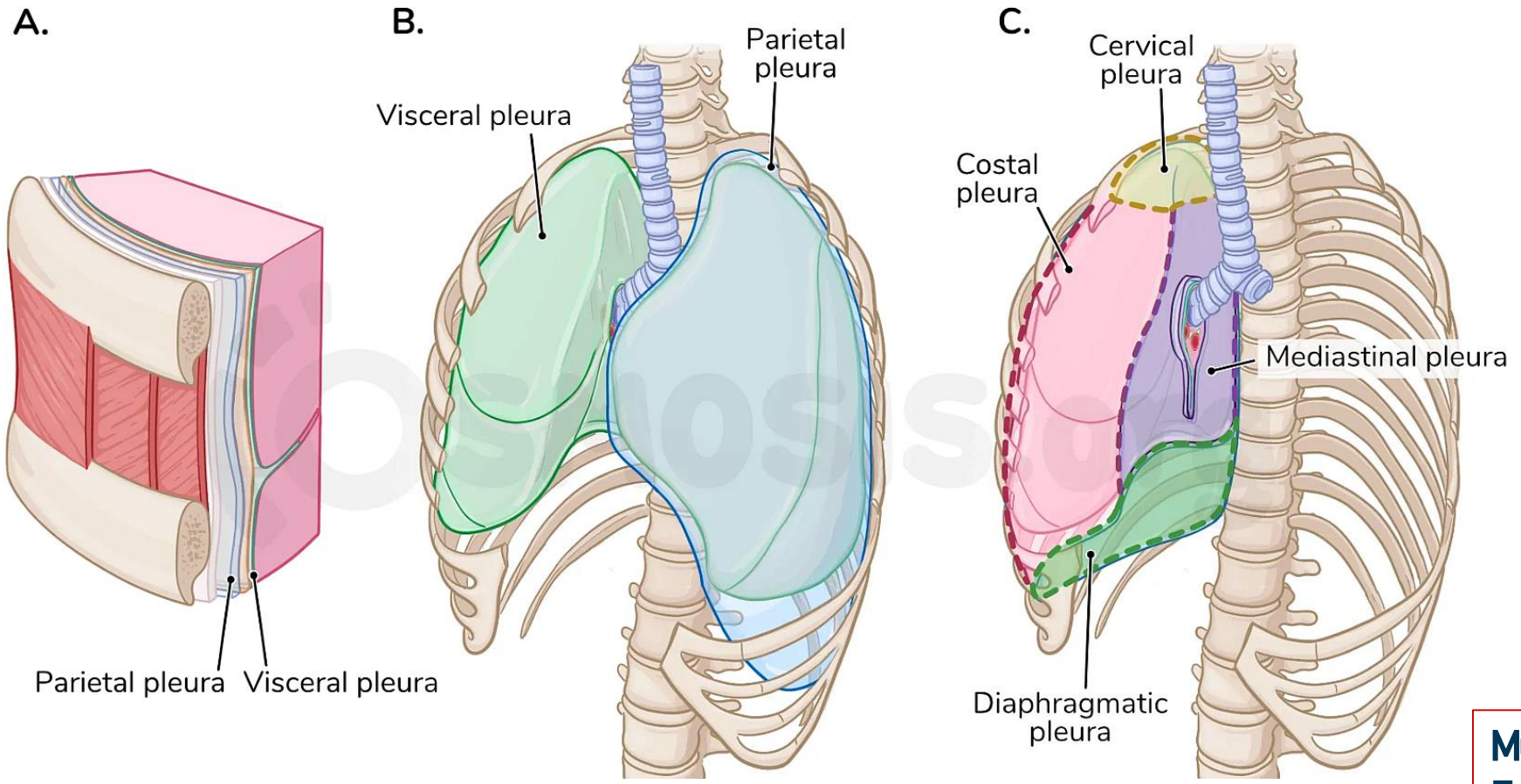
- Nasal cavity, paranasal sinuses
- Larynx – cartilages, muscles (the innervation and function including), membranes, cavities; glottis, vocal ligg. and mm.; princip of fonation
- Bronchial tree – primary, secondary, and tertiary (segmental bronchi – pulmonary segments) – terminal, respiratory bronchioles; respiratory divisions; basic respiratory muscles and dynamics; functional and nutritive pulmonary circulation
- Lungs – segments, fissures, gross anatomy (lingula, pulmonary ligament, hilum right vs. left, impressions); projection of the lung apex, base (lower border of the visceral pleura); secondary pulmonary lobule, lymph drainage
- **Pleura** – visceral and parietal – parts, recesses, projection; borders
- **Mediastinum** – divisions, review of the organs and structures
- **Layers of the thoracic wall**
- **Respiration muscles and mechanics**

THORAX
Learning goals, review

You should be able to describe (demonstrate):

- Boundaries of the thoracic inlet and outlet, and recognize the structures that pass through them
- Layers of the thoracic wall, fascias, structures of the intercostal space
- Pectoral muscles: extrinsic and intrinsic
- Parietal and visceral pleura, the costodiaphragmatic recesses
- Borders and divisions of the mediastinum
- Structures of the mediastinum: superior vena cava, brachiocephalic veins, arch of aorta – brachiocephalic trunk, common carotid aa., subclavian aa., trachea, main bronchi, heart, pericardium, phrenic nerve(s), vagus nerve(s), thoracic duct, sympathetic trunk, splanchnic nerves, azygos veins

Layers of the thoracic wall



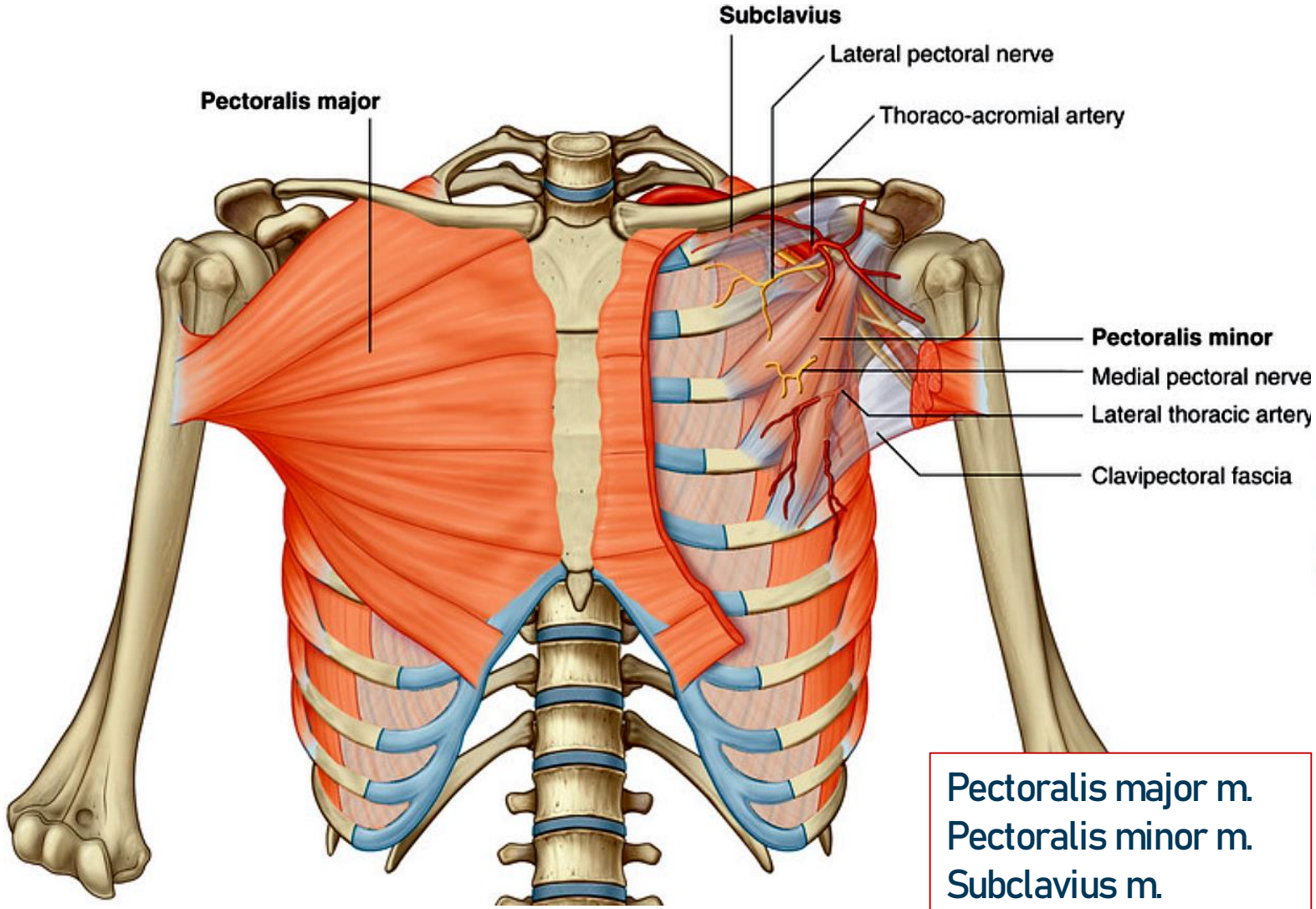
Layers:
Skin
Subcutis
Thoracic (clavipectoral) fascia
Extrinsic pectoral muscles
Ribs and intercostal muscles
Endothoracic fascia
Parietal pleura
Visceral pleura

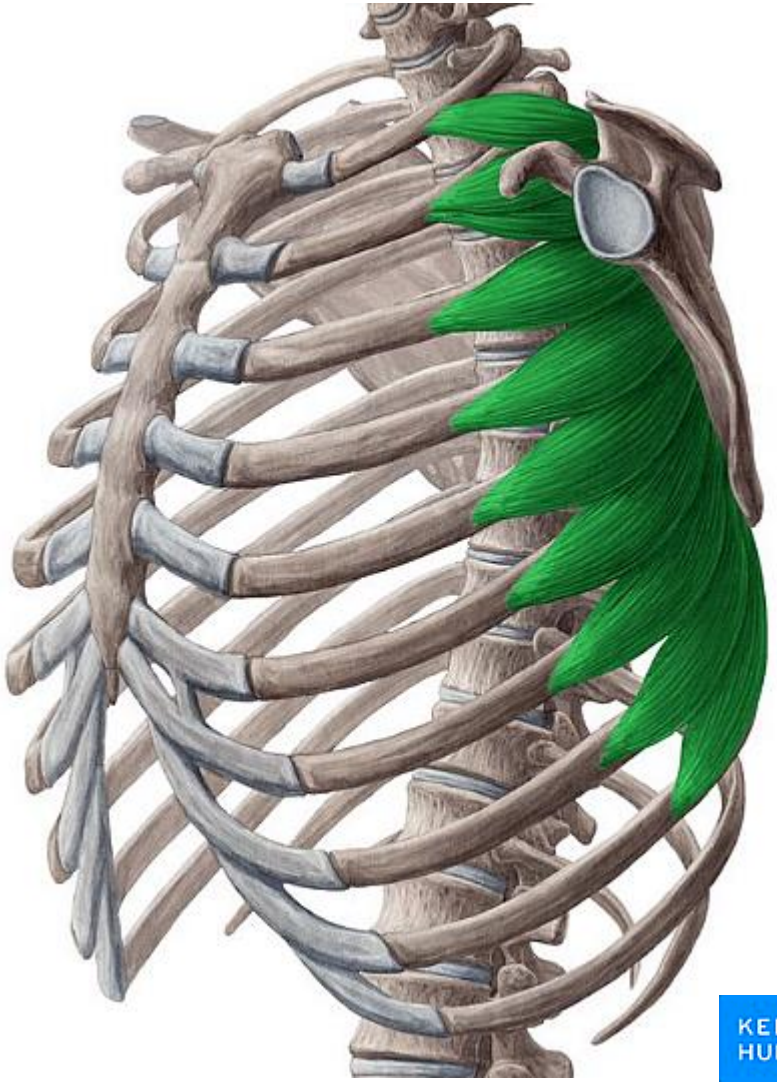
Muscles:
Extrinsic (thoracohumeral)
Intrinsic (intercostal)
Diaphragm

Fig.: Layers of the thoracic wall, visceral (B) and parietal (B, C) pleurae

Pectoral muscles (1)

Extrinsic (thoracohumeral mm): originate from the anterior thoracic wall and insert into bones of the upper limb





Pectoralis major m.
Pectoralis minor m.
Subclavius m.
Serratus anterior m.

KEN HUB

Pectoral muscles (1)

Extrinsic (thoracohumeral mm): originate from the anterior thoracic wall and insert into bones of the upper limb

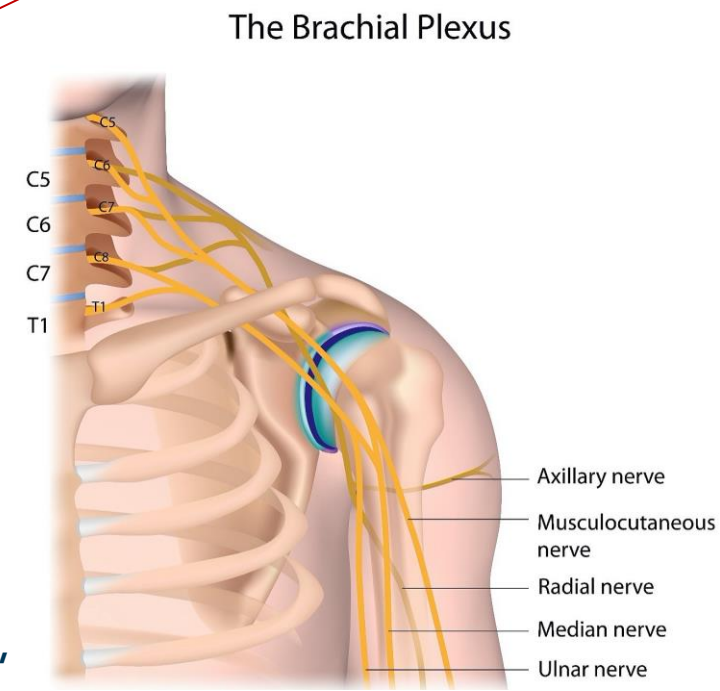
Pectoralis major
O: Medial half of clavicle (clavicular part); sternum, upper six costal cartilages (sternal part); aponeurosis of external oblique muscle (abdominal part)
I: Lateral lip of bicipital groove of humerus
F: Shoulder adduction and medial rotation; clavicular part powers shoulder flexion
IN: Pectoral nerves (C5-T1), brachial plexus

Pectoralis minor
O: Ribs III to V, near costal cartilage
I: Coracoid process of scapula
F: Scapular protraction; powers reach-beyond-reach motion at shoulder
IN: Medial pectoral nerve (C8, T1), brachial plexus

Subclavius
O: 1st rib and costal cartilage
I: Middle one-third of clavicle, inferior surface
F: Clavicular depression; anchors clavicle
IN: Nerve to subclavius (C5, C6), brachial plexus

Serratus anterior
O: Ribs 1-9
I: Scapula: inferior angle and medial border
IN: Long thoracic nerve (C5- C7)
F: Draws-rotates scapula anterolaterally, suspends scapula on thoracic wall (*pulses – scapula alata*)
Mnemonics: 'SALT' (stands for serratus anterior - long thoracic) & 'C5, 6, 7 raise your arms to heaven!'

CAUTION! Innervation comes from the brachial plexus!



Attachments (O = origin, I = insertion) F = Function IN = Innervation

Pectoral muscles (2)

Intrinsic (intercostal mm): fill the intercostal spaces

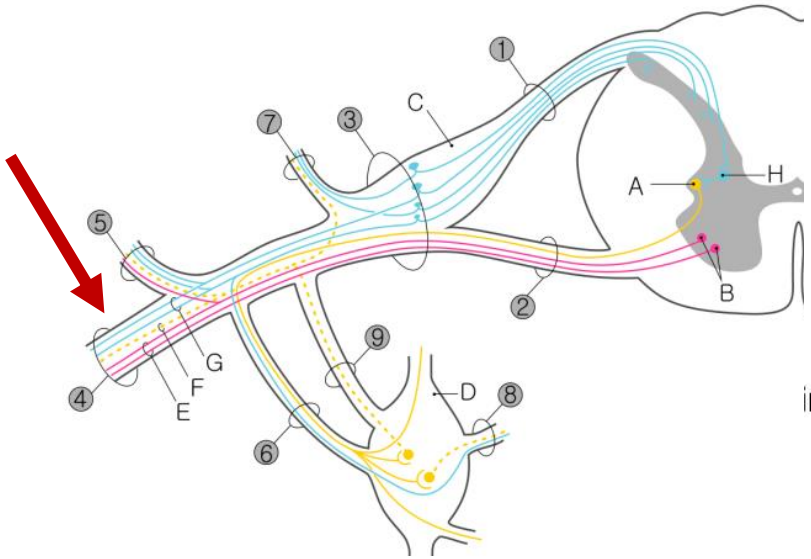
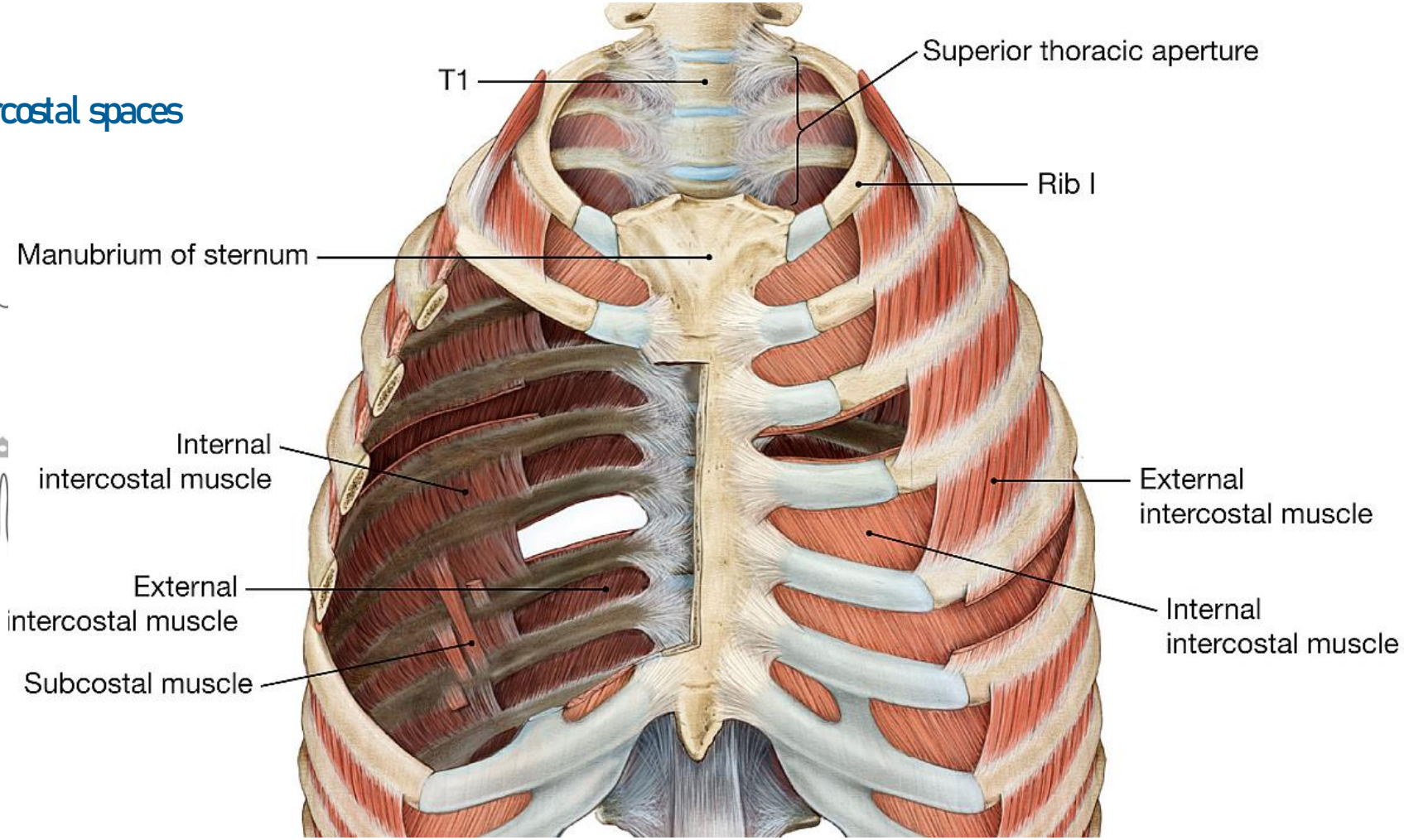


Fig.: Scheme of a spinal nerve



CAUTION: Intercostal nerves are peripheral nerves that originate DIRECTLY from the anterior branches of the thoracic nerves.

Pectoral muscles (2)

Intrinsic (intercostal mm): fill the intercostal spaces

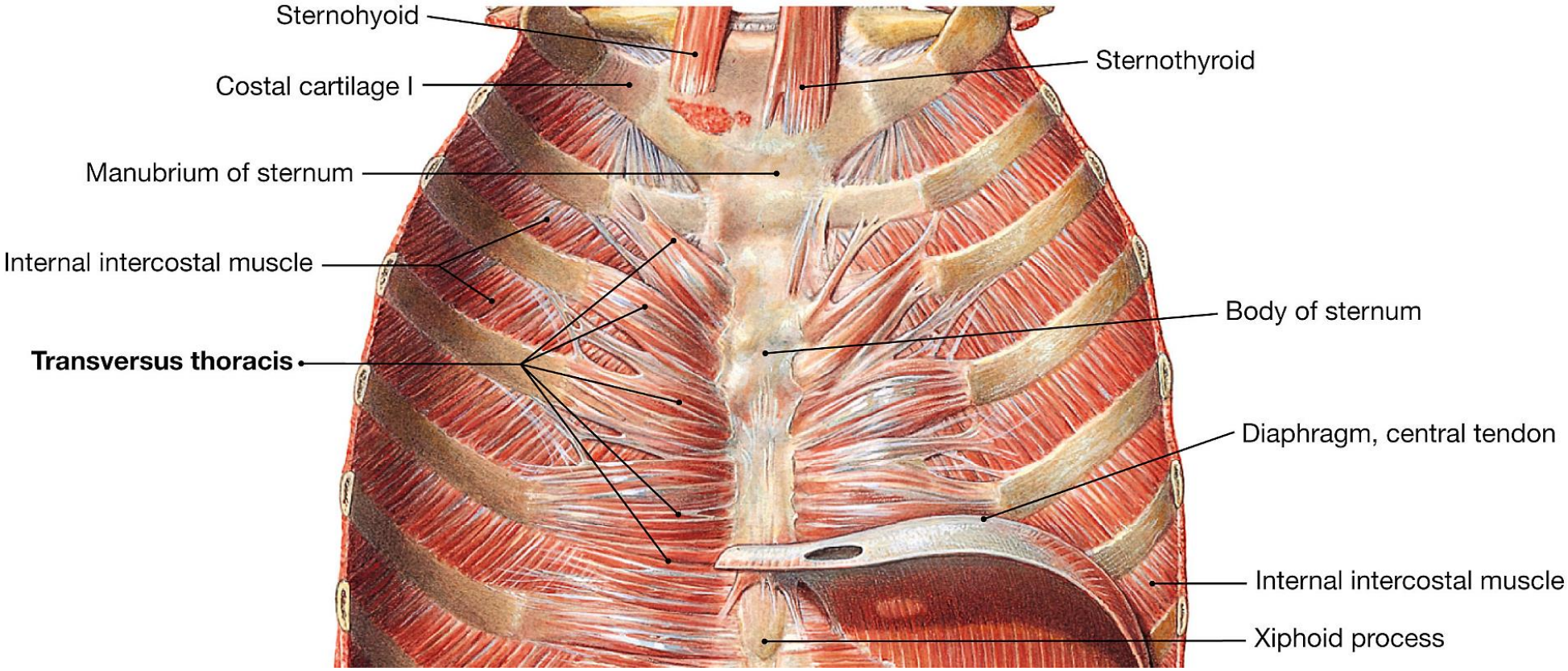


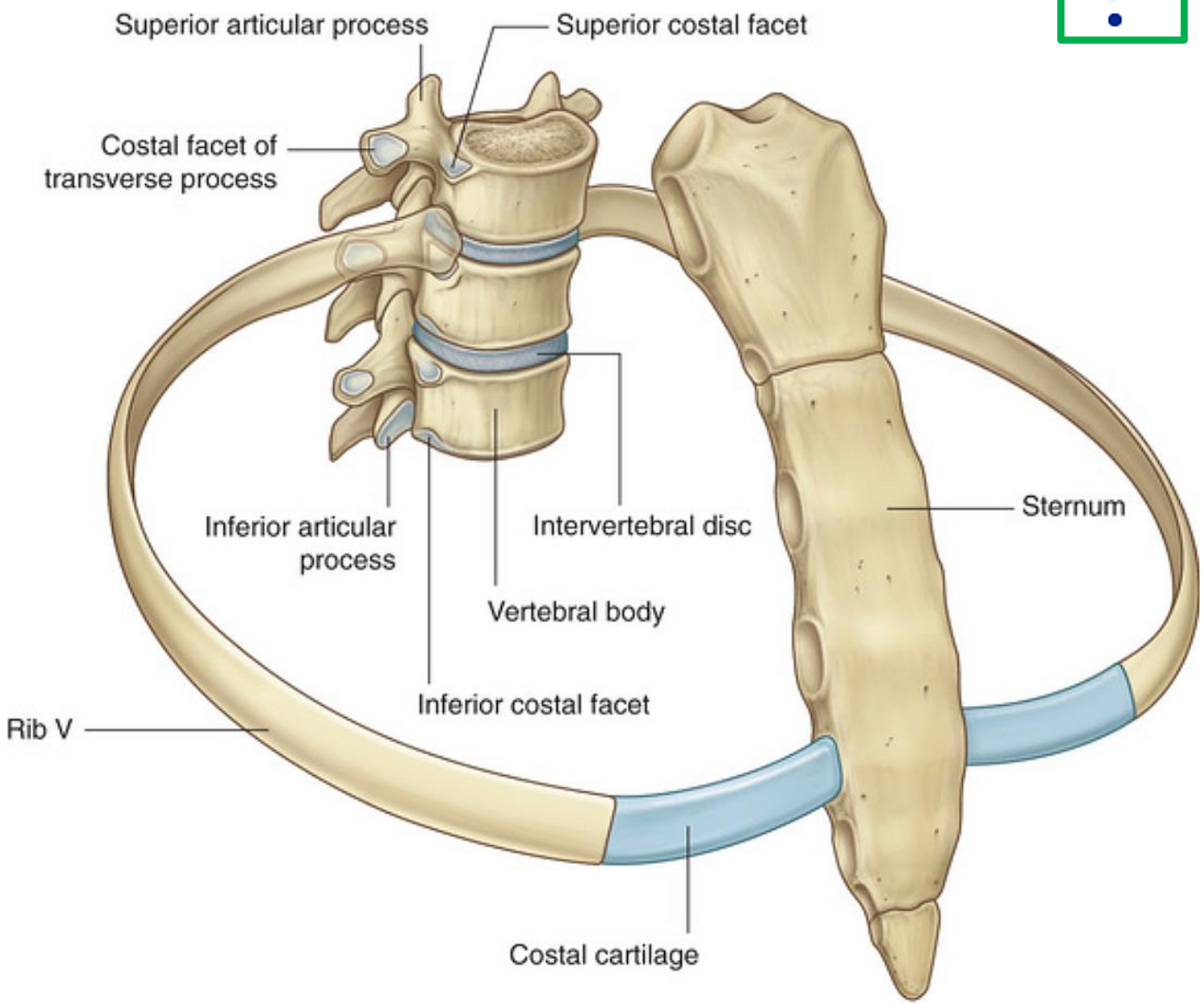
Fig.: Muscles of the anterior thoracic wall; posterior view with posterior part of the thoracic cage removed.

The **external intercostal** muscles project from posterior cranial to anterior caudal, they extend between the **BONY rib** segments. They **elevate the ribs** during inspiration. The **internal and innermost** intercostal muscles project from posterior caudal to anterior cranial, and extend in between the **cartilaginous** parts if the ribs. They act during expiration by **depressing the ribs**. The **subcostal** muscles which stretch across multiple segments and serve the same function as the internal (innermost) intercostal muscles.

Quizzlet: **If you agree** with the statement, **put your hand up**. Thank you :)

1. There are 7 true, 2 false and 3 floating ribs in the thorax.
2. Costal head articulates with the 2 adjacent vertebral bodies, and the intervertebral disc.
3. Sternum possesses the jugular notch.

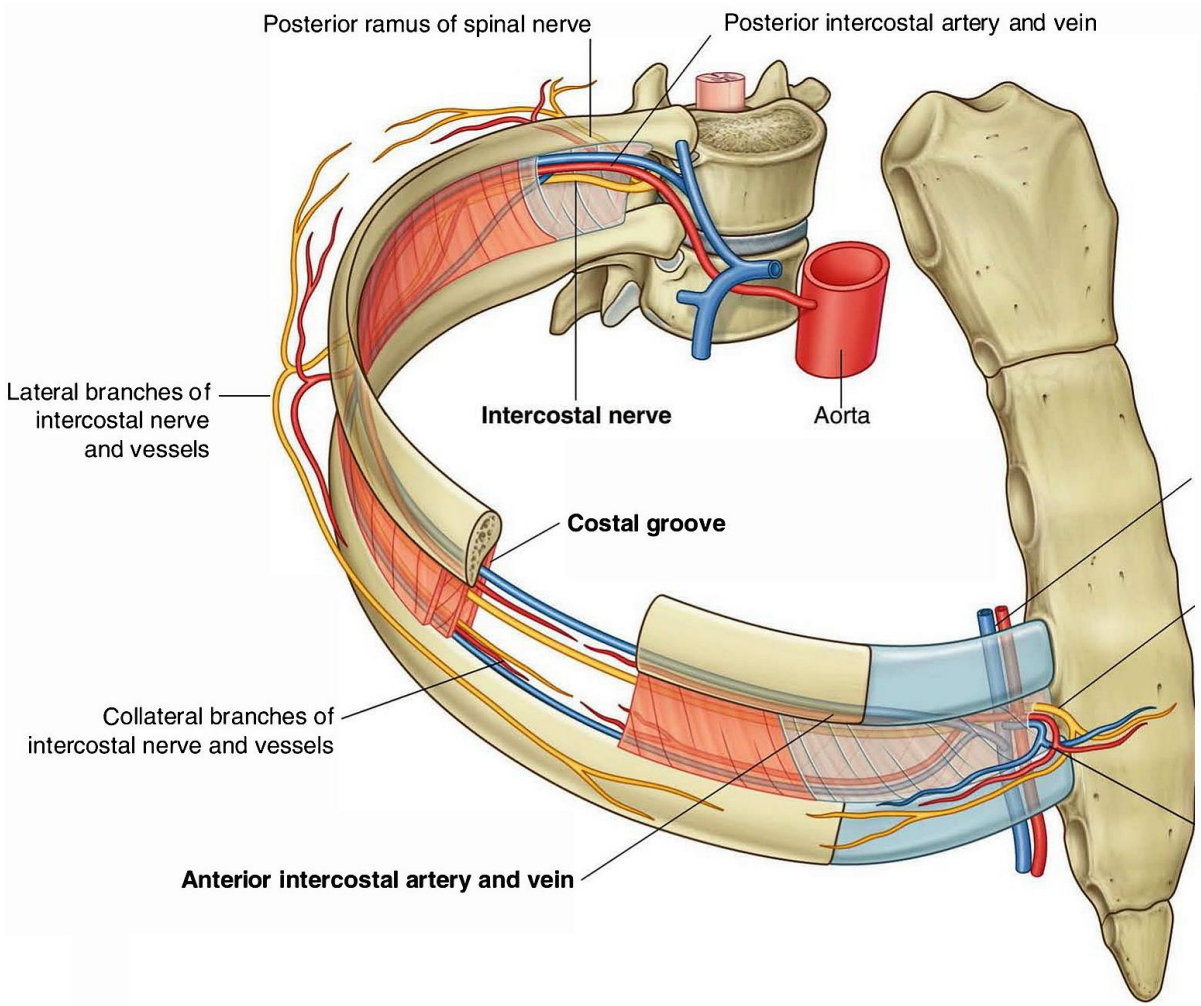
Where is the subcostal groove?

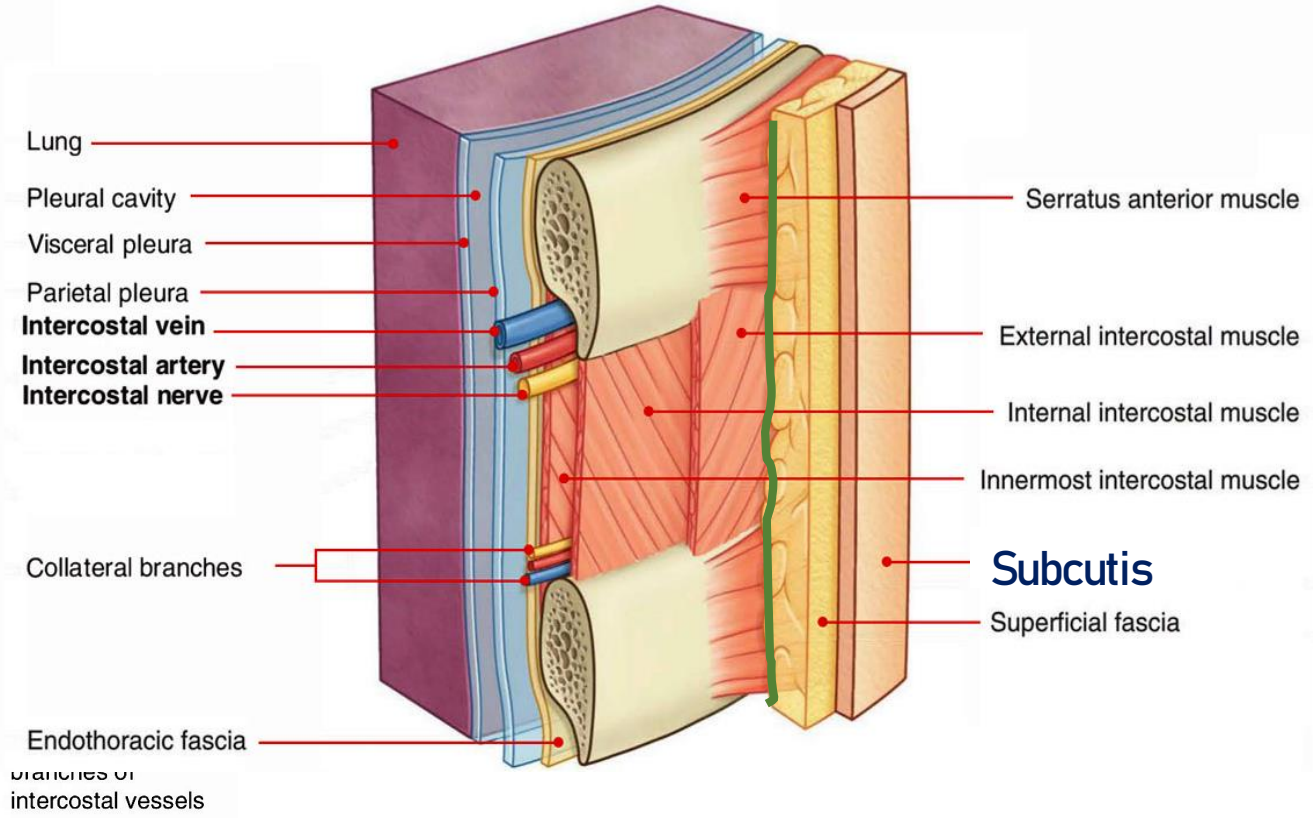


Intercostal space and structures

Mnemonics: VAN
Posterior intercostal Vein
Posterior intercostal Artery
Intercostal Nerve

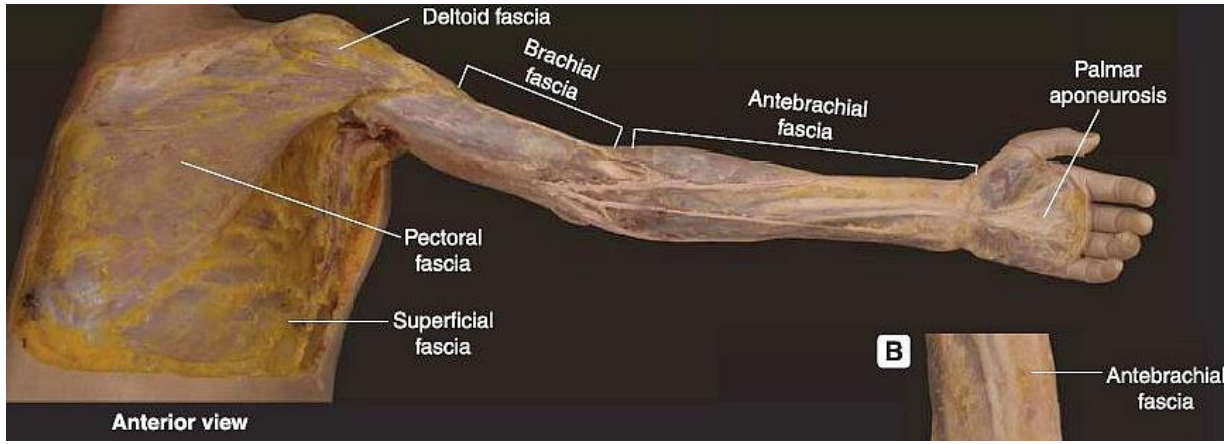
FASCIAS?





Pectoral fascias

Thoracic fascia (superficial)
Clavipectoral fascia (! pectoralis minor and subclavius muscle)
Endothoracic fascia



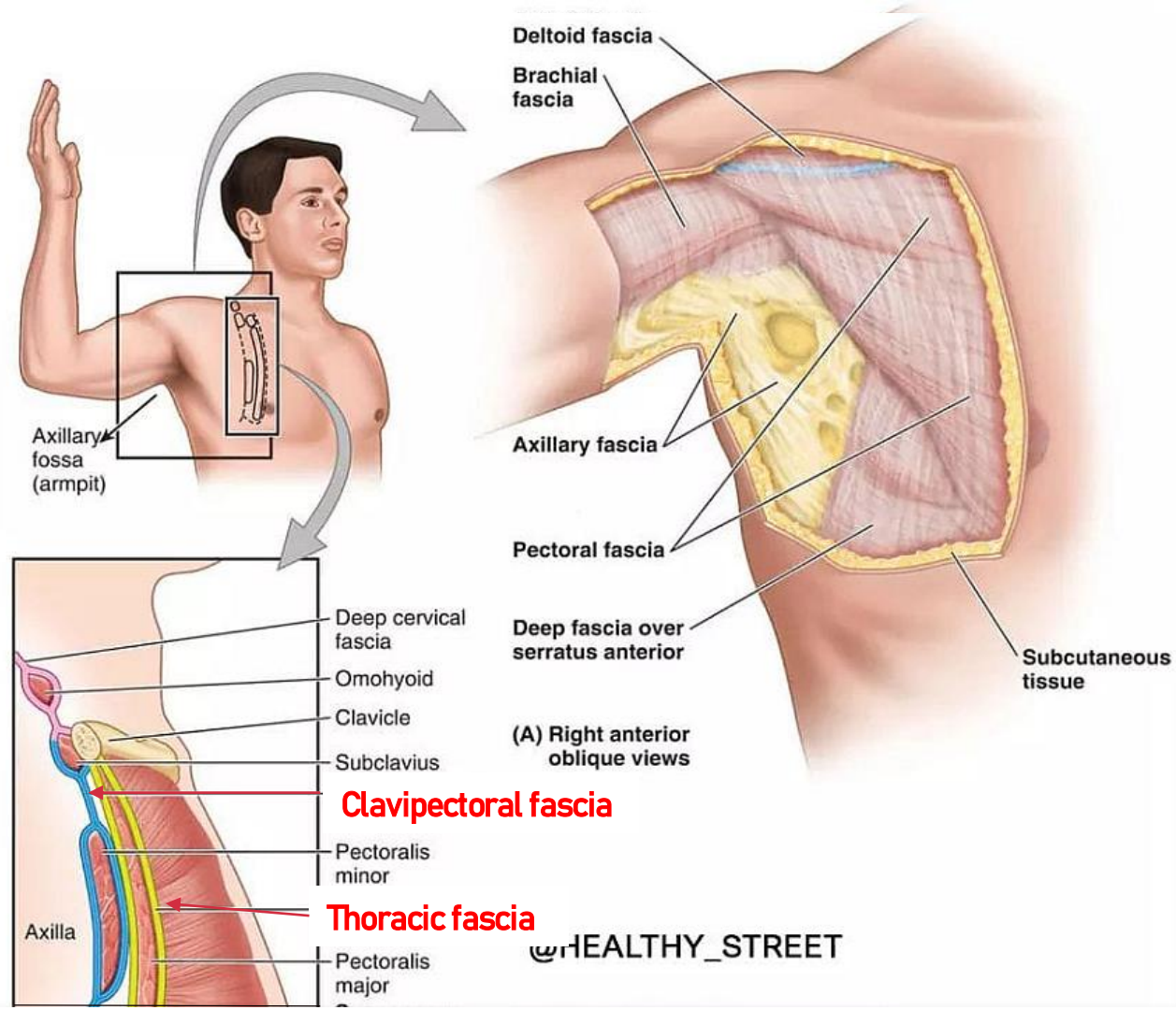
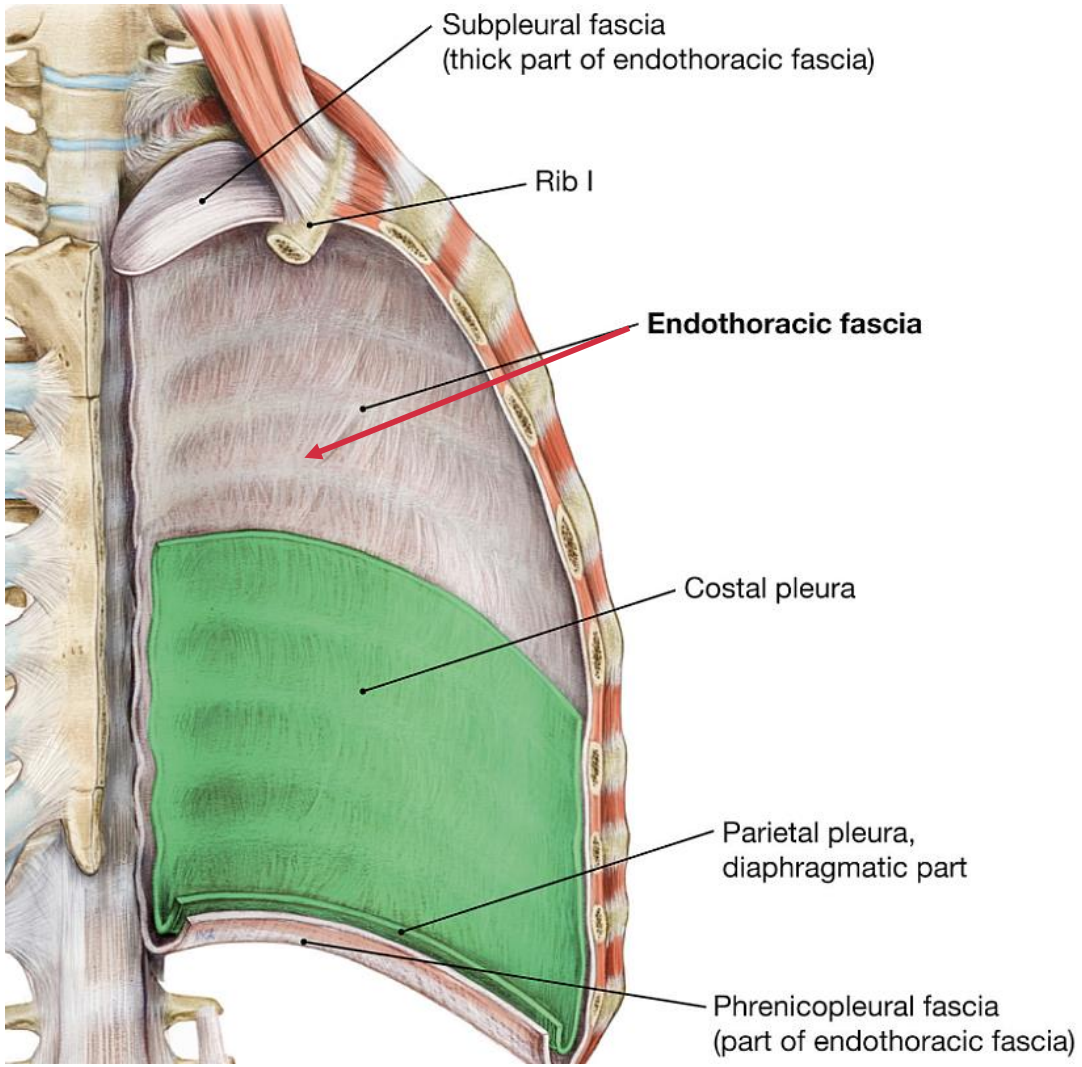


Fig.: Thoracic fascia continues into the axillary and brachial fascia

Pectoral fascias

Endothoracic fascia: between the intercostal muscles and parietal pleura



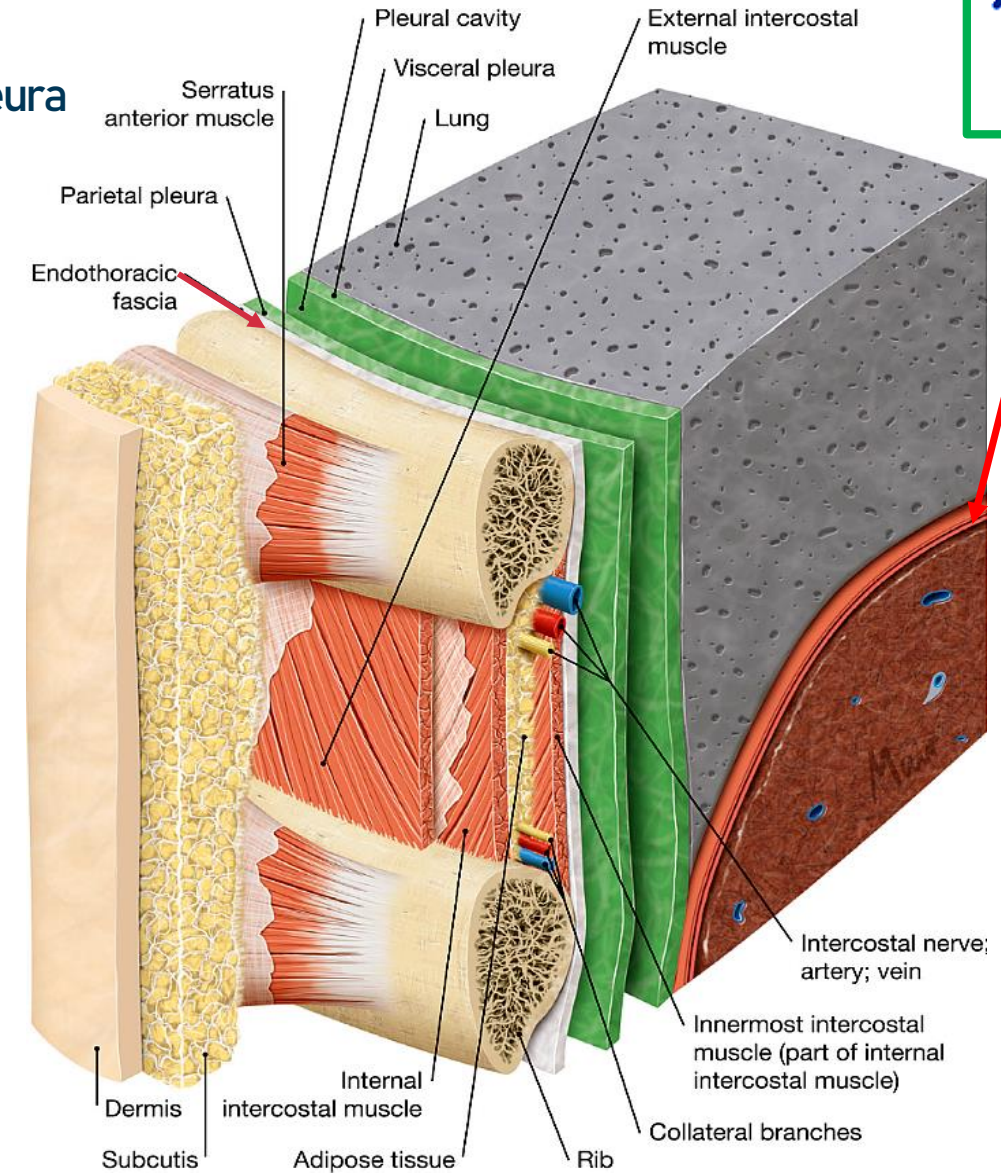


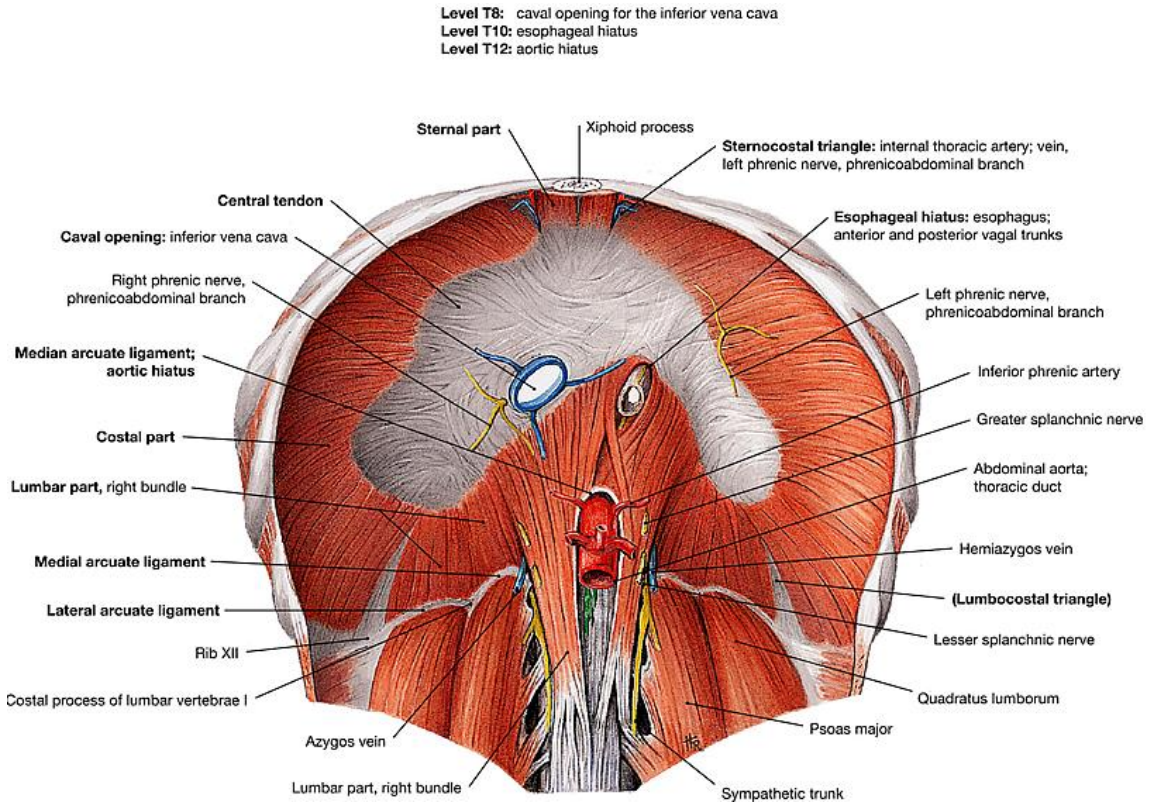
Fig.: Layers of the thoracic wall

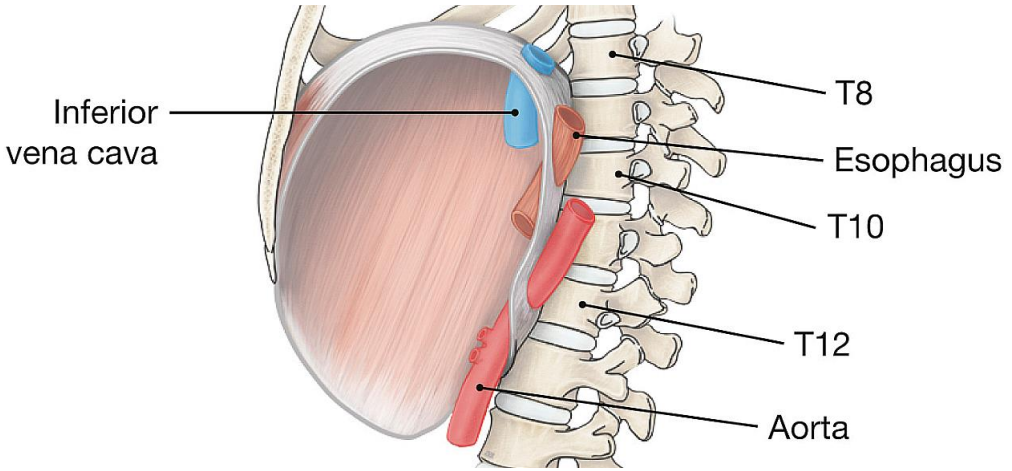
Pectoral muscles – diaphragm

The musculotendinous diaphragm seals the inferior thoracic aperture. Muscle fibers of the diaphragm arise radially from the large **central tendon**. Because of the oblique angle of the bony inferior thoracic aperture, the posterior attachment of the diaphragm is inferior to the anterior attachment.

The diaphragm form domes superiorly. The **right dome** is higher than the left, reaching **as far as rib V**.
The **esophagus** and **inferior vena cava** penetrate the diaphragm; the aorta passes posterior to the diaphragm.

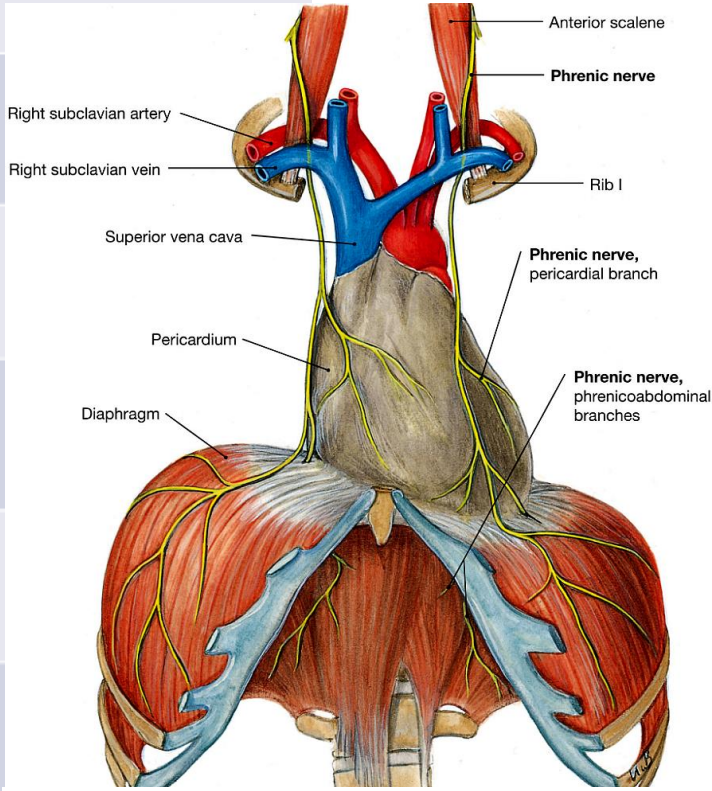
Notice – which tissue surrounds the inferior vena cava, eosophagus and aorta?





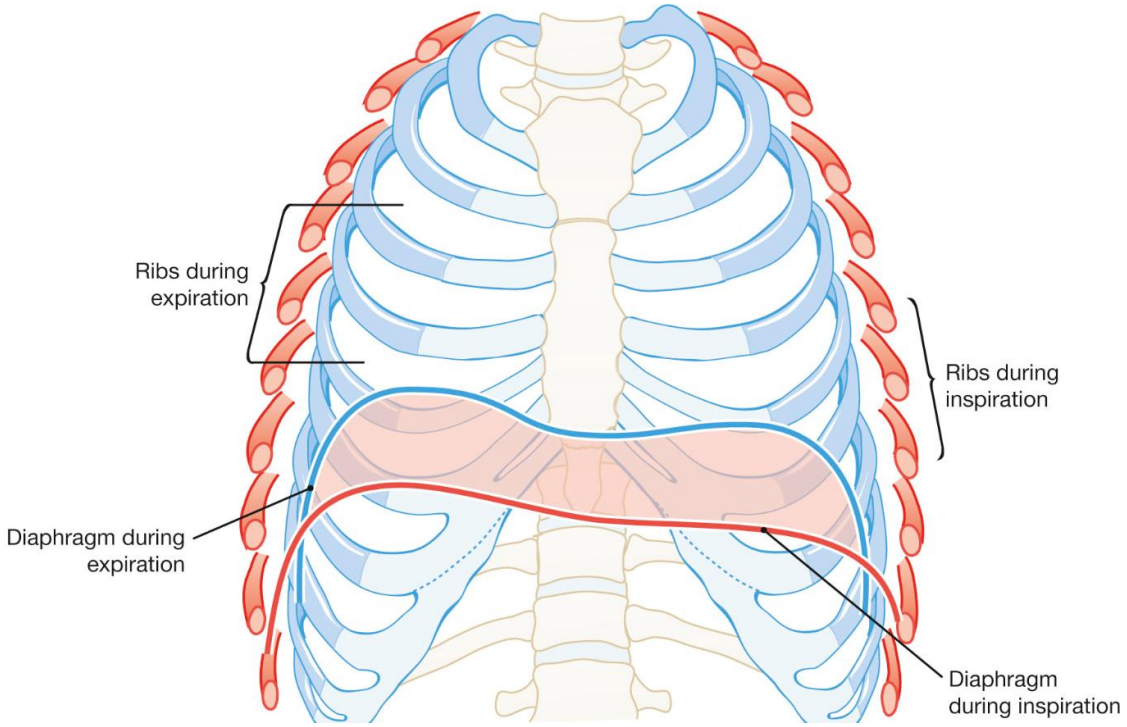
Muscles of Respiration

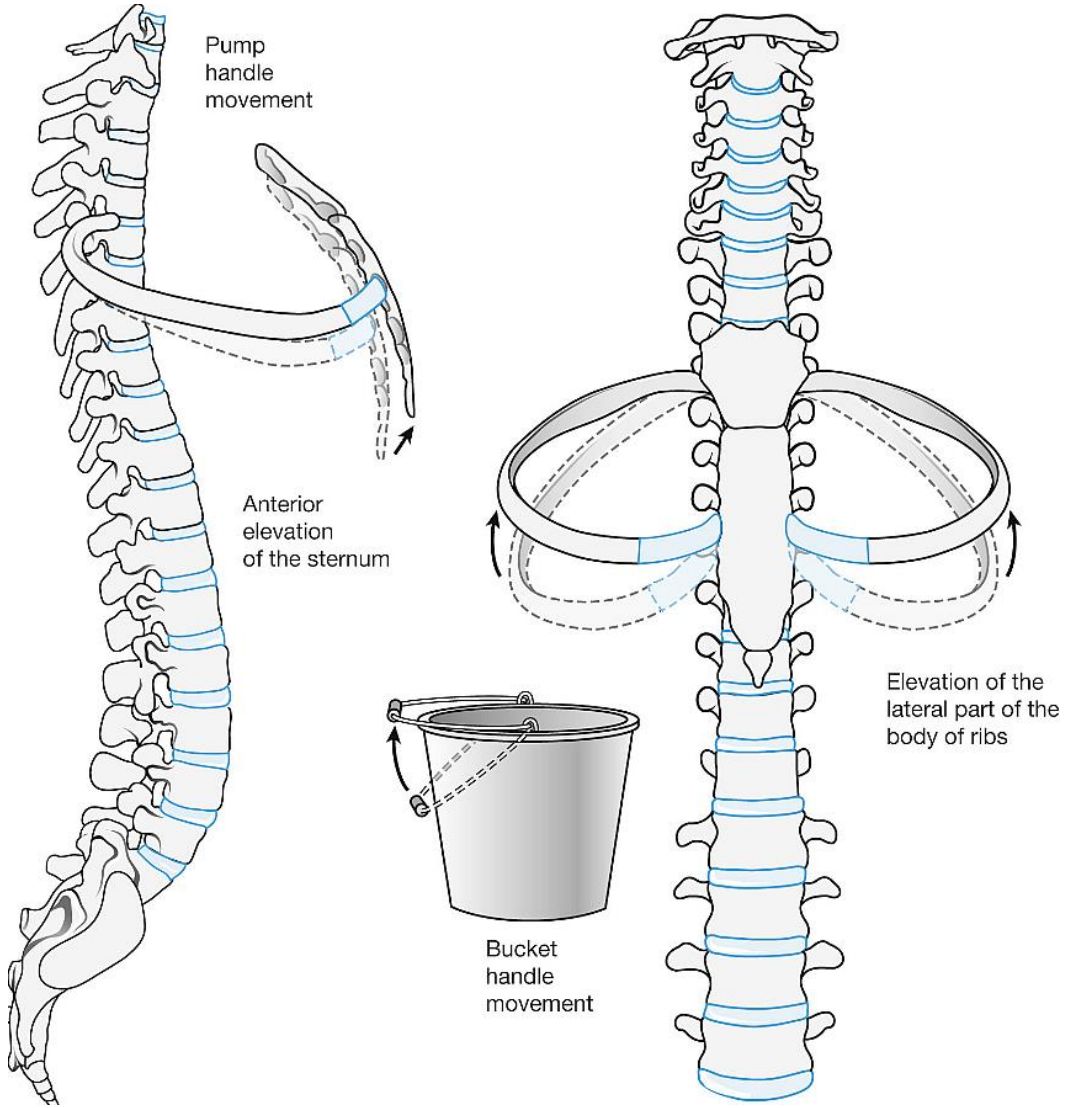
Muscle	Innervation	Action
Scalene muscles (anterior, middle and posterior scalene)	Muscular branches of cervical and brachial plexus (C3–C6)	Inspiration (auxiliary) Elevation of 1st rib (anterior and middle scalene muscles) and of 2nd rib (posterior scalene muscle)
External intercostal muscles	Intercostal nerves	Inspiration (elevation of ribs)
Internal intercostal muscles	Intercostal nerves	Expiration (depression of ribs)
Innermost intercostal muscles	Intercostal nerves	Expiration (depression of ribs)
Transversus thoracis muscle	Intercostal nerves	Expiration (depression of ribs)
Subcostal muscle (inconsistent)	Intercostal nerves	Expiration (depression of ribs)
Diaphragm	Phrenic nerve (C3–C5)	Inspiration
Latissimus dorsi muscle	Thoracodorsal nerve (C6–C8)	Forced expiration (coughing) Compresses lower rib cage when arms are fixed



Phrenic nerve – cervical plexus – C3-5 C4!!

Respiratory mechanics





As the **diaphragm contracts**, the height of the domes decreases and the volume of the thorax increases. In forced respiration, **the auxiliary inspiratory muscles** of the thoracic wall contribute to increased transverse and anteroposterior dimensions of the thorax. **Normal expiration is a passive action.**

Notice the function of the negative pressure in the pleural cavity!

Inferior thoracic aperture

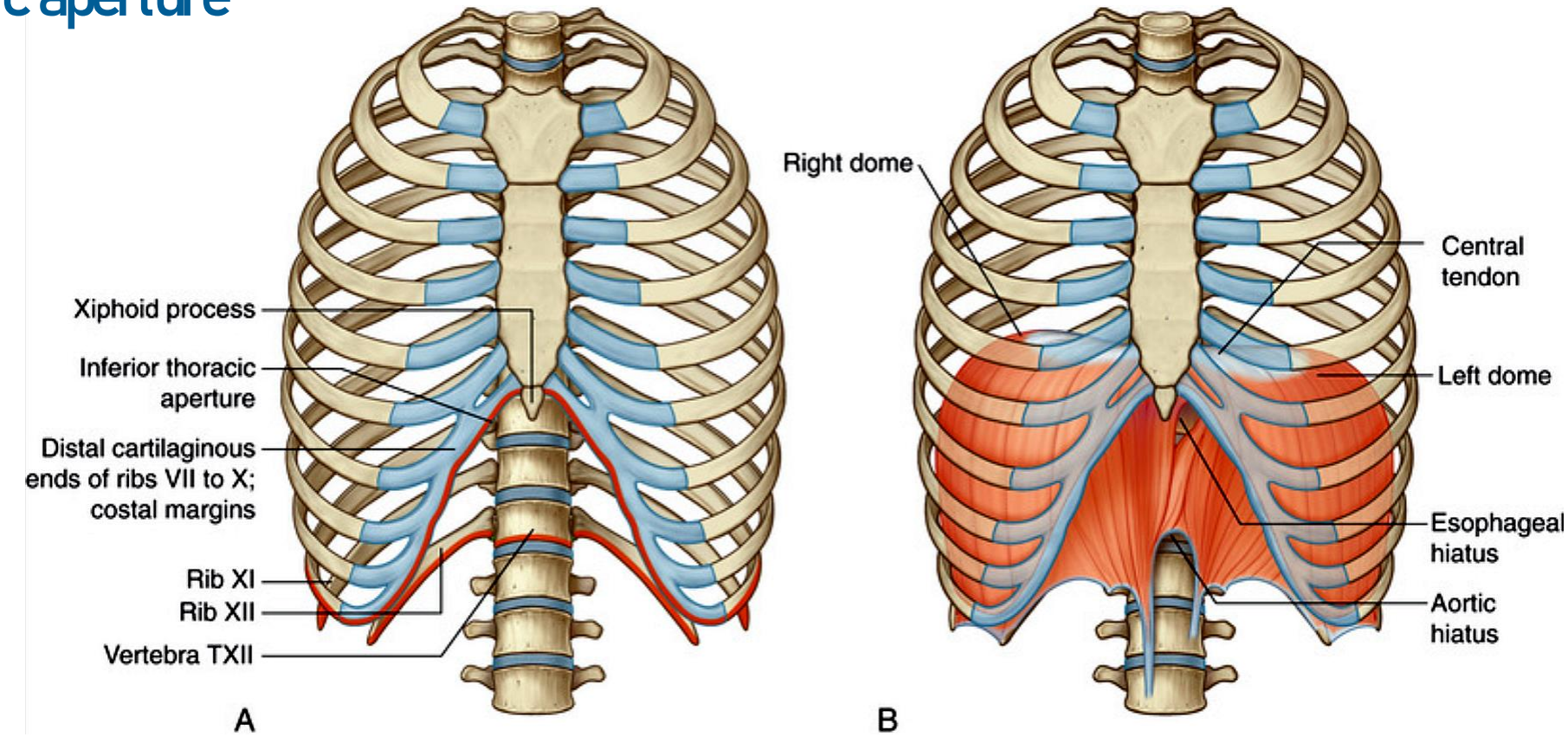


Fig. B: Deep border – diaphragm

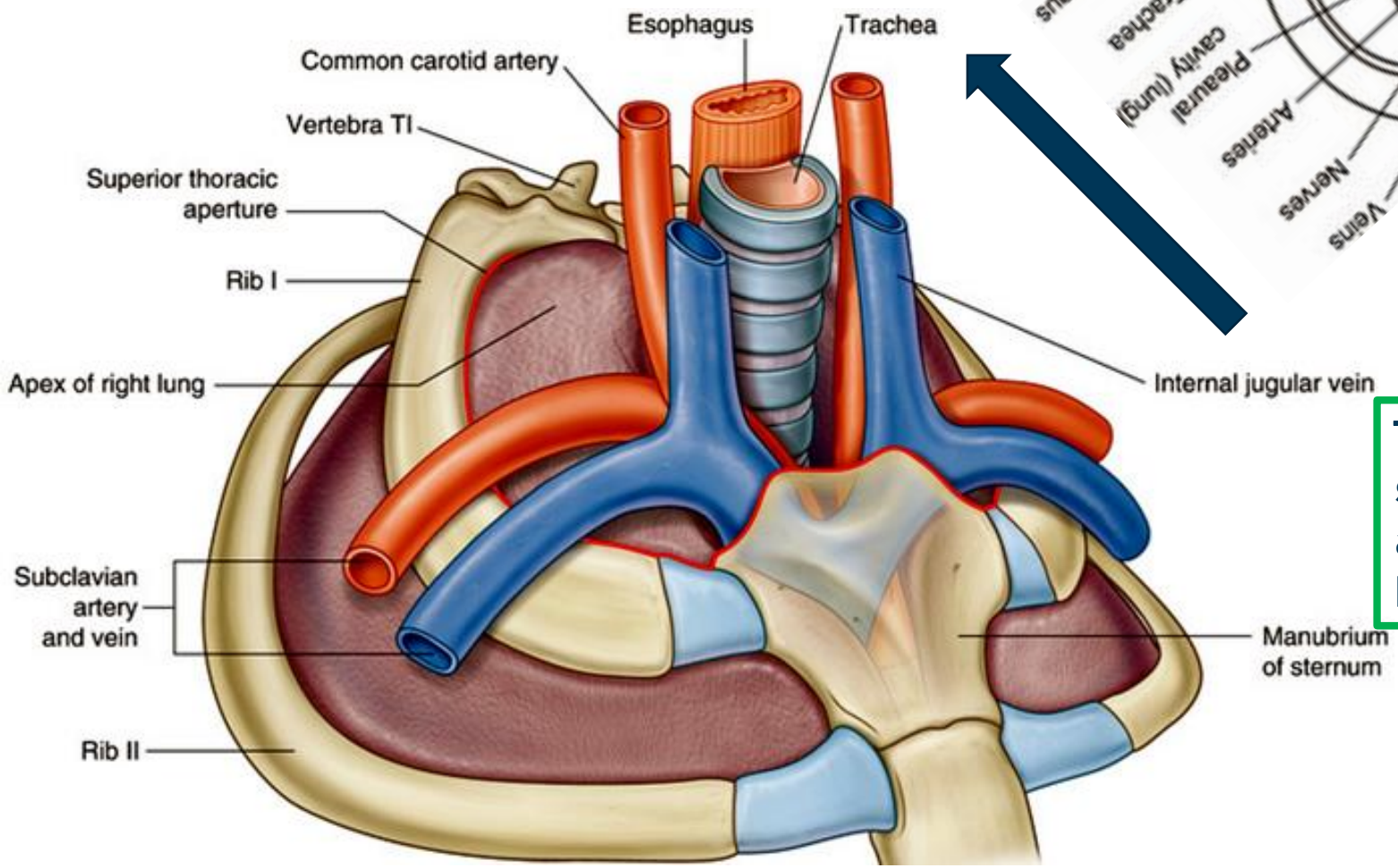
The inferior thoracic aperture is closed by the diaphragm, and structures passing between the abdomen and thorax pierce it.

Inferior thoracic aperture, superficial border **(Fig. A)**:

- vertebra TXII posteriorly,
- lower edge of the ribs
- the xiphoid process anteriorly

Superior thoracic aperture

Border:
Sternum, 1st rib, 1st thoracic vertebra



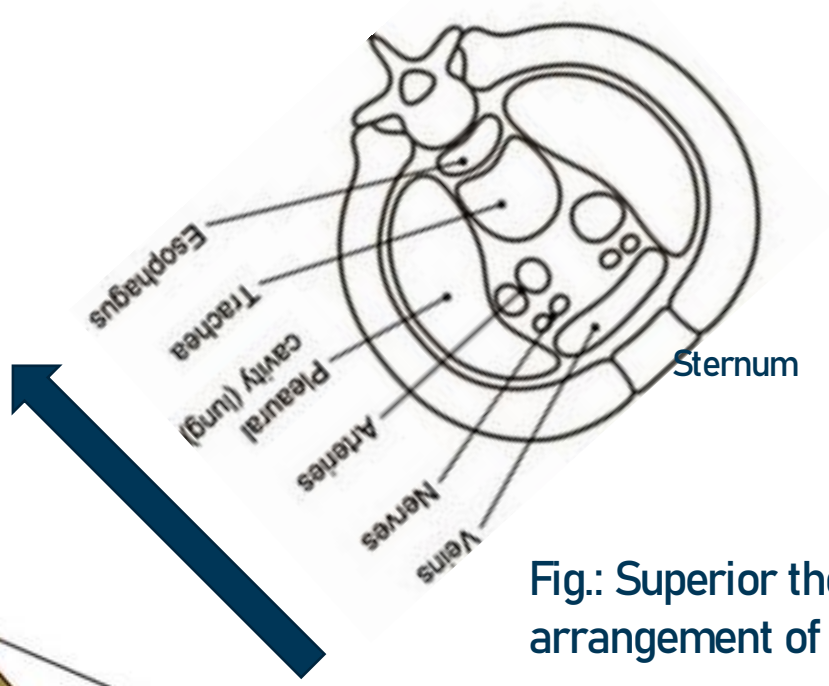
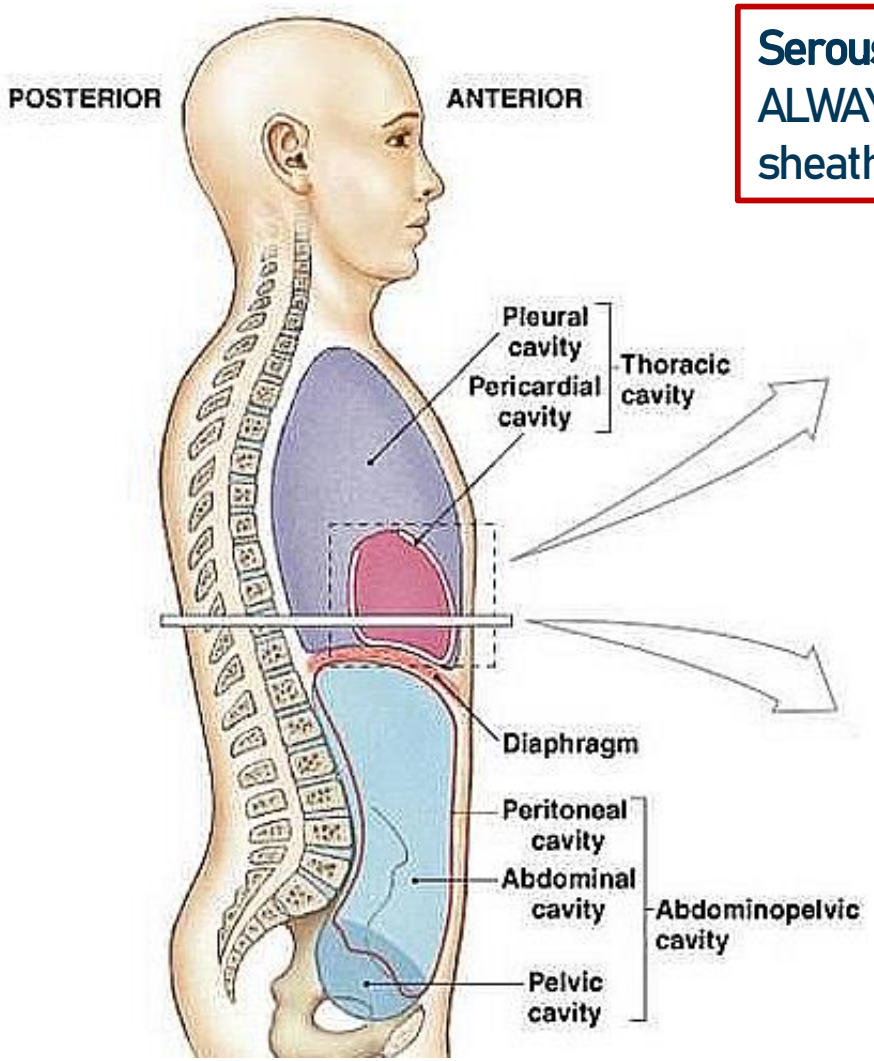


Fig.: Superior thoracic aperture, arrangement of organs (structures)

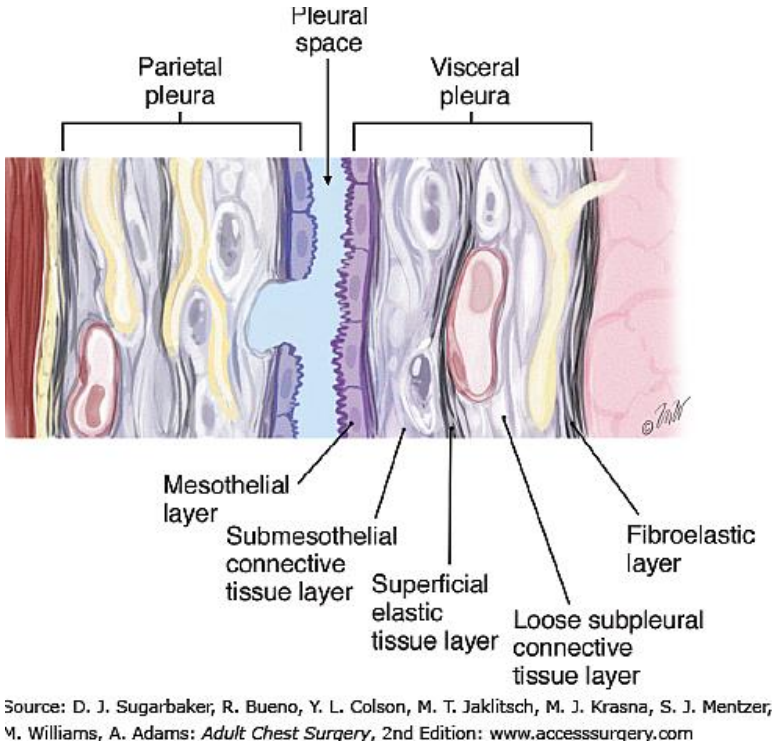
The thoracic cavity is found between the superior and inferior thoracic apertures. There are 2 pleural cavities and the mediastinum in between

Coelomic cavities, serous membranes



Serous membranes:
ALWAYS the **parietal and visceral** sheath

Serous membranes:
pleura
pericardium
peritoneum



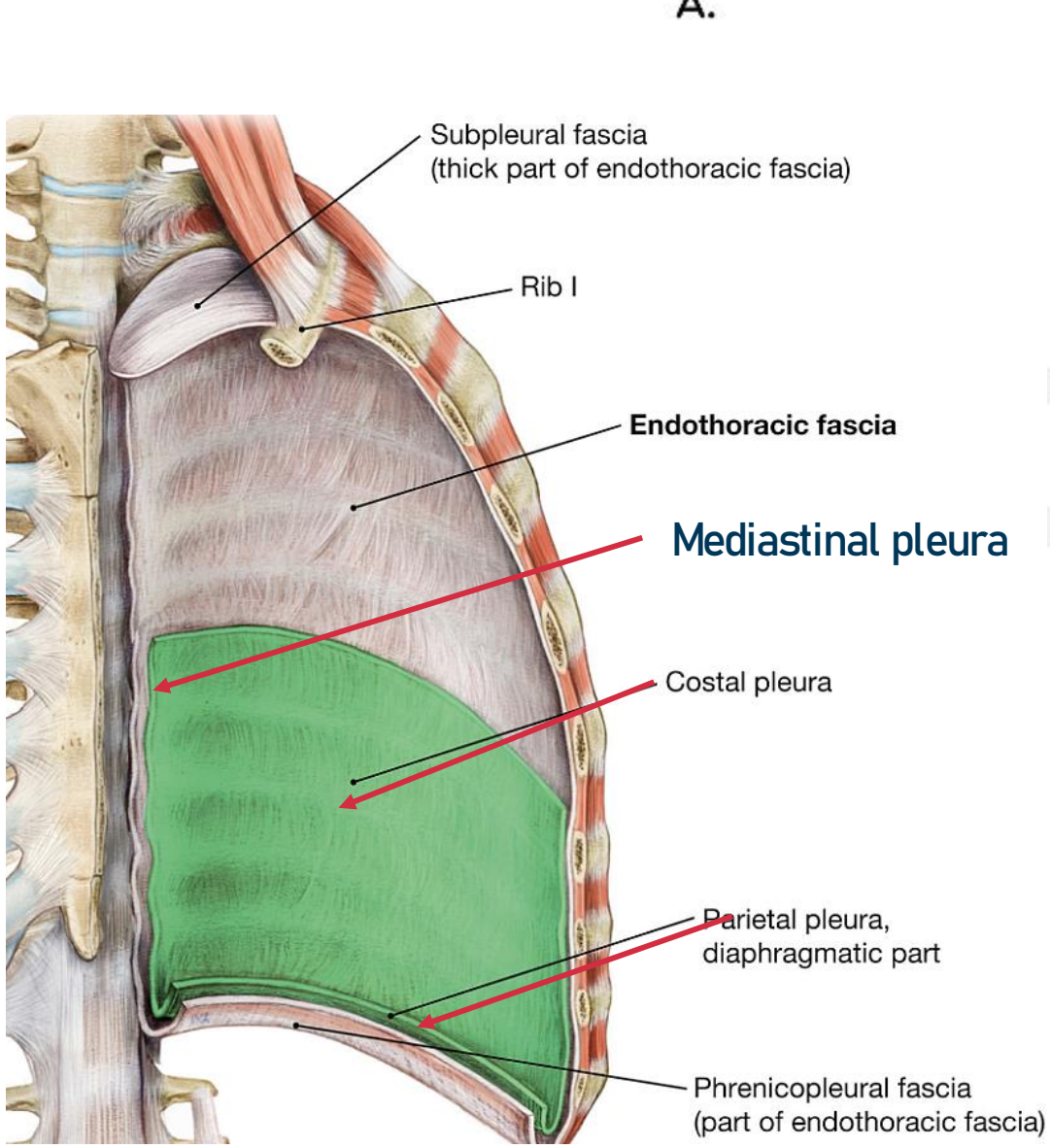
Source: D. J. Sugarbaker, R. Bueno, Y. L. Colson, M. T. Jaklitsch, M. J. Krasna, S. J. Mentzer, M. Williams, A. Adams: *Adult Chest Surgery*, 2nd Edition: www.accesssurgery.com

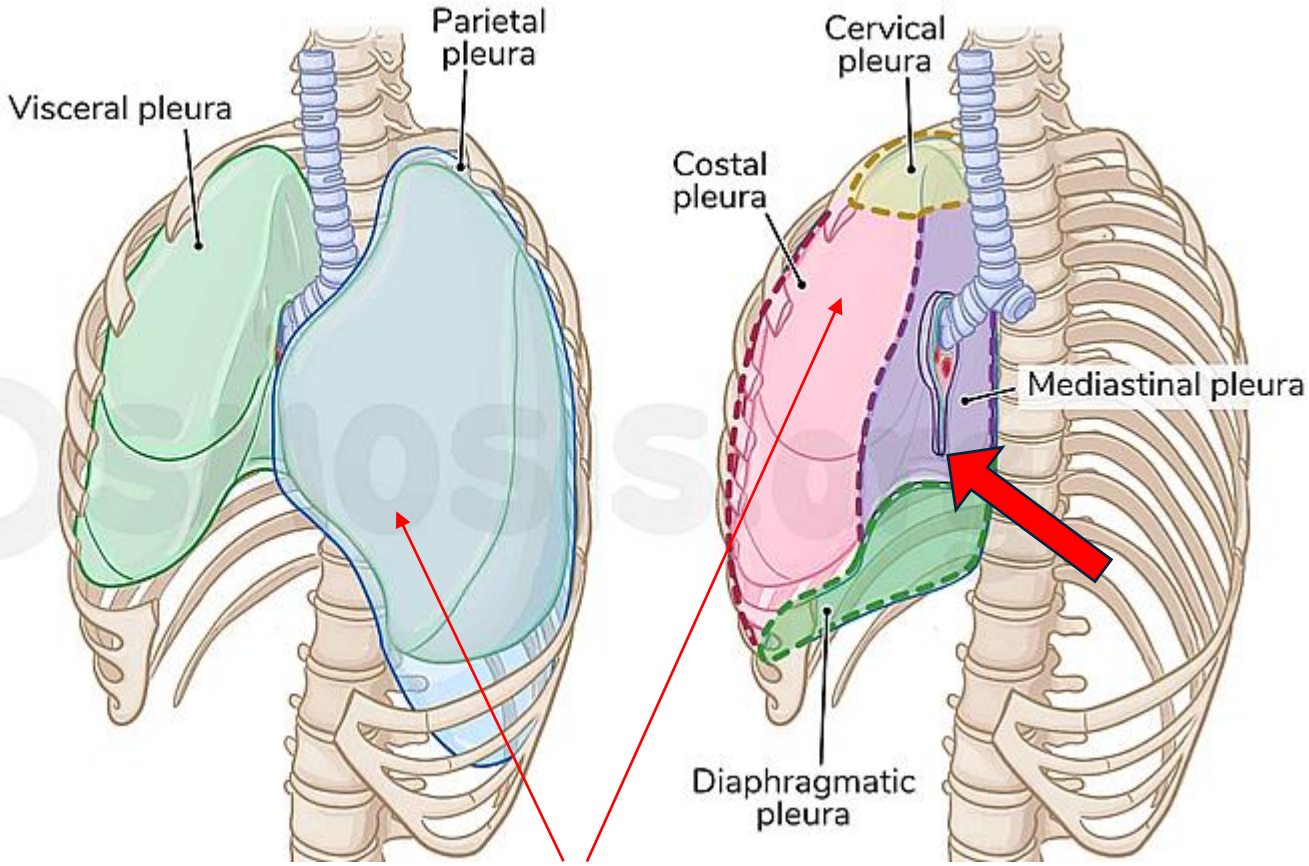
Fig.: Structure of a serous membrane

Mesothelial cells, connective tissue
! Rich vasculature and innervation!

Pleural visceral and parietal

The dome-shaped layer of parietal pleura lining the cervical extension of the pleural cavity is the **cervical pleura** (pleural cupola).



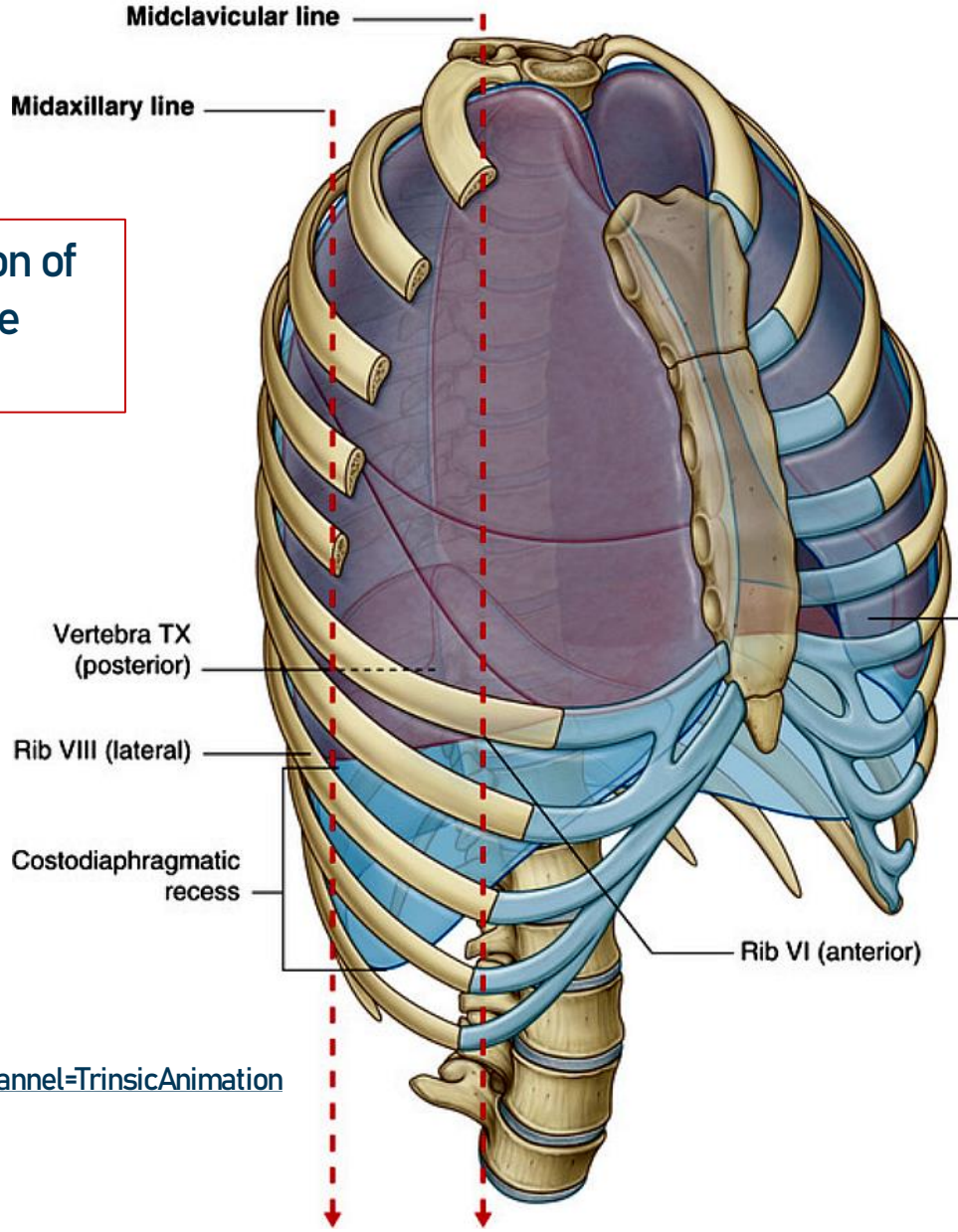


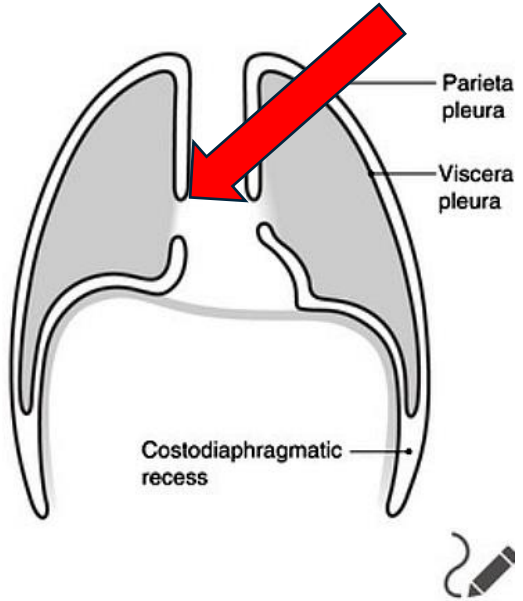
The parietal pleura adheres to the thoracic wall (**costal part**), at the costomediastinal recess continues into the **mediastinal part**. Caudally it continues onto the diaphragm (**diaphragmatic part**), the costodiaphragmatic recess is the deepest space of the pleural cavity. Red arrow – pulmonary ligament, see the next slide.

Pleural recesses

Costodiaphragmatic recess – collection of pleural effusion – **deepest space** of the pleural cavity

Costomediastinal recess
Phrenicomediastinal recess





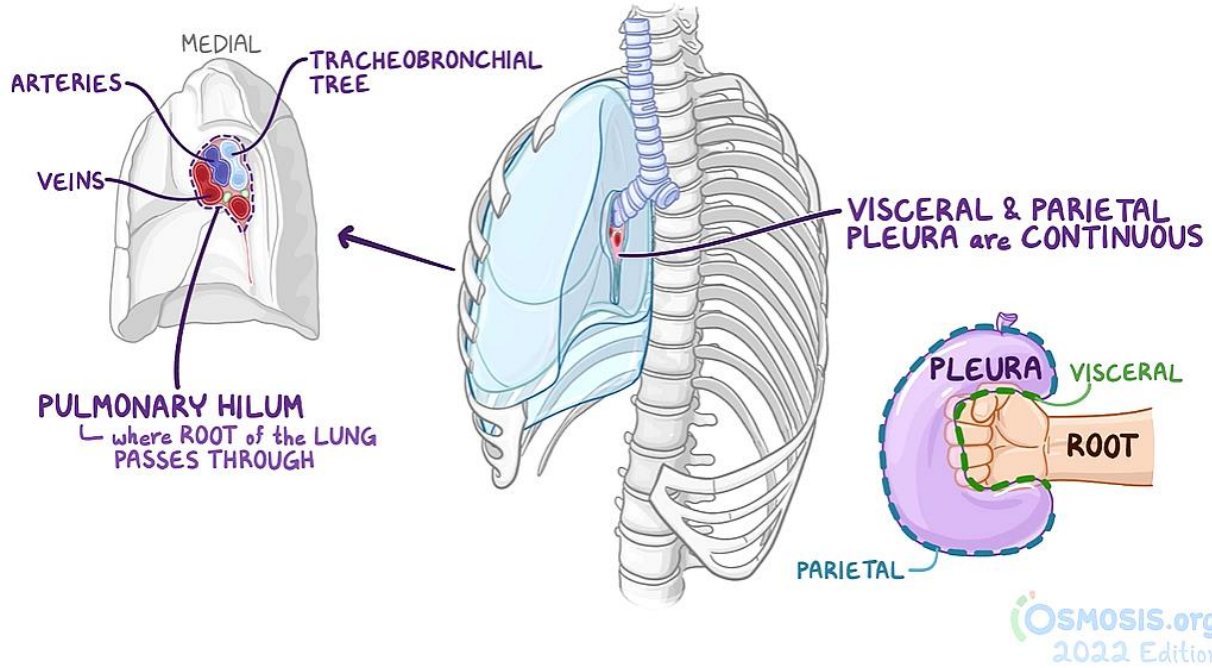
Parietal pleura FLUENTLY continues into the visceral pleura at the pulmonary hilum (red arrow), the **pleural duplication** is called the **pulmonary ligament**.

Pleural effusion, thoracenthesis
https://www.youtube.com/watch?v=z0dCL4CHGSk&ab_channel=TrinsicAnimation

Pleura, time for the video! or a quick break :)

Watch this video first (9 mins), it may help you to answer the following questions.
https://www.osmosis.org/learn/Anatomy_of_the_pleura

Anatomy of the pleura



1. Can the deepest space of the pleural cavity be filled with a fluid?
2. Does the parietal pleura continue with the visceral one?
3. Does the visceral pleura reach the depth of the lung fissures?

OSMOSIS from ELSEVIER

ANSWERS

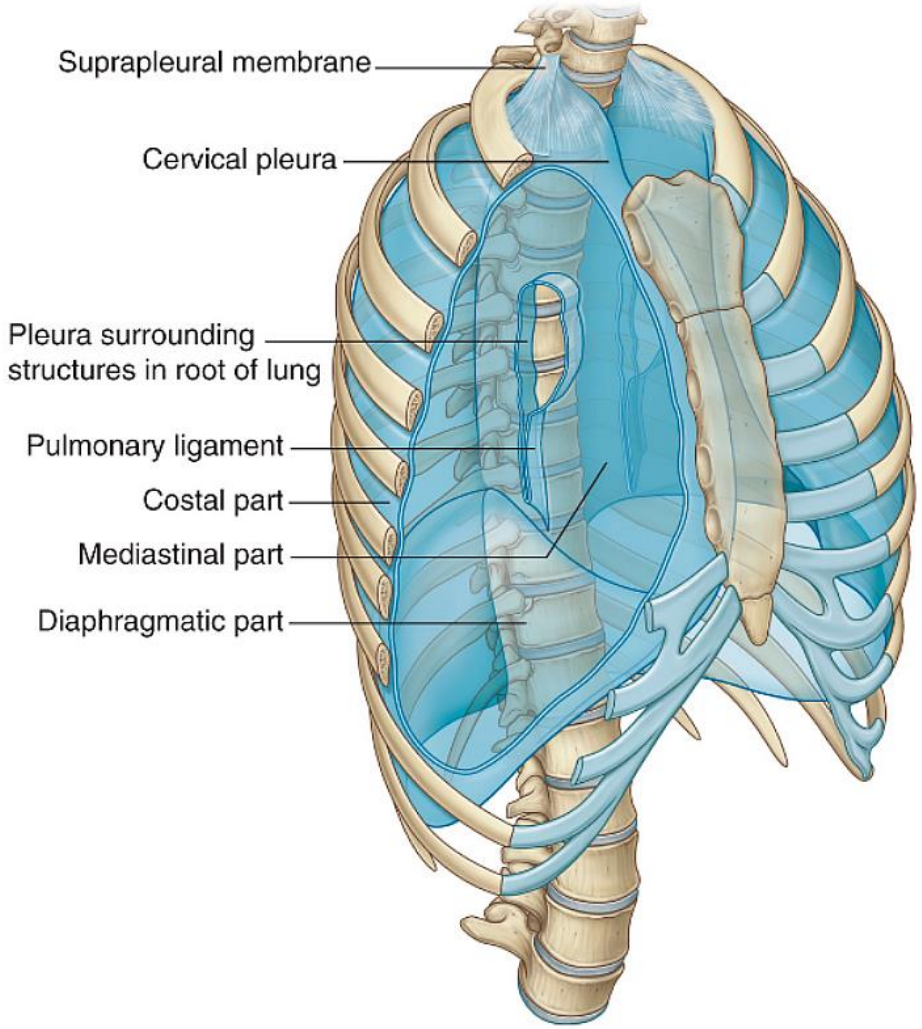
- Yes.

In the costodiaphragmatic recess, where the diaphragmatic pleura continues into the costal one.

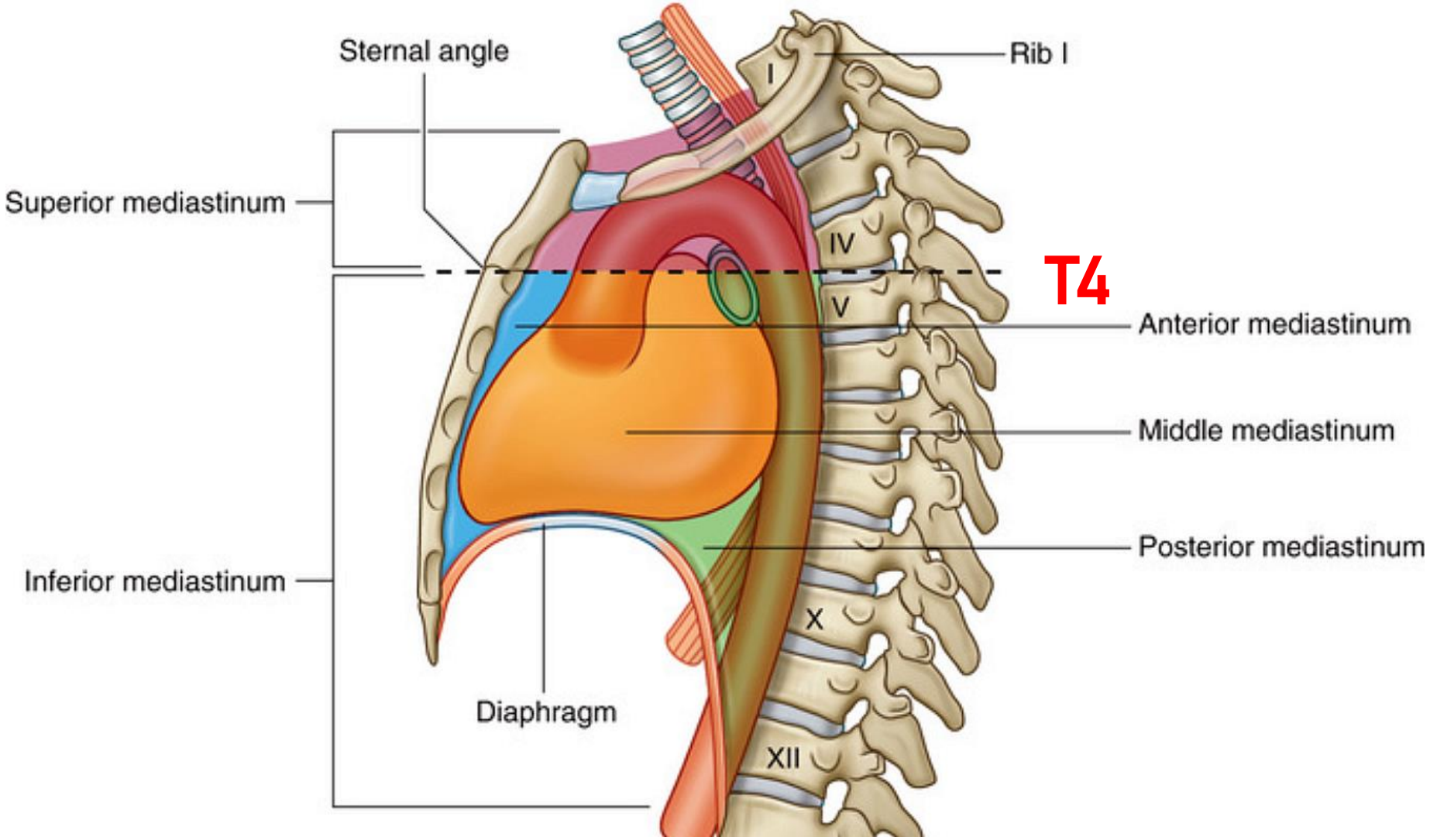
- Yes.

Around the hilum they fluently continue with each other, the line is visible and forms caudally the pulmonary ligament.

- *Yes, it does. It copies the surface of the organ, the fissures including.*

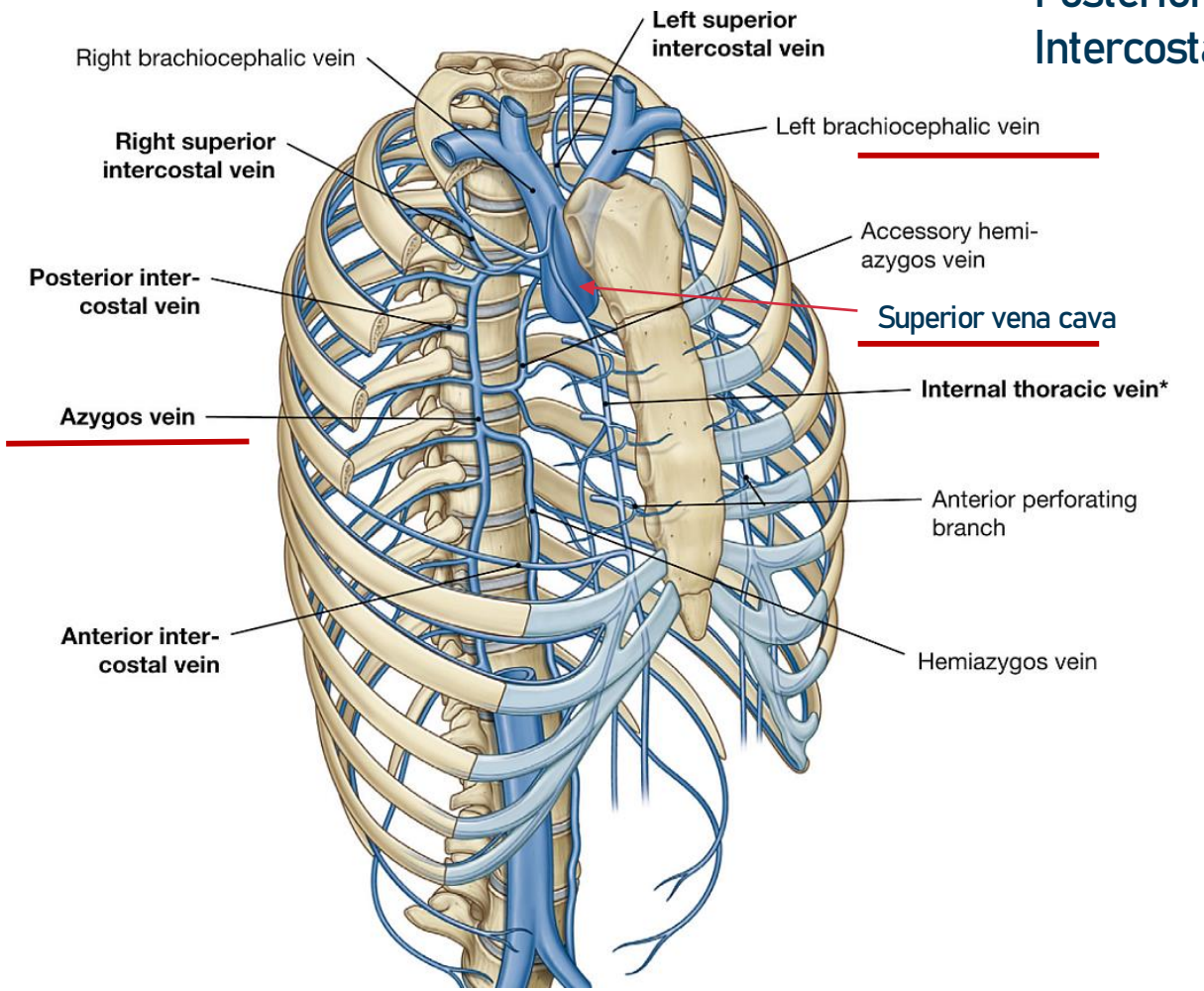


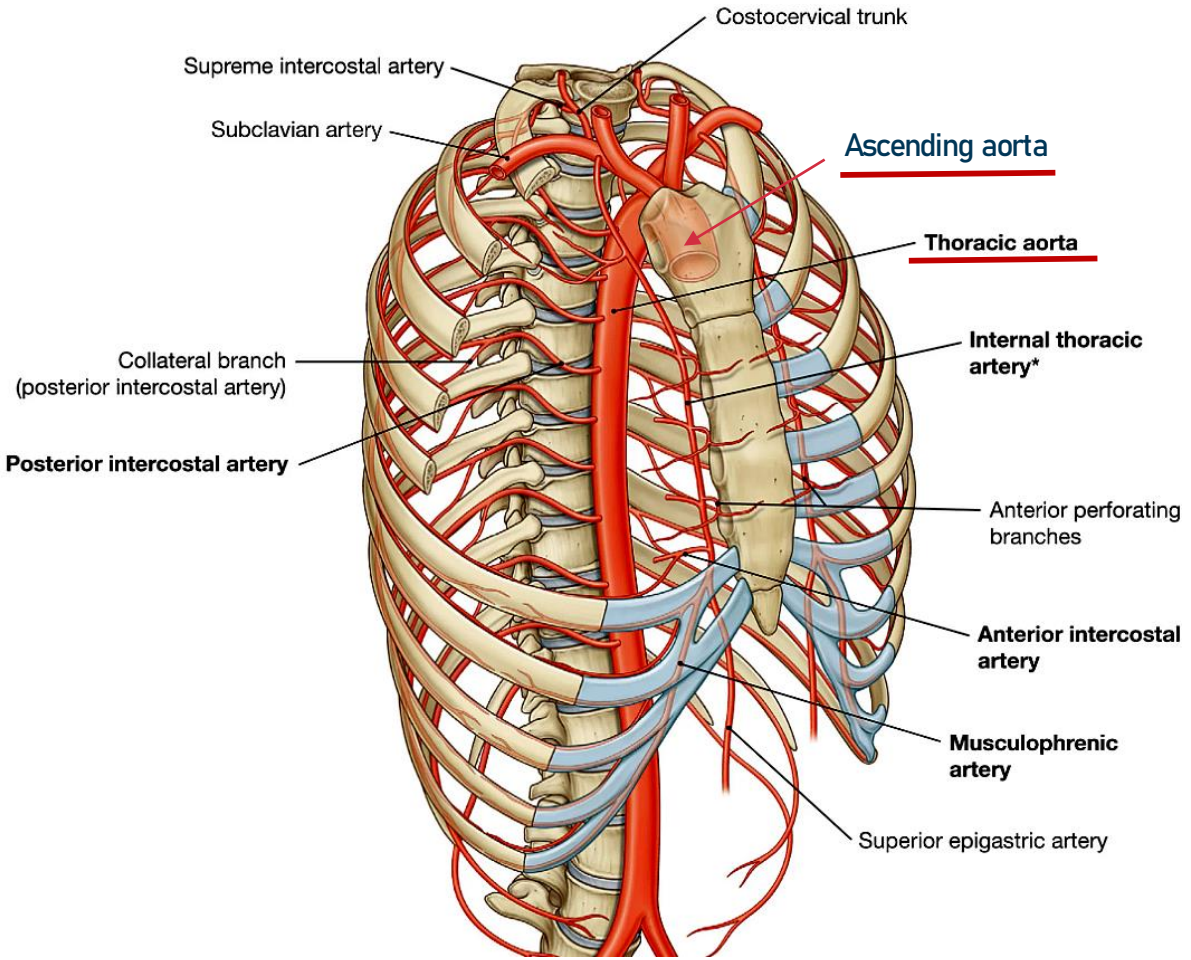
Divisions of the mediastinum



Intercostal space and structures

Mnemonics: VAN
Posterior intercostal Vein
Posterior intercostal Artery
Intercostal Nerve





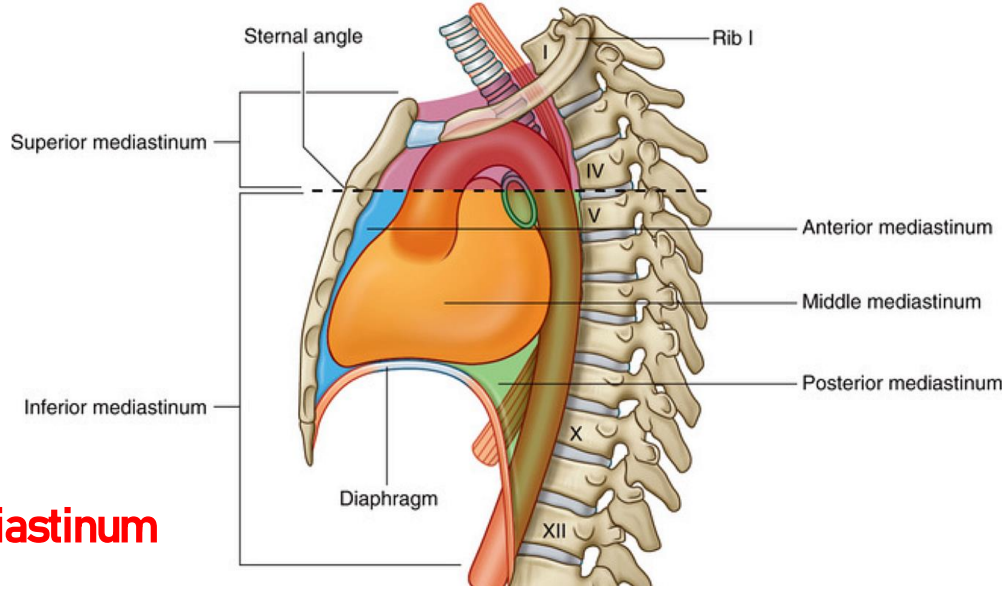
Divisions of the mediastinum

INFERIOR MEDIASTINUM

Anterior Mediastinum
Internal thoracic artery and vein
Thymus (juvenile)

Middle Mediastinum
Heart and pericardium
Hilum of the lungs
Phrenic nerves and pericardiacophrenic vessels

Posterior Mediastinum
Thoracic aorta
Vagus nerve (right and left vagal trunks)
Azygos and hemiazygos veins
Esophageal nerve plexus
Thoracic sympathetic trunks and splanchnic nerves
Intercostal neurovascular structures
Esophagus
Thoracic duct
Posterior mediastinal lymph nodes



Superior Mediastinum

Thymus
Brachiocephalic vein
Superior vena cava
Arch of Aorta:
– Brachiocephalic trunk
– Left common carotid artery
– Left subclavian artery
Vagus and phrenic nerves
Left recurrent laryngeal nerve
Sympathetic trunks
Trachea
Esophagus
Thoracic duct

Clinical notes

A **PNEUMOTHORAX** is caused by the presence of air within the pleural cavity (Fig.). When air enters the pleural cavity, the negative pressure essential for the inspiration disappears, and the tissue elasticity of the lung parenchyma causes its collapse.

The most common clinical symptoms are:

Acute, sharp, stabbing chest pain that worsens when trying to breathe in; choking, coughing.

Concerning the MR image ⟶

- Can the visceral or parietal pleura be recognized?
- Is it possible to demonstrate the costodiaphragmatic angle (recess)?

Fig.: Thorax, magnetic resonance (MR) of the chest air in the pleural cavity (1), the left lung collapsed

ANSWERS

- Can the visceral or parietal pleura be recognized in the figure?
- Is it possible to demonstrate the costodiaphragmatic angle (recess)?

1A – visceral pleura on the costal surface of the left lung

1B – visceral pleura in the interlobar fissure of the right lung

2 – parietal pleura

3 – costodiaphragmatic recess filled with air

green ellipse - costodiaphragmatic recess filled with the lung parenchyme

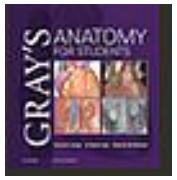


Fig.: Thorax, magnetic resonance

REVISION, ie. How much do you remember?

How would you define the following structures?
Which of them are found in the mediastinum?

1. Pleura
2. Thoracic duct
3. Aorta
4. Pulmonary trunk
5. Superior vena cava
6. Phrenic nerve (n.)
7. Vagus nerve

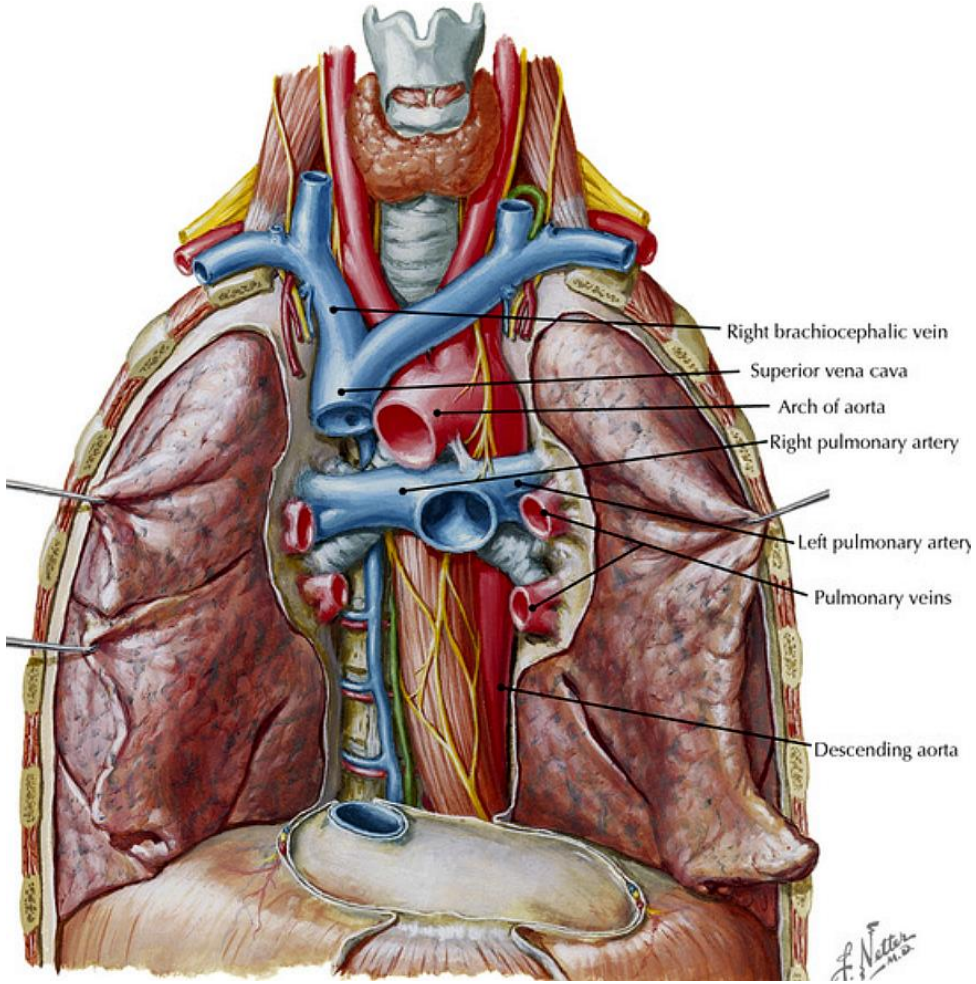


Fig.: Thorax, frontal section

NOTICE:
In tubal structures consider their origin, course, and termination.

The structures are **also marked in the figure**:

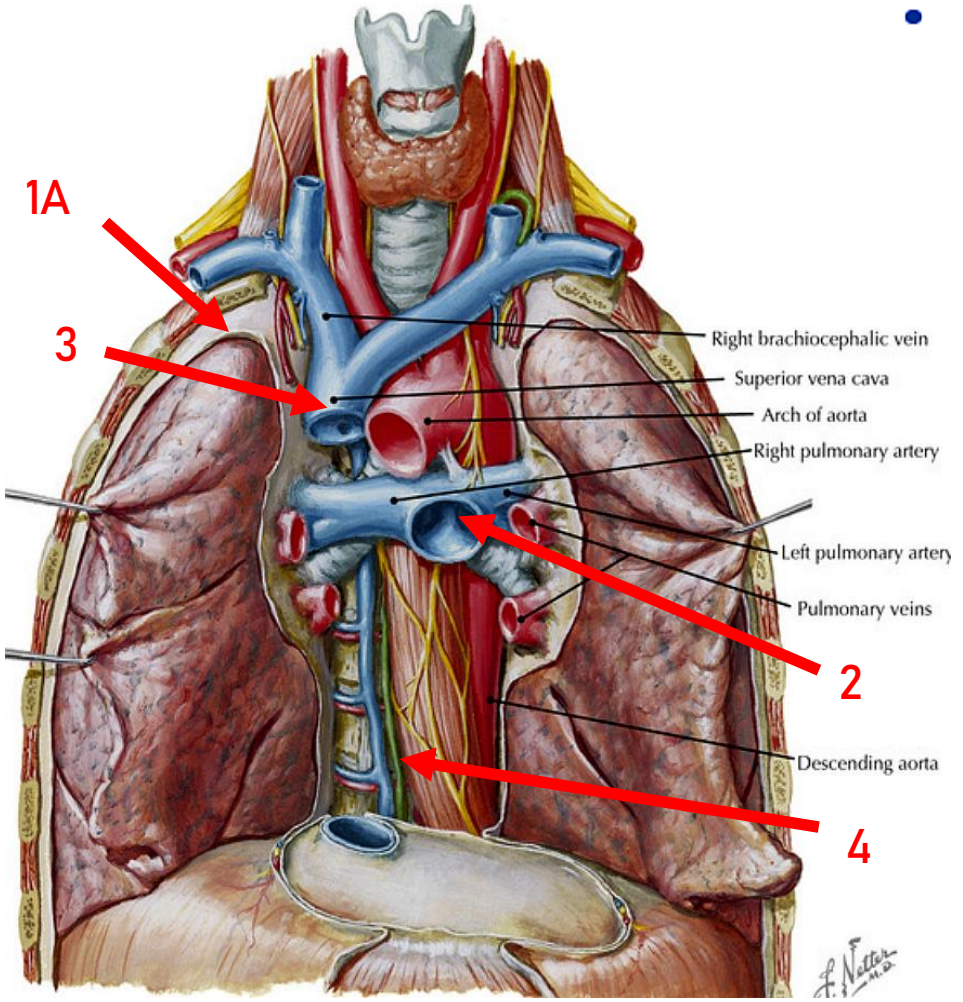
ANSWERS

1. **The pleura** is a **serous** (= glossy and very specific) **membrane**, as such it is formed by two parts: the **parietal** (borders the pleural cavity, 1A) and the **visceral**. It is capable of producing fluid.

2. The **pulmonary trunk** a big, elastic artery that arises from the right cardiac ventricle and conveys the DEoxygenated blood into the lungs where it terminates in the perialveolar capillary plexuses.

3. The **superior vena cava** is a big vein originating from the confluence of the right and left brachiocephalic veins. It terminates in the right cardiac atrium, the ostium is valveless.

4. The **thoracic duct** is the main lymphatic duct of the human body. It originates just under the diaphragm next to the aorta and ascends between it and the azygos vein. It terminates at the left venous angle (the confluence of the LEFT internal jugular and the subclavian veins).



1A – parietal pleura, 2 – pulmonary trunk, 3 – superior vena cava, 4 – thoracic duct

ANSWERS

5. The **aorta** is the main, elastic artery of the human body. It arises from the left cardiac ventricle. The first ascending part continues into the aortic arch (5A) and the descending aorta (5B).
6. The **phrenic nerve** is a peripheral nerve that originates from the cervical spinal nerves (their plexus). The phrenic n. gives the motor innervation to the diaphragm so that it is the main inspiratory muscle.
7. The **vagus nerve** is the largest cranial nerve, that originates in the brain stem and runs through the head, neck, and thorax down the abdominal cavity. It is the major parasympathetic nerve in the human body.

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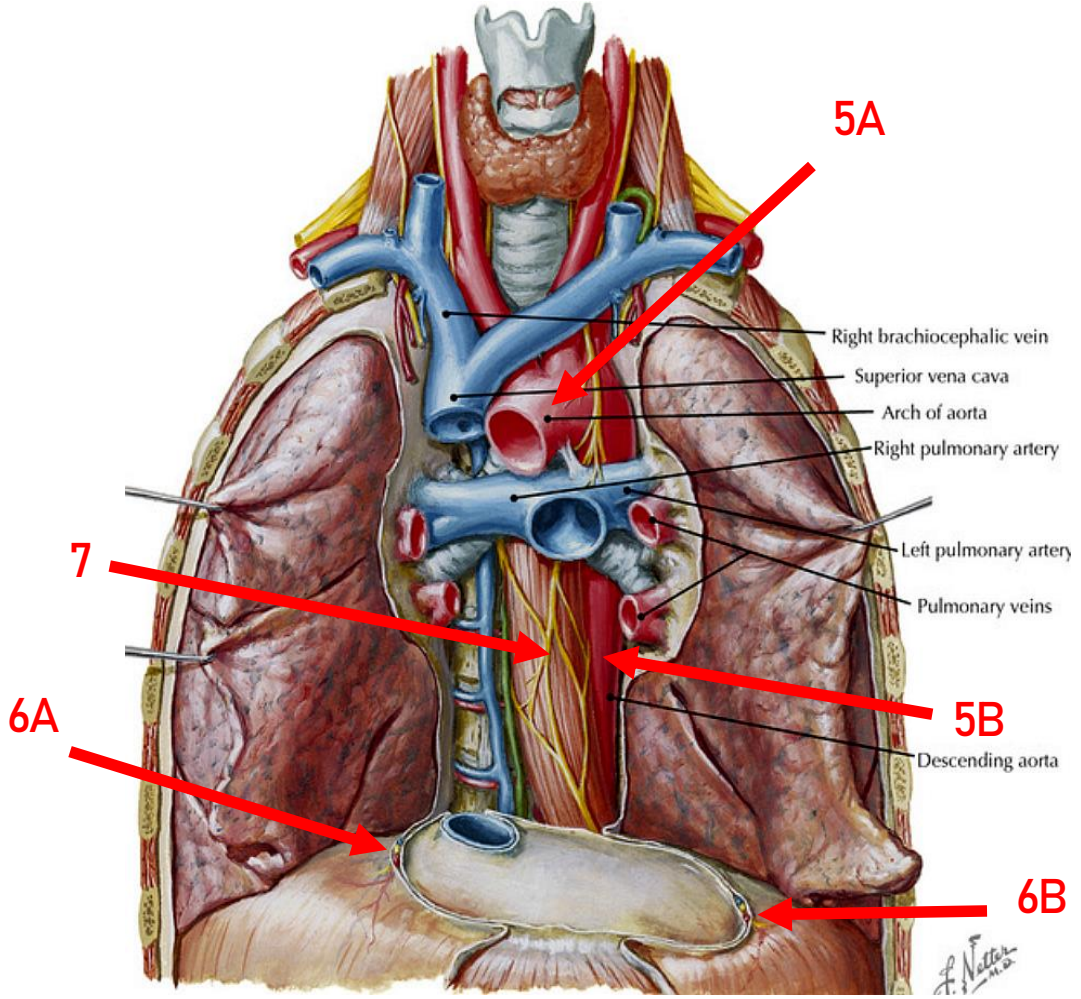
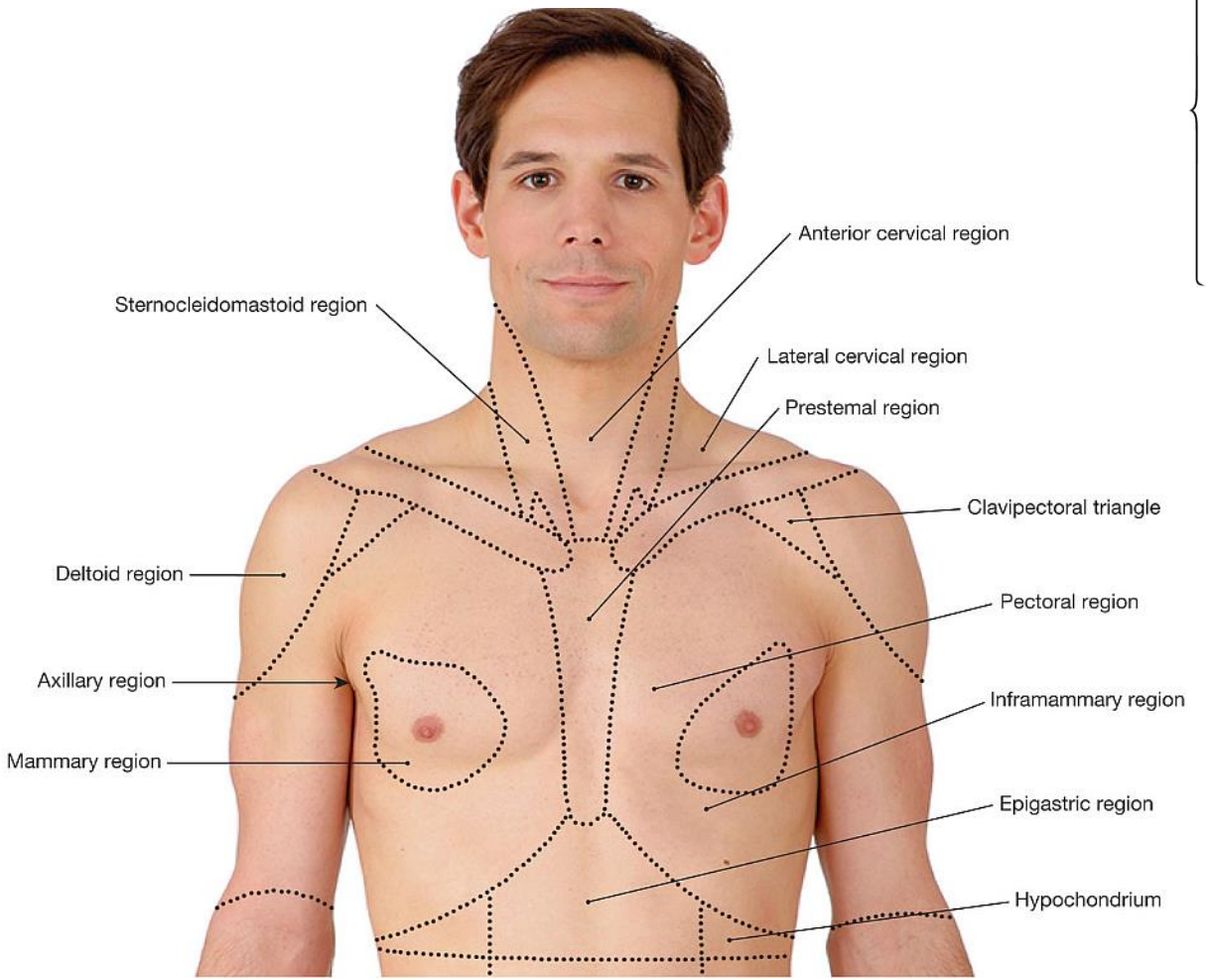
1. ~~Pleura~~
2. Thoracic duct
3. Aorta
4. Pulmonary trunk
5. Superior vena cava
6. Phrenic nerve (n.)
7. Vagus nerve

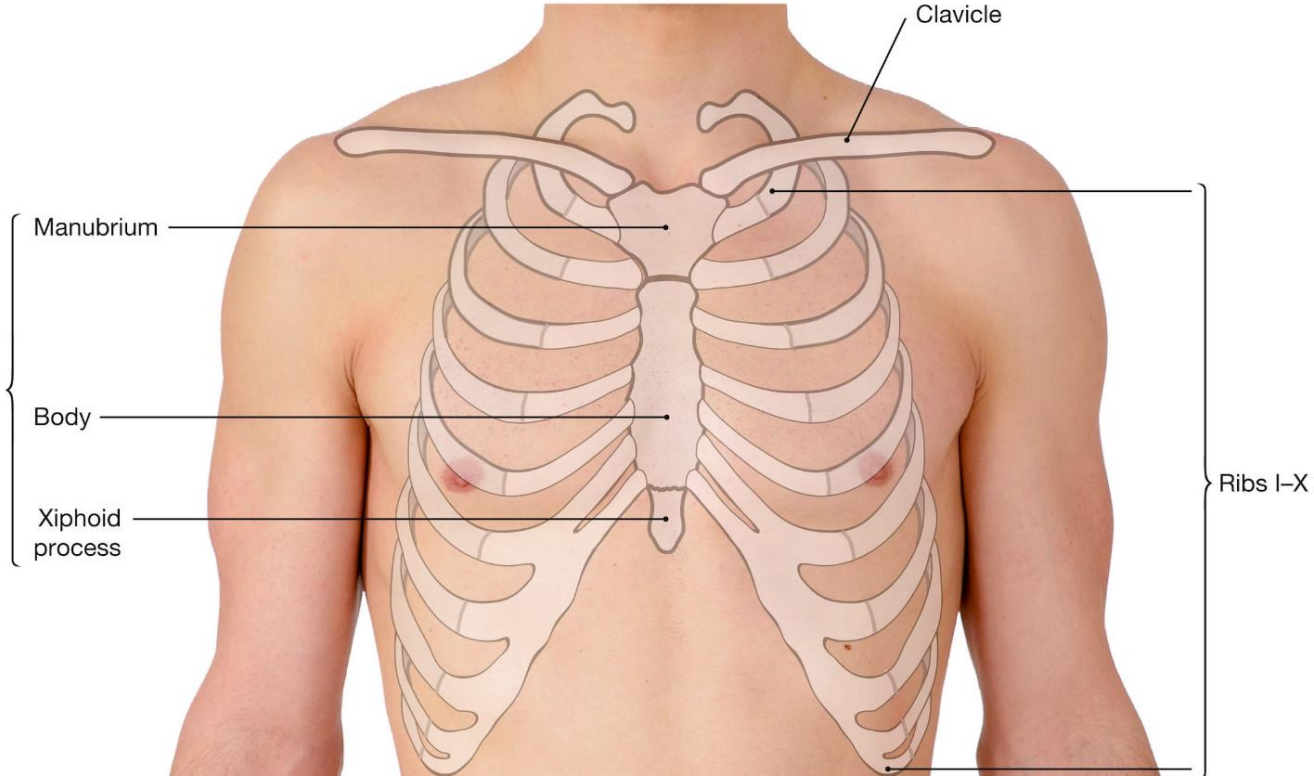
All of the listed structures, except for the pleura, are found in the mediastinum.



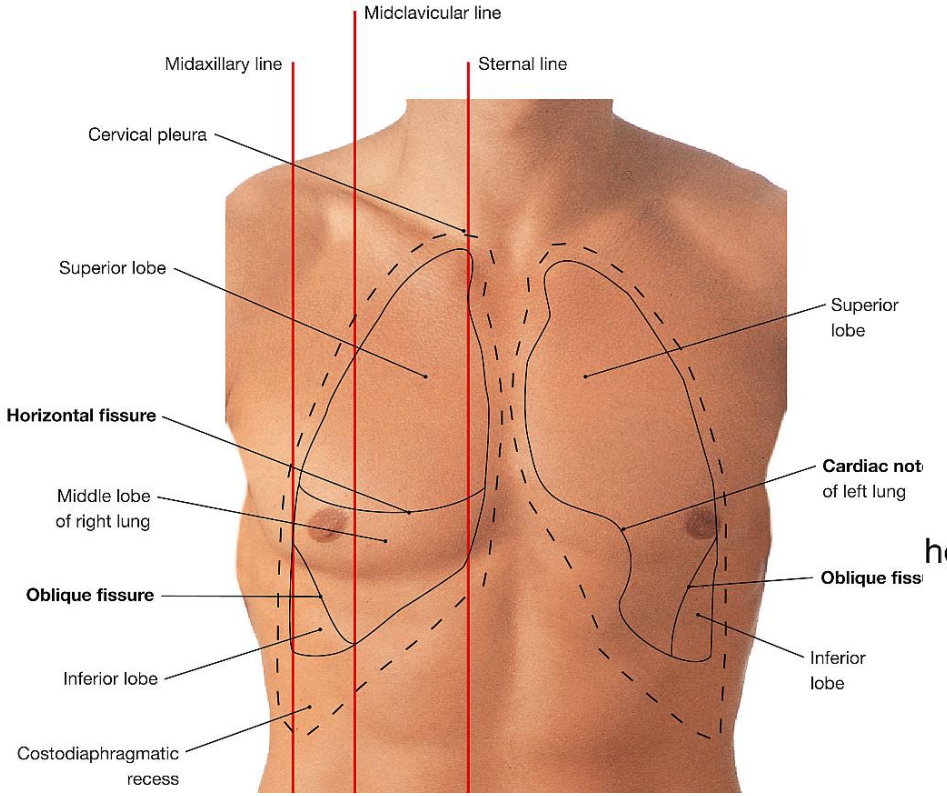
5A – arch of aorta, 5B – descending aorta, right (6A) and left (6B) phrenic nerve, 7 – left vagus nerve

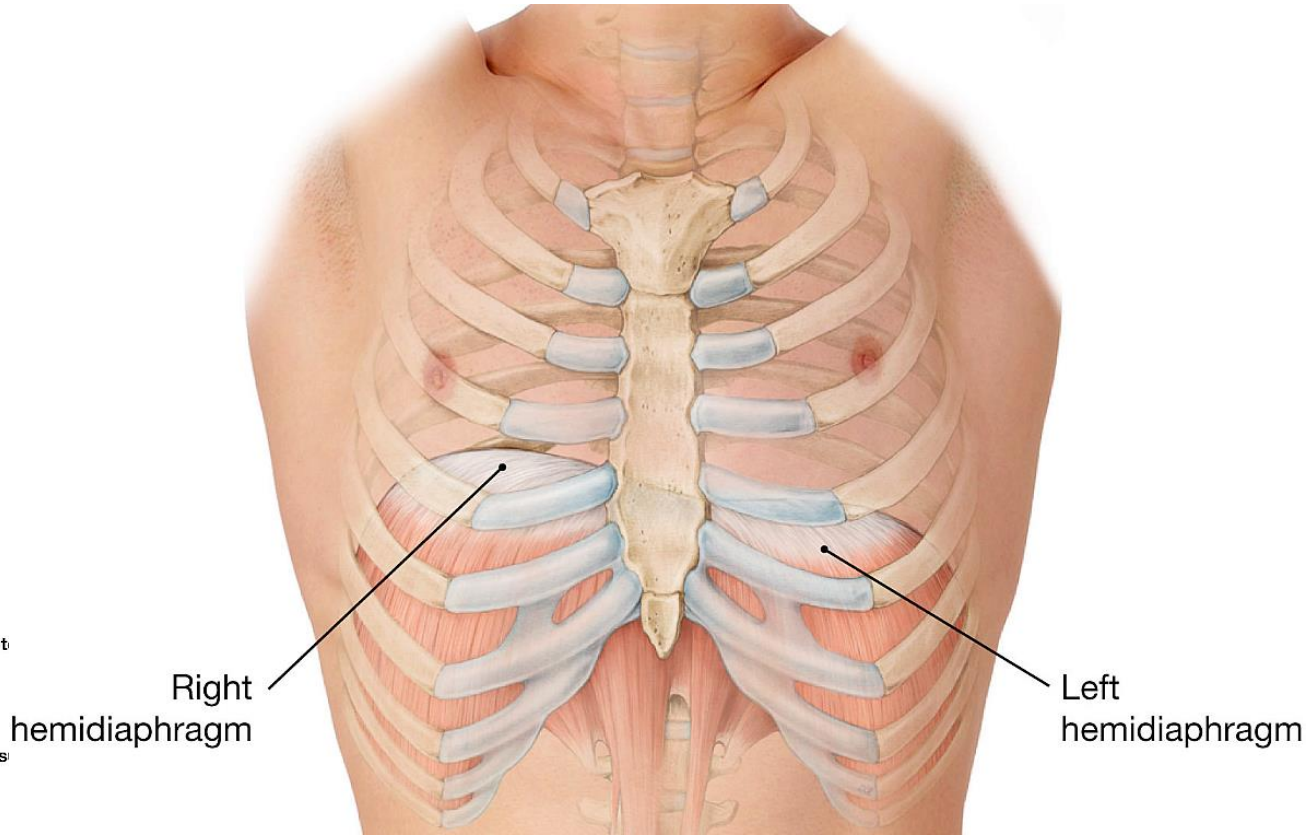
Surface anatomy

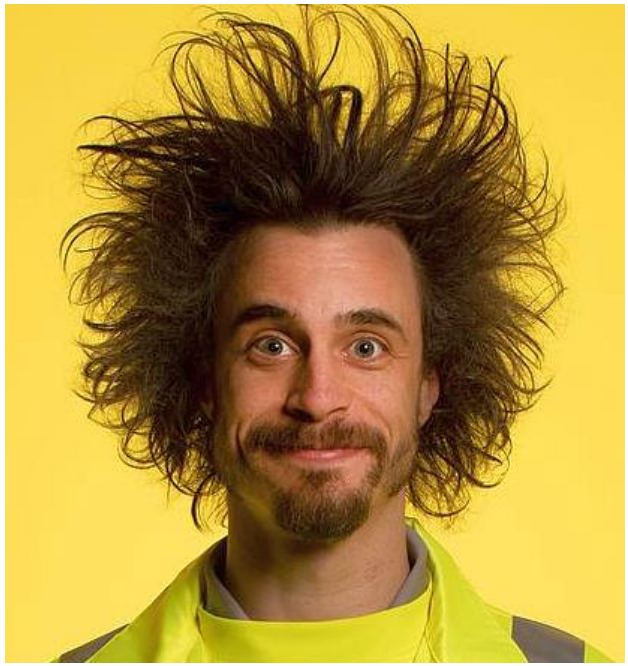




Surface anatomy







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