ANATOMY OF THE MEDIASTINUM

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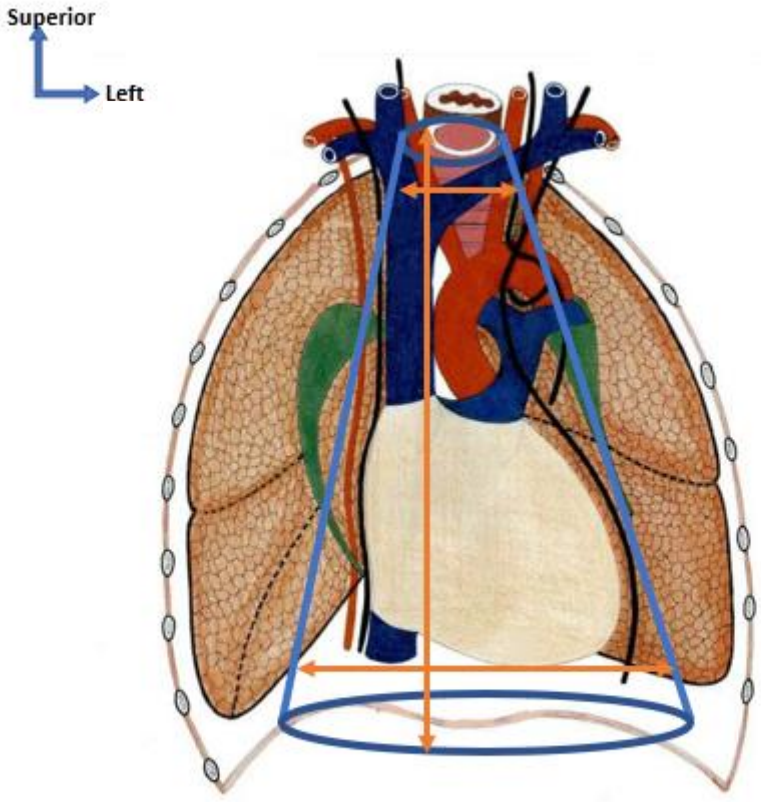
I. DEFINITION:

- The mediastinum is the median region of the thorax.
- It is the part of the thorax located between the two pleuropulmonary regions.
- It contains numerous organs surrounded by loose connective and adipose tissue. These organs have close and relatively constant anatomical relationships with one another.

II. DESCRIPTIVE ANATOMY:

1. Shape:

- Schematically, the mediastinum has the shape of a truncated pyramid with a lower base.
- It represents approximately one-fifth of the thoracic cavity volume.
- In adults, it has an average height of **15 to 20 cm**, a width of **4 to 5 cm at the top**, and **12 to 15 cm at the bottom**.



Anterior view of the thorax

2. Boundaries:

- **Anteriorly:** The sternum.
- **Posteriorly:** The vertebral column from T1 to T12.
- **Superiorly:** The superior thoracic aperture.
- **Inferiorly:** The diaphragm.
- **Laterally:** The mediastinal pleurae.

3. Subdivision:

Felson's classification, the most widely used, divides the mediastinum into **three compartments** in the anteroposterior plane:

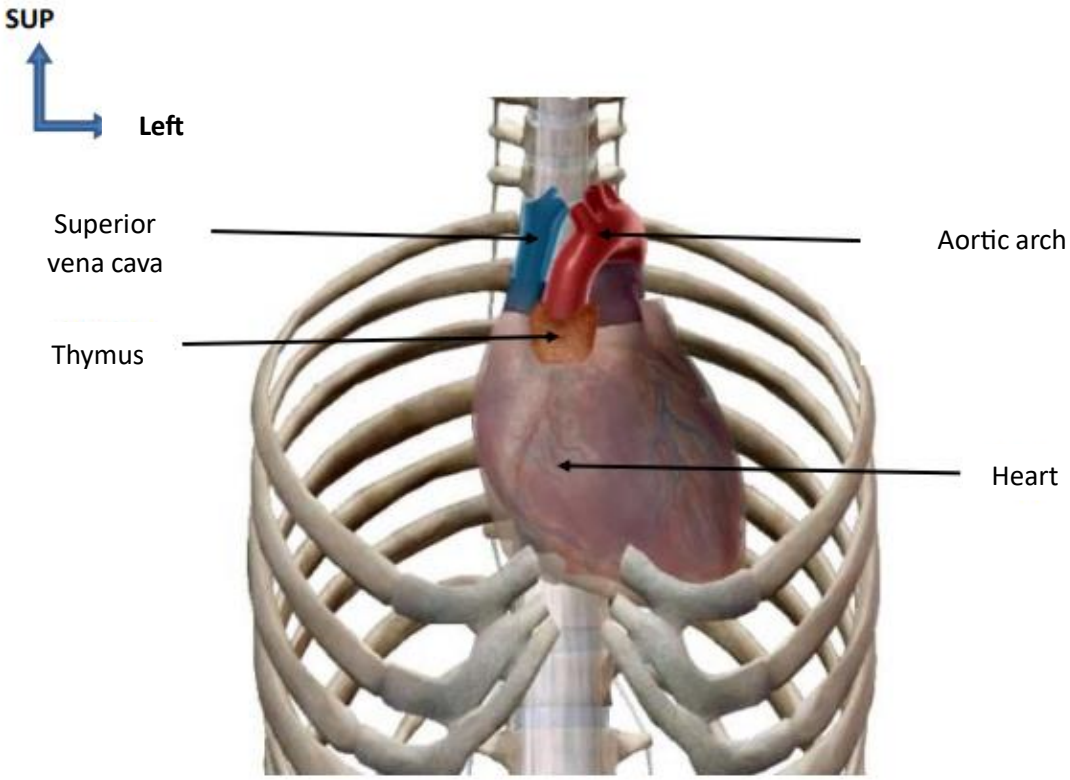
- **Anterior mediastinum**: Located in front of the trachea and pericardium. It contains :
    - The thymus.
    - The supracardiac vessels (ascending aorta, pulmonary arteries, superior vena cava).
    - The heart.
- **Middle mediastinum**: Corresponds to the **tracheobronchial axis**. It contains :
    - The **tracheobronchial tree.**
    - The **pulmonary arteries and veins.**
    - The **aortic arch** and **arch of the azygos vein.**
    - **Lymphatic structures.**
- **Posterior mediastinum**: Located behind the tracheobronchial axis. It contains :
    - The esophagus.
    - Various nerves.
    - The descending aorta and azygos vein.
    - The thoracic duct.
    - Lymph nodes.

III. TOPOGRAPHIC ANATOMY

1.Anterior mediastinum:

The anterior mediastinum is occupied by:

- The thymus.
- The supracardiac vessels (including the ascending aorta, pulmonary arteries, and superior vena cava).
- The heart and its pericardium.



Anterior view of the thorax

A. The thymic cavity – the thymus:

The thymus is a lymphoid organ that is particularly well-developed at birth and during early childhood.

a. Location:

- The thymus is a cervicothoracic organ, situated within a fibrous cavity called the thymic cavity, located at the most anterior part of the superior mediastinum.
- This cavity is positioned in front of the venous plane of the large supracardiac vessels and behind the sterno-chondral plane.
- The thymic cavity is bordered by:

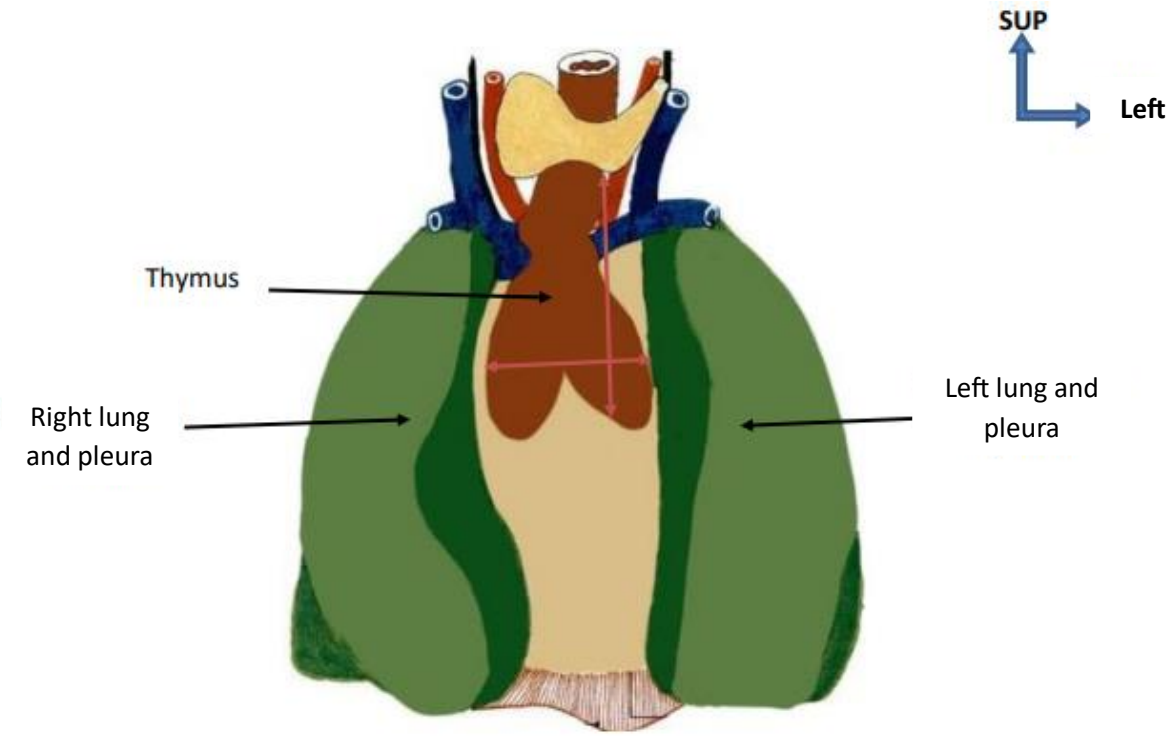
- **Anteriorly**: The sternum superiorly and the superior sterno-pericardial ligament inferiorly.
- **Posteriorly**: The thyro-pericardial lamina superiorly and the fibrous pericardium inferiorly.
- **Laterally** : The lungs.

b. Dimensions:

- In the newborn, the thymus weighs **5 grams** and measures **5 cm in length**, with a **width and thickness of 1 to 2 cm**.
- By the age of 3 years, the thymus reaches its maximum volume and weighs between **25 to 40 grams**.
- After puberty, involution of the organ begins, and it regresses at varying rates, though it does not disappear completely.
- In adults, the vestiges of the thymus form scattered lymphoid nodules within the pericardial adipose tissue.

c. Shape and consistency:

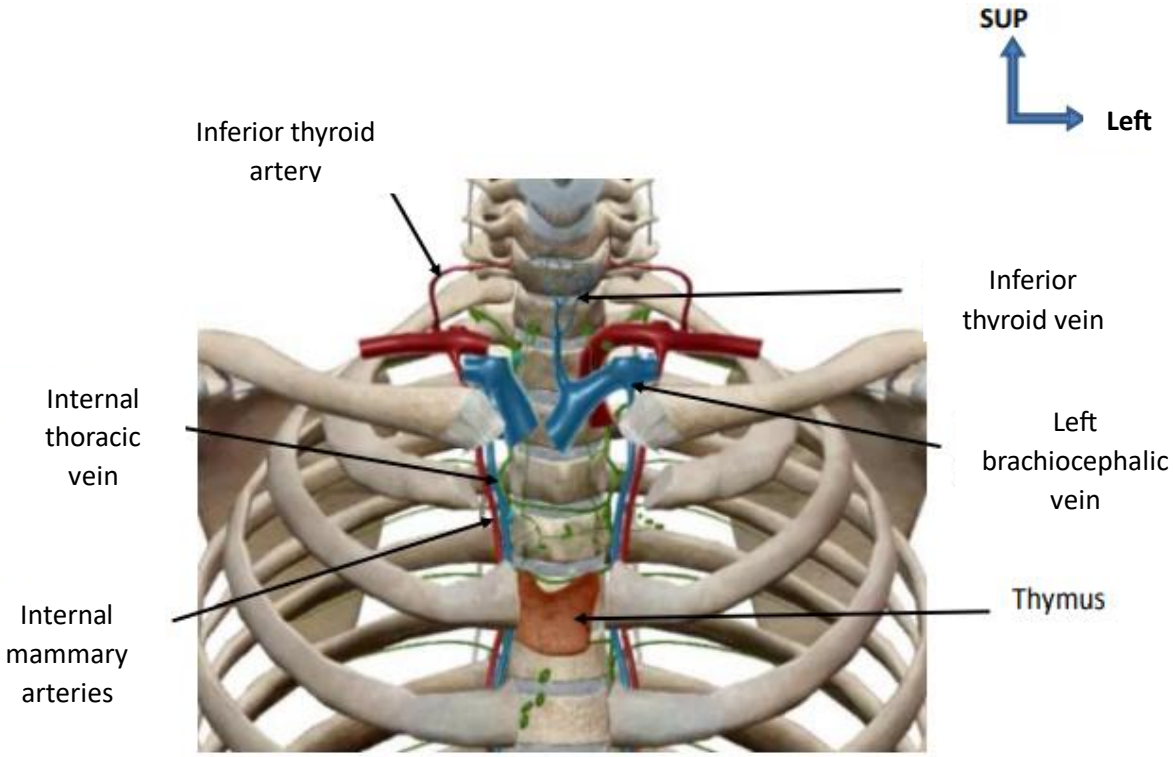
- The thymus is soft in consistency and gray-pink in color. It is composed of two lobes, the right and left, which are joined at the midline in their middle region.
- The left lobe is usually more developed than the right.
- For each lobe, a **body** and two **upper** and **lower extremities** are distinguished.
- The two upper extremities are directed toward the neck and almost reach the thyroid gland.



Anterior view of the thorax

d. Vascularization – innervation – lympathic drainage system:

- The thymus is supplied by the trabecular artery (originating from the internal thoracic artery) and by branches of the inferior thyroid artery.
- The venous drainage is carried out by the inferior thyroid veins, internal thoracic vein, and the left brachiocephalic vein.
- The lymphatics of the thymus drain into the lymph nodes of the anterior mediastinal lymphocenters (transverse and internal thoracic).
- The thymus is innervated by the branches of the inferior and superior mediastinal sympathetic plexus and peri-arterial parasympathetic system.



Anterior view of the thorax

B. The superior vena cava:

a. Location:

- The superior vena cava is entirely located within the thoracic cavity, occupying the upper paramedian right portion of the superior mediastinum.
- Positioned above the heart, it lies between the ascending aorta on the left and the right lung on the right.

b. Origin:

- It results from the fusion of the right and left brachiocephalic veins at the level of the posterior surface of the first right costal cartilage.
- This origin is superficial, in contact with the anterior thoracic wall.

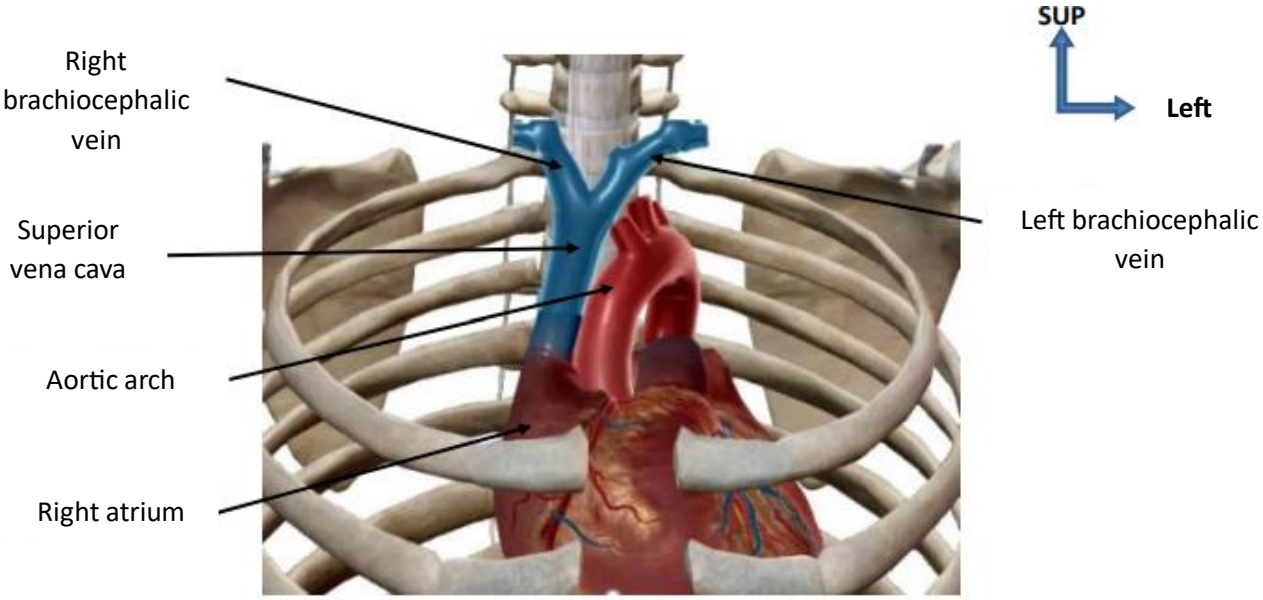
c. Course:

- The superior vena cava descends obliquely backward and to the right, molding itself around the posterior right side of the ascending aorta.

- It penetrates the pericardial sac and opens into the right atrium through a non-valvular opening, with an approximate length of 8 cm.

d. Collateral branches:

The only **regular collateral** is the **azygos vein**, which it receives just before entering the pericardium. This vein joins with the superior vena cava at its lower end, where it unites with the ascending lumbar vein.



Anterior view of the thorax

C. Ascending aorta:

The aorta is the main trunk that gives rise to all the systemic arteries of the human body.

a. Origin:

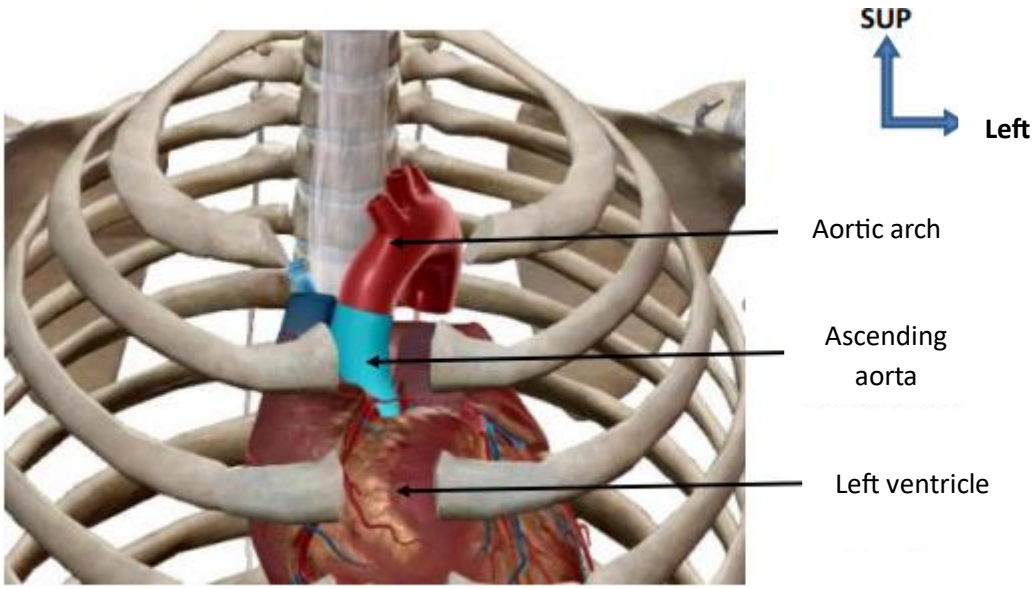
The ascending part of the aortic arch originates at the base of the left ventricle, at the aortic orifice.

b. Course and termination:

It first ascends obliquely upward, forward, and to the right for about 3 to 4 cm, then continues vertically upwards for approximately 3 cm, reaching the level of the first left chondro-sternal junction, where it changes direction and becomes the aortic arch.

c. Dimensions:

- **Length**: **6 cm**
- **Caliber**: **2.5 to 3 cm**



Anterior view of the thorax

D. The pulmonary artery trunk:

The pulmonary artery is the functional artery of the lungs, responsible for the pulmonary circulation, carrying blood rich in CO2 but not vascularizing the lungs.

a. Origin:

It originates behind the 3rd left intercostal space, at the pulmonary orifice of the right ventricle.

b. Course and termination:

- The pulmonary trunk travels upward, to the left, and primarily backward, passing around the left side of the ascending aorta.

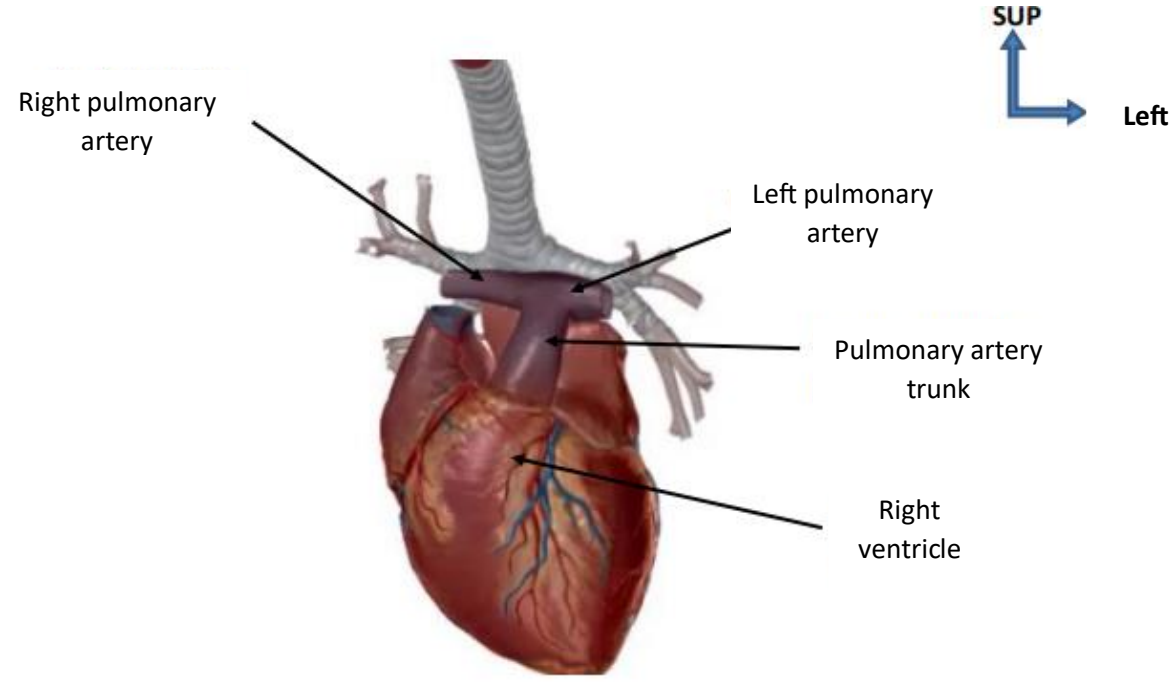
- It then divides beneath the aortic arch into the right and left pulmonary arteries, each of which reaches the hilum of the corresponding lung.
- During its course, the pulmonary trunk is initially intrapericardial, then extrapericardial.

c. Dimensions:

- **Length**: **5 cm**
- **Diameter**: **3.5 cm**

d. Collaterals:

The pulmonary trunk divides into the **right and left pulmonary arteries**.



Anterior view of the heart

E. Phrenic nerves:

The phrenic nerve is a mixed nerve, with its motor portion responsible for innervating the diaphragm and its sensory portion providing sensation to the three serous membranes: pleura, pericardium, and the supramesocolic portion of the peritoneum.

a. Origin:

The phrenic nerve originates in the neck, at the level of the 4th cervical vertebra.

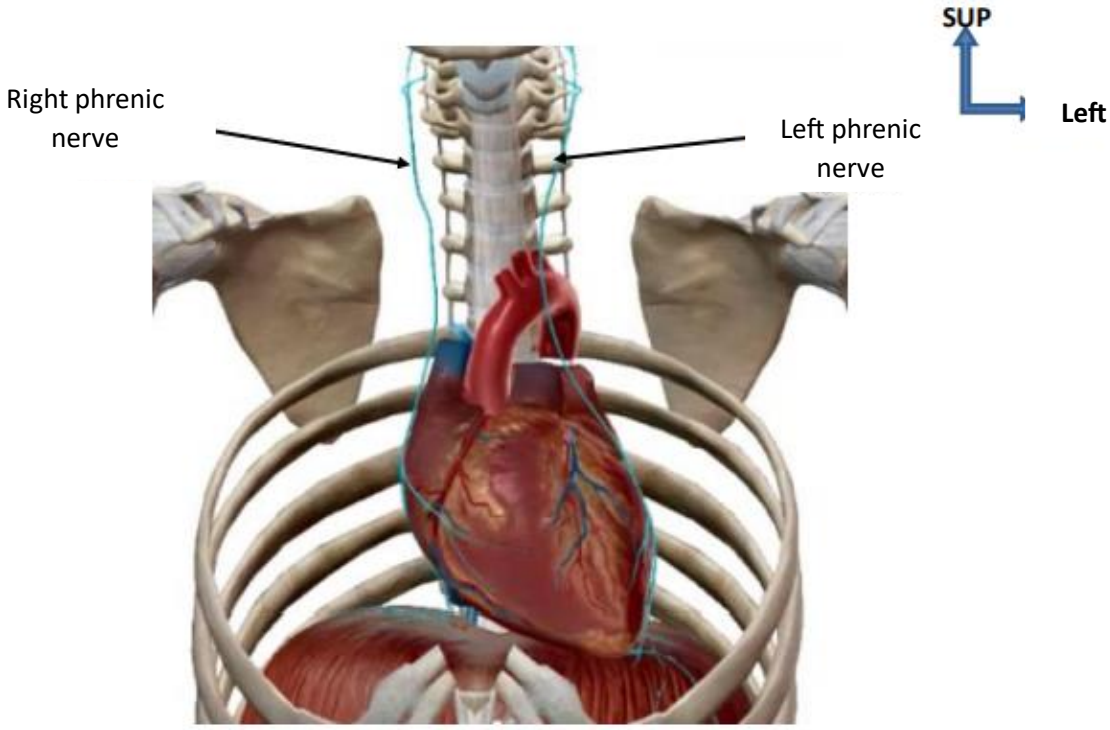
b. Course:

The two phrenic nerves have somewhat different courses in the thoracic cavity.

- The right phrenic nerve descends almost vertically, positioned between the pleura and pericardium.
- The left phrenic nerve follows a curved path, with an internal concavity, to bypass the apex of the heart.

c. Termination:

- The right phrenic nerve reaches the diaphragm laterally and slightly anterior to the foramen of the inferior vena cava.
- The left phrenic nerve reaches the diaphragm slightly posterior to the apex of the heart.



Anterior view of the thorax

F. Heart and pericardium:

See the course **"Heart and Pericardium"** in the **cardiovascular system** section.

2.Middle mediastinum:

- Trachea and bronchial division.
- Pulmonary arteries.
- Pulmonary veins.
- Aortic arch.
- Azygos arch.
- Lymphatics and nerves.

A. The tracheobronchial tree – the trachea:

Trachea:

a. Definition:

- The trachea is a fibro-muscular-cartilaginous conduit that belongs to the lower respiratory tract.
- It is responsible for carrying both respiratory and phonatory air.
- The bronchi are air-conducting passages similar to the trachea and are situated between the trachea and the alveoli.

b. Descriptive anatomy of the trachea:

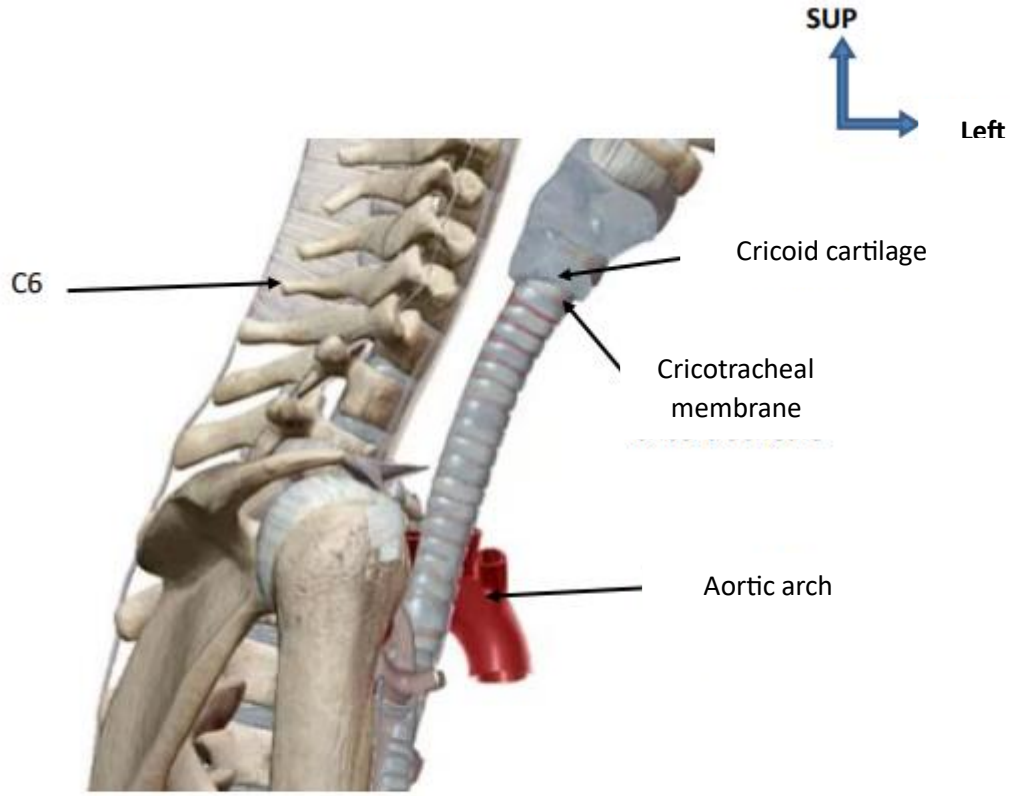
- **Origin:**
  The trachea begins as a continuation of the larynx, at the level of C6 and the lower border of the cricoid cartilage, to which it is attached by the cricotracheal membrane.

- **Course:**
  - The trachea descends obliquely downward and backward, following the direction of the thoracic spine.

- The lower end of the trachea is slightly deviated to the right (about 1 cm) by the aortic arch.

- **Dimensions (**average in adults**) :**
    - **Length : 12 - 14 cm**
    - **Caliber : 12 - 16 mm**

- **Termination:**
  The trachea ends at the level of the 5th thoracic vertebra, where it bifurcates into the right and left primary bronchi.



Lateral view of the thorax

Main bronchi:

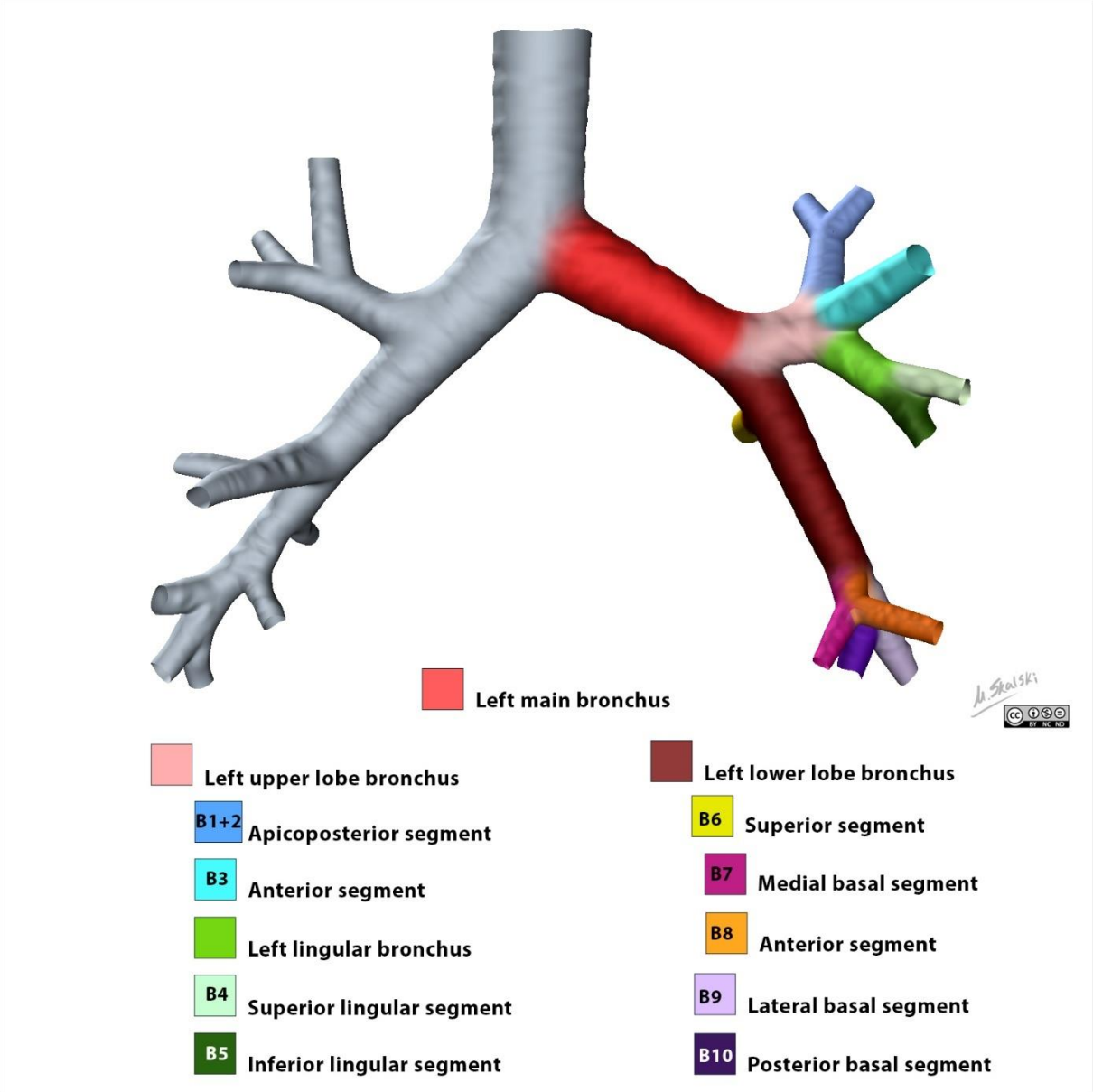
The **main bronchi** (also known as **primary bronchi**) are the initial branches of the trachea that lead to the lungs.

- **Origin:**
  They arise from the bifurcation of the trachea, which occurs at the level of the 5th thoracic vertebra.

- **Left main bronchus:**
  The left main bronchus is longer, more horizontal, and passes under the aortic arch to enter the left lung.

- **Right main bronchus:**
  The right main bronchus is shorter, wider, and more vertical. It is also more in alignment with the trachea and enters the right lung.

- **Function:**
  The main bronchi transport air from the trachea into the lungs. Each bronchus divides into secondary (lobar) bronchi, which then continue to divide into tertiary bronchi, eventually leading to the bronchioles and alveoli.



B. Pulmonary arteries:

a. Pulmonary trunk:

The **pulmonary trunk** transports deoxygenated blood from the **right ventricle** to the two lungs.

- **Origin:**
  The pulmonary trunk originates at the base of the right ventricle through the ostium of the pulmonary trunk.

- **Dimensions:**
  On average, it is **5 cm** long and has a **3 cm** diameter.

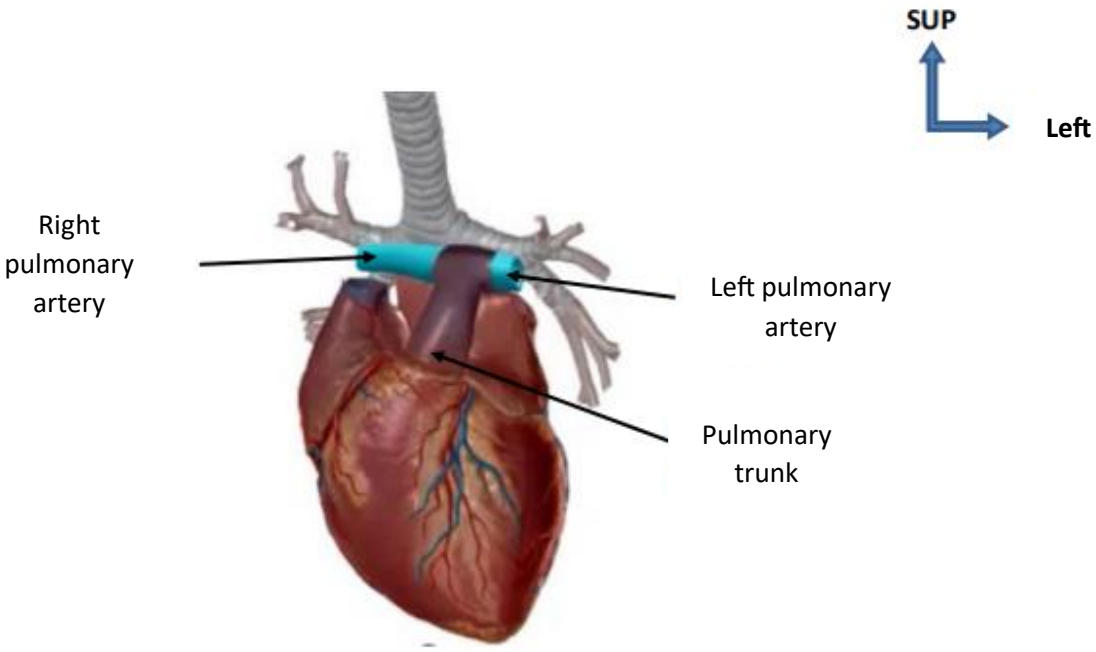
- **Direction:**
  The pulmonary trunk travels obliquely upward, backward, and to the left, passing around the left side of the ascending aorta. It is almost horizontal in orientation.

- **Termination:**
  It bifurcates into the right and left pulmonary arteries.

b. Terminal branches:

- **Right pulmonary artery:**
  - The right pulmonary artery is longer and larger than the left.
  - It measures **5 to 6 cm** in length and **20 mm** in diameter.
  - Its course is horizontal.

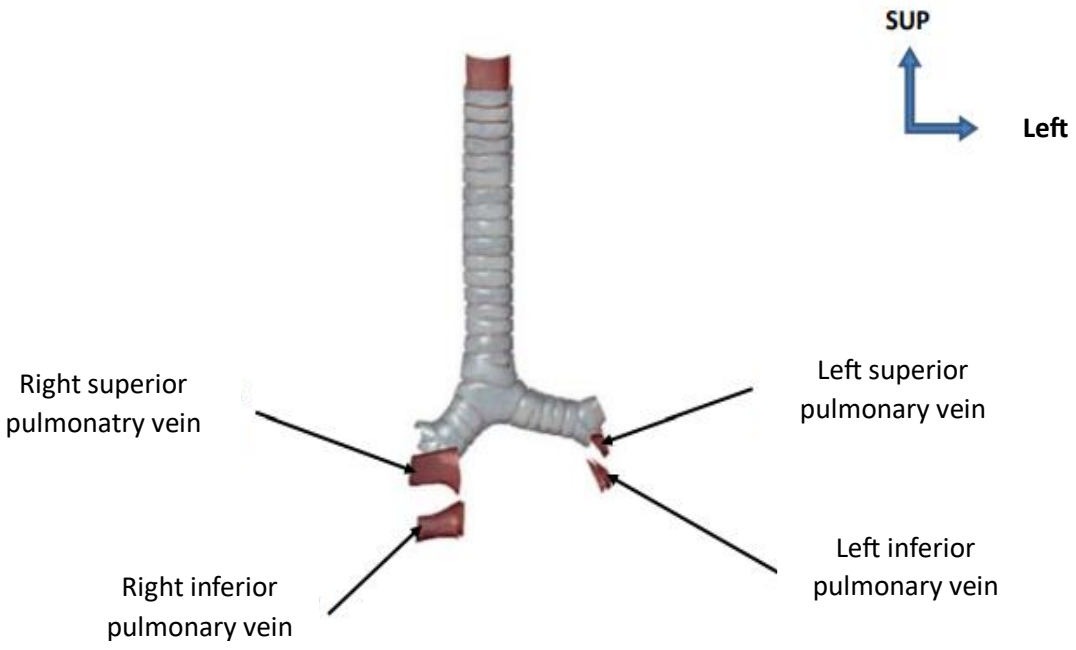
- **Left pulmonary artery:**
  - The left pulmonary artery is **3 cm** long on average and **18 mm** in diameter.
  - The arterial segmental bifurcation is aligned with the bronchial bifurcation.



Anterior view of the heart

C. Pulmonary veins:

- The pulmonary veins originate from the perialveolar capillary network and gradually converge into larger trunks.
- There are **four terminal pulmonary veins**:
    - Two **right pulmonary veins**: **superior** and **inferior**
    - Two **left pulmonary veins**: **superior** and **inferior**
    - The **superior pulmonary vein** on the right drains the upper and middle lobes, while the left superior pulmonary vein drains the upper lobe.
    - The **inferior pulmonary veins** drain the lower lobe on both the right and left sides.
- All four pulmonary veins empty into the left atrium.



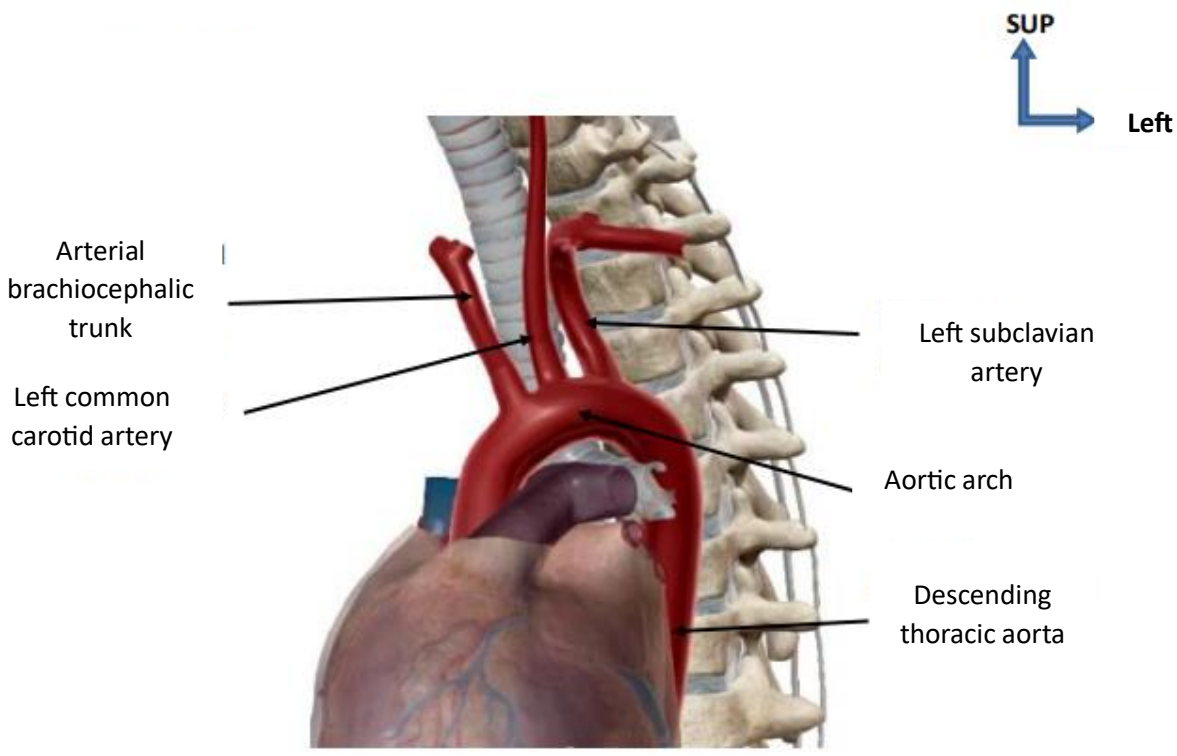
Anterior view of the trachea and the pulmonary veins

D. The horizontal portion of the thoracic aorta - aortic arch:

- The aortic arch is located at the level of T4, above the left pulmonary pedicle and the bifurcation of the pulmonary artery.

- It is directed backward and to the left in the anterior and superior mediastinum and continues into the posterior mediastinum, where it becomes the descending thoracic aorta after passing through a narrowing called the aortic isthmus.

- The aortic arch gives rise to the following arteries:
    - **Brachiocephalic trunk.**
    - **Left common carotid artery.**
    - **Left subclavian artery.**



Lateral view of the thorax

E. Azygos arch:

The azygos arch is a portion of the azygos venous system that arches over the right bronchus and drains blood from the posterior thoracic wall and parts of the abdomen into the superior vena cava.

- **Location**:
  The azygos arch is situated posterior to the right main bronchus and curves over the right primary bronchus and the right lung root.

- **Function**:
  It connects the azygos vein to the superior vena cava and serves to drain deoxygenated blood from the right side of the thorax and abdomen, assisting in venous return to the heart

4. Posterior mediastinum:

Located behind the trachea, the posterior mediastinum contains:

- Descending thoracic aorta.
- Thoracic esophagus.
- Thoracic duct.
- Azygos system.
- Splanchnic nerves and vagus nerves.
- Lymphatic nodes.

A. Descending aorta:

The descending thoracic aorta:

- **Origin**:
  The descending thoracic aorta continues from the aortic arch, located on the left side of T4.

- **Course**:
  It travels downward and slightly inward, running along the left side of the thoracic vertebral column.

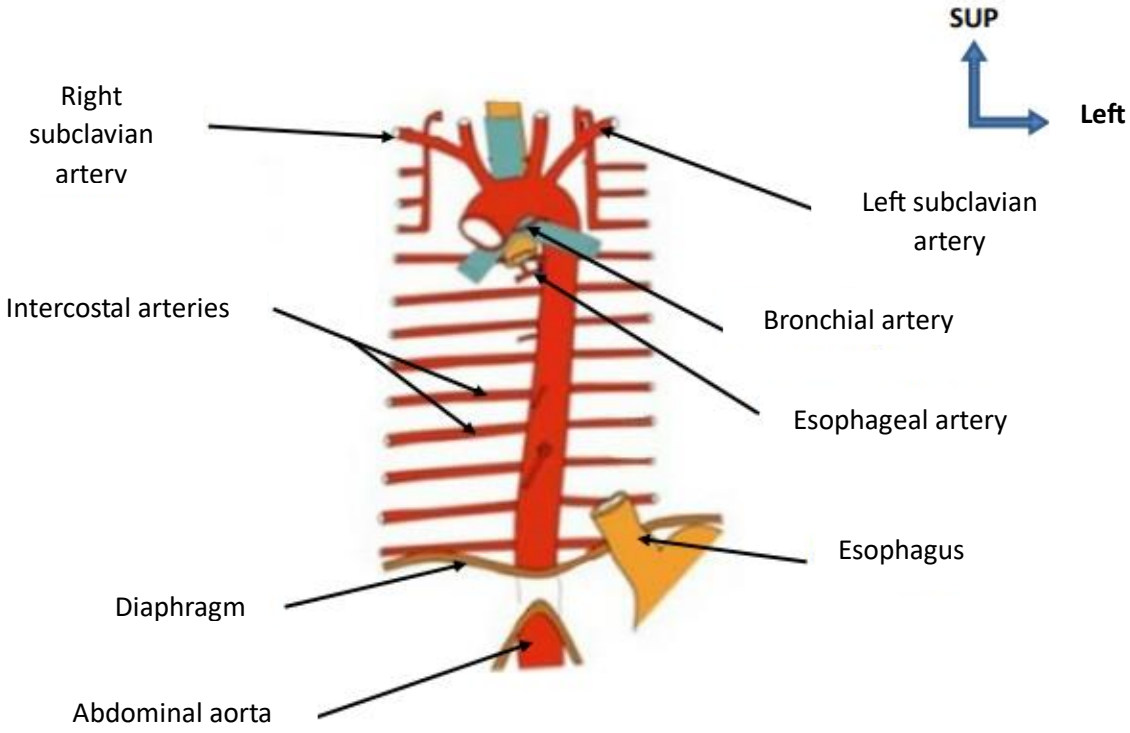
- **Termination**:
  It passes through the diaphragm via a fibrous hiatus between the two pillars.

- **Dimensions:**
  Its length is between **20 to 25 cm**, and its average diameter is **20 mm**.

- **Collateral branches**:
  - **Parietal branches**:

- ✓ **Intercostal arteries**: Apart from the first three, which arise from a common trunk (collateral branches of the subclavian artery), the last nine intercostal arteries originate from the **lateral faces of the aorta** and supply each intercostal space.
- ✓ **Superior phrenic arteries**: Supply the superior surface of the **diaphragmatic muscle**.

- **Visceral branches**:
  - ✓ **Esophageal arteries**
  - ✓ **Bronchial arteries**
  - ✓ **Posterior mediastinal arteries**: Supply the lymphatics, pleura, and pericardium.



Collateral branches of the thoracic aorta

B. Thoracic esophagus:

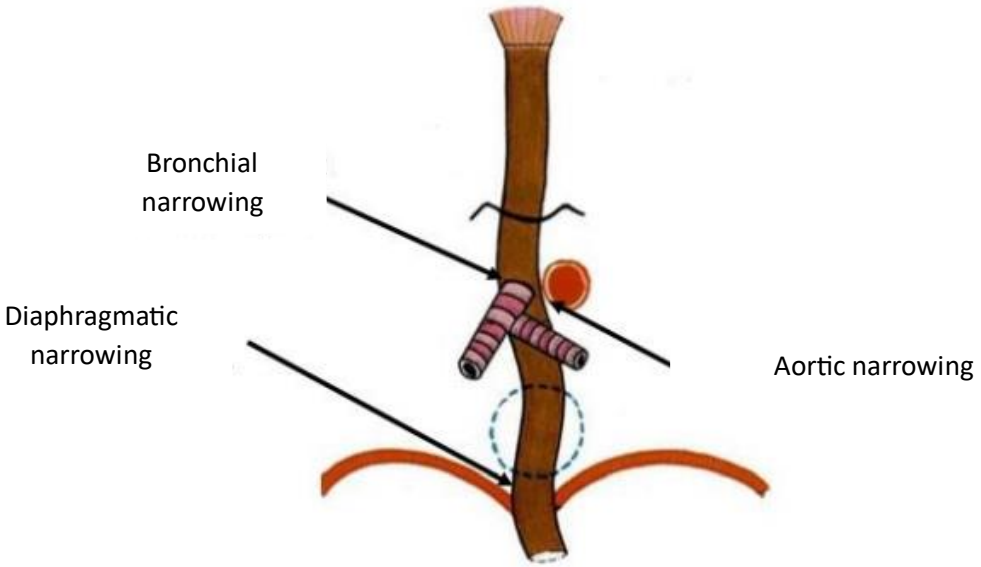
- The thoracic esophagus is a segment of the digestive tract that connects the pharynx at the top to the stomach at the bottom.

- It extends from the T2 disc to the left side of T10, where it passes through the diaphragm to become abdominal.

- **Origin**:
  It continues from the cervical esophagus, beginning at the superior thoracic aperture.

- **Course**:
  The esophagus follows an italic 'S' shape, being displaced to the right by the aortic arch.

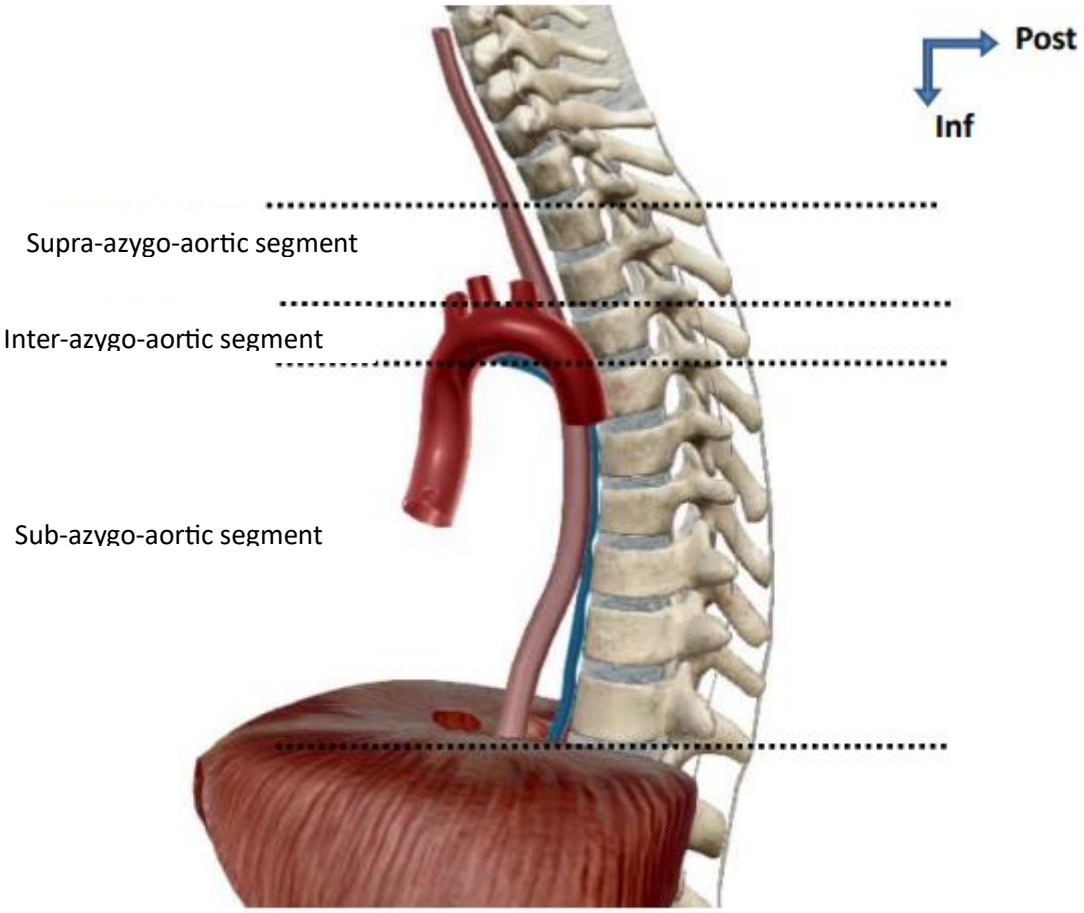
- **Termination**:
  It passes through the diaphragm at the level of T10.



Anterior view of the esophagus

- **Constrictions**:
  The esophagus has three main narrowing points:
  - **Aortic constriction**: Near the aortic arch at T4.

- **Bronchial constriction**: Near the left main bronchus at T5.
- **Diaphragmatic constriction**: At the esophageal hiatus of the diaphragm at T10.



Lateral left view showing the different segments of the esophagus

C. Thoracic duct

- **Origin:**

- The thoracic duct originates below the diaphragm by the union of two lumbar trunks (right and left), which collect lymph from the two lower limbs, and the intestinal trunk, which collects lymph from the intestines.
- It begins behind the aorta, at L1 (though there may be variations), in a dilated area known as the **cisterna chyli**.

- **Diameter:**

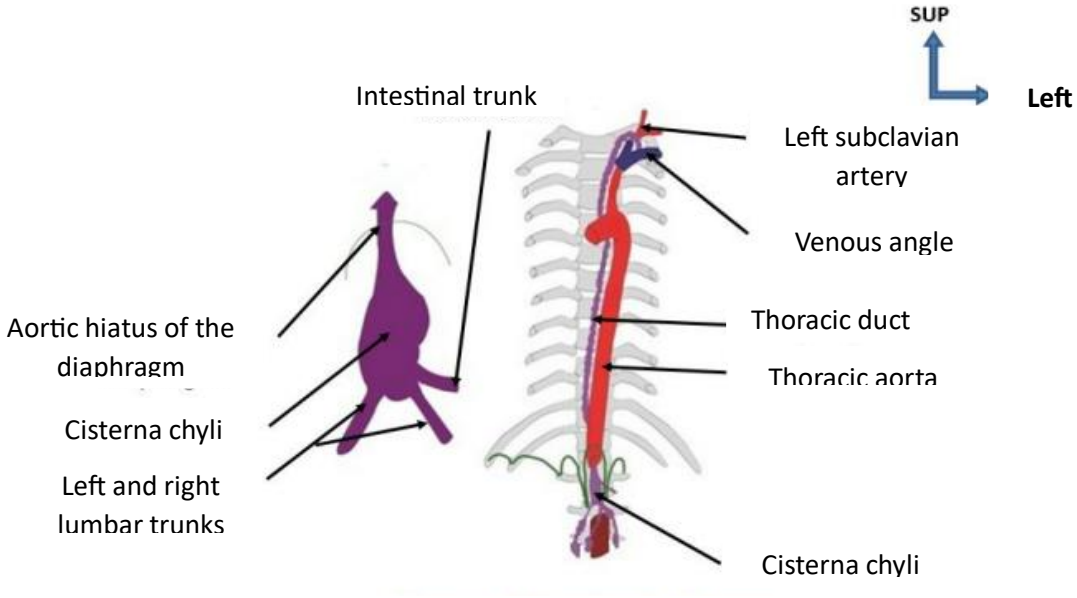
The diameter of the thoracic duct is variable. It is **2-3 mm** in the middle portion, but it is dilated at its origin (approximately **5 mm**) and also at the level of its arch.

- **Course:**

- The thoracic duct has a mostly vertical trajectory.
- It passes through the aortic hiatus and runs along the descending thoracic aorta on its right border, slightly posterior.
- The duct crosses in front of the aorta, passes under the esophagus, and moves towards the left side.
- It ascends, adhering to the left side of the trachea and following the right surface of the left subclavian artery.

- **Termination:**

- The thoracic duct terminates above the left clavicle, forming a loop with the convexity directed upwards.
- It empties into the venous confluence at the left jugulo-subclavian junction (where the left jugular vein and left subclavian vein meet).



Anterior view of the thorax

D. Azygos system:

The azygos venous system is a thoracic venous system that forms an anastomotic connection between the superior and inferior venae cavae. It serves as a collateral system to bypass any blockages in the cava veins (such as tumor compression or thrombosis). It includes the **azygos vein** (a large vein located to the right of the midline) and a group of veins formed by the **hemiazygos** and **accessory hemiazygos veins** (located on the left side of the midline).

a. Azygos vein

- **Location**:
  The azygos vein is positioned against the right side of the thoracic spine. It is exclusively located within the thoracic cavity and occupies the deepest part of the posterior mediastinum.

- **Origin**:
  The azygos vein originates in the posterior infra-mediastinal space, where it is formed by the fusion of two roots at the level of T11:
  - **External root**: The right lumbar ascending vein and the 12th right intercostal vein combine to form the external root of the azygos vein.

- **Internal root**: Thin and variable, the internal root often arises from the posterior surface of the inferior vena cava (cavo-azygos-lumbar channel).

- **Course**:
  The azygos vein has two segments:
  - **Vertical (ascending) portion**: The azygos vein ascends vertically from the bottom to the top along the right side of the thoracic spine until reaching T4.
  - **Arciform portion (azygos arch)**: At the level of T4, the azygos vein leaves the vertebral column, bends forward and slightly outward, forming an arch with a concave lower part that crosses over the right pulmonary pedicle.

- **Termination**:
  It drains into the posterior part of the superior vena cava, in its extrapericardial segment.

- **Dimensions**:
  - **Length**: 20 to 25 cm.
  - **Caliber**: The diameter increases from top to bottom. It is approximately **4 mm** at the origin and **10 mm** at the termination

b. Hemiazygos vein

- The hemiazygos vein originates in the lower thorax (infra-mediastinal posterior space) through two roots:
  - **External root**:
    It is formed by the left ascending lumbar vein, which joins the 12th left intercostal vein.
  - **Internal root**:
    It is variable and formed by the renal-azygos-lumbar arc, which anastomoses with the first left lumbar vein.
- The union of these two roots occurs at the level of T12, slightly lower than the origin of the azygos vein.
- In the posterior mediastinum, the hemiazygos vein ascends vertically along the left side of the vertebral column.
  At the level of T8 or T9, it inclines to the right and proceeds obliquely upwards and to the right.

It passes behind the descending aorta and the thoracic duct, ending at an acute angle into the azygos vein.

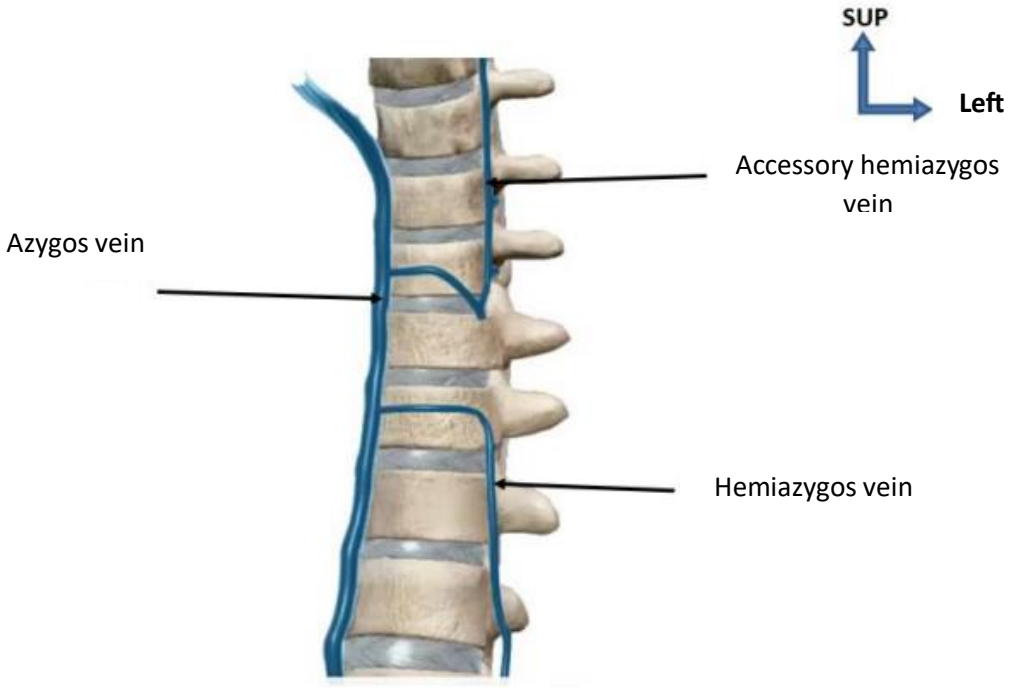
- Main tributaries include the last four or five left intercostal veins, esophageal veins, and posterior mediastinal veins.

c. Accessory hemiazygos vein

The accessory hemiazygos vein has a variable origin:

- **Origin**:
    - It may arise at the termination of the first left intercostal vein, in which case it drains venous blood from the first seven left intercostal veins.
    - Alternatively, it may arise below the third left rib, in which case it drains venous blood from the fourth, fifth, sixth, and seventh left intercostal spaces.

- **Course**:
  The accessory hemiazygos vein descends vertically along the left side of the vertebral column. At the level of T7, it empties perpendicularly into the azygos vein.



The azygos system

E. Vagus nerve:

- The vagus nerve (or pneumogastric nerve) is the 10th cranial nerve.
- It is a mixed nerve, both motor and sensory, and is involved in somatic and autonomic functions. Among all cranial nerves, it has the widest range of innervation.
- Each vagus nerve innervates structures in the cranial cavity, neck, thorax, abdomen, and extends to the pelvis.
- The two vagus nerves are not symmetrical, and their targets differ.

- **Origin:**

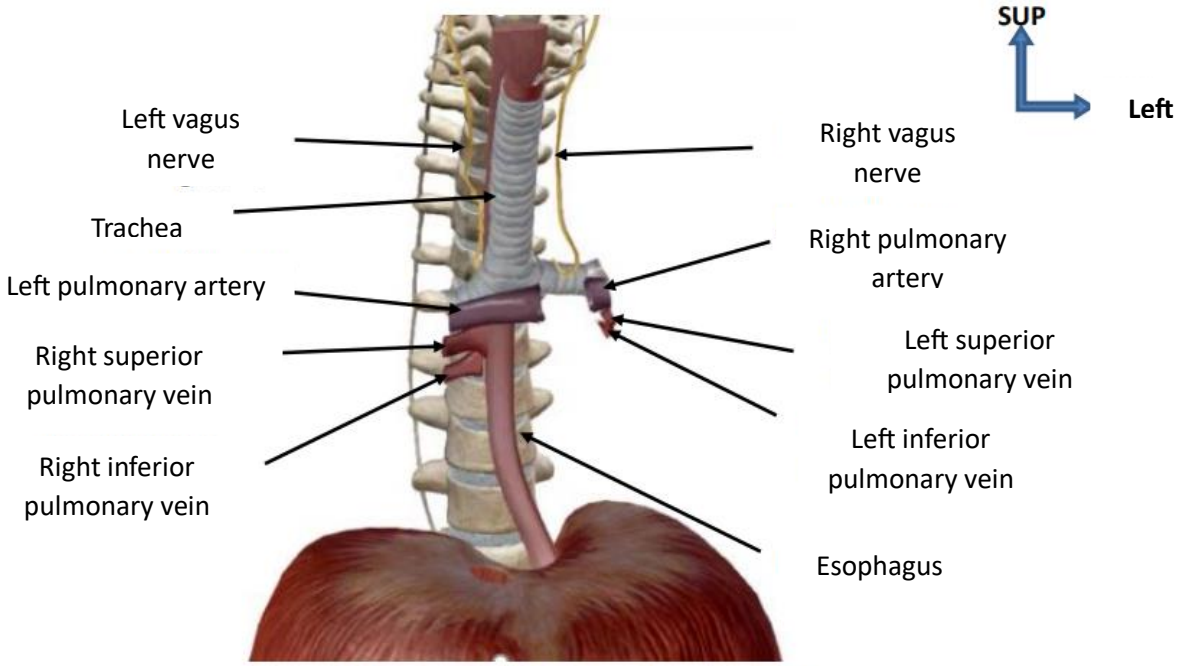
The vagus nerve originates in the skull, posterior to the bulbar olive.

- **Course:**

- The vagus nerve runs along the posterior-lateral border of the trachea until its bifurcation.
- It then passes behind the pulmonary pedicle, sliding along the right and then posterior side of the esophagus, where it forms the esophageal plexus with its left counterpart.

- **Termination:**

It passes through the esophageal hiatus behind the esophagus and enters the abdomen.



Anterior view of the thorax

F. Mediastinal ganglia:

There are four main groups of ganglia in the thorax:

1. **Diaphragmatic ganglia**: Located above the diaphragm, around the base of the pericardium.
2. **Anterior mediastinal ganglia**: Situated in front of the aortic arch, the superior vena cava, and the brachiocephalic trunks.
3. **Intertracheobronchial ganglia**: Grouped around the trachea and both bronchi.
4. **Posterior mediastinal ganglia**: Located on the lateral faces of the retropericardial portion of the esophagus.

Lymphatic collecting trunks

The thoracic cavity is traversed by collecting trunks of the lymphatic system. All of these trunks drain into the **junction of the left internal jugular and subclavian veins**. The major trunks are:

- **Jugular trunk**: Receives lymphatic circulation from the corresponding half of the head and neck.
- **Mediastinal trunk**: Receives lymphatic circulation from the thoracic organs and part of the thoracic wall.
- **Thoracic duct**: Collects lymphatic circulation from the lower limbs, abdomen, and part of the thoracic wall.

IV. CLINICAL APPLICATIONS:

1. Pneumomediastinum

- **Definition**:

Pneumomediastinum refers to the **presence of air** within the **mediastinum**.

- **Main Causes of pneumomediastinum** :
    - **Alveolar rupture**: Air escapes into the lung interstitium and translocates to the mediastinum.
    - **Esophageal perforation**: A tear in the esophagus allows air to enter the mediastinum.
    - **Rupture of the esophagus or intestines**: Air from the neck or abdomen passes into the mediastinum.

- **Symptoms**:

The main symptom is retrosternal chest pain, which may occasionally be severe.

- **Clinical examination**:
    - **Subcutaneous emphysema**, often around the xiphoid process, may be observed.

- A crackling or clicking sound synchronized with heartbeats may be heard, most prominently above the heart when the patient is in left lateral decubitus position (**Hamman's sign**).

- **Diagnosis**:

The diagnosis is confirmed with a **chest X-ray**, which reveals air in the mediastinum.

Frontal chest X-Ray

- **Treatment**:

Treatment is generally not required. However, in cases of compressive pneumomediastinum with compression of mediastinal structures (which is rare), relief can be achieved by needle aspiration, leaving the needle's tip open to the air, similar to the treatment for compressive pneumothorax.

- **Hospitalization**:

Hospitalization is necessary if the pneumomediastinum is secondary to a rupture of the esophagus or intestines, but not necessarily if it is secondary to alveolar rupture.

2. Thymoma:

- **Definition:**
  Thymoma is a rare **epithelial tumor** derived from the thymic gland epithelium.

- **Clinical description:**
  Half of the patients are **asymptomatic**, and in the other half, symptoms include **dyspnea**, **chest pain**, upper **respiratory tract infections**, **fatigue**, **weight loss**, **cough**, or **pneumonia**. Thymomas are often associated with **autoimmune myasthenia**, an autoimmune disease characterized by diplopia, ptosis, dysphagia, and muscle weakness.

- **Diagnostic methods:**
  Diagnosis relies on clinical examination, radiological investigations, and pathological examination of the excised tissue. Chest radiographs may show mediastinal widening or loss of the retrosternal clear space. CT scans, MRI, MR angiography, and/or positron emission tomography (PET) may be indicated for tumor staging. A biopsy, generally performed by percutaneous needle aspiration under CT or ultrasound guidance, is necessary for diagnosis.

- **Management and Treatment:**
  For early-stage tumors, **complete surgical excision** (usually via median sternotomy) is the treatment of choice.
  In advanced stages (Stage II of the Masaoka classification) and high-risk histological subtypes (B3), surgical excision is combined with **adjuvant therapy** (postoperative radiotherapy) or neoadjuvant therapy.
  Total thymectomy generally improves myasthenic symptoms.

VI. CONCLUSION:

- The mediastinum is a region containing vascular, nervous, respiratory, digestive, and glandular elements, as well as an important lymphatic crossroads.
- It is continuous and contiguous with the cervical, abdominal, and retroperitoneal regions.
- Its content, relationships, and location at the center of the chest make it complex.