Mediastinum

The mediastinum is the midline region of the thoracic cavity between the two lungs and their pleural cavities. It contains a heterogeneous collection of structures.

Subdivisions of the Mediastinum

Two most popular schemes are:

1) Four compartment model
    a) used by anatomists and many clinicians
    b) superior mediastinum versus inferior mediastinum – demarcated by a plane passing through the sternal angle and the T4 - T5 intervertebral disc
    c) subdivisions of the inferior mediastinum
        i) anterior mediastinum –between posterior surface of the sternum and anterior surface of the fibrous pericardium.
        ii) middle mediastinum – the region occupied by the heart, pericardium, and the roots of the great vessels.
        iii) posterior mediastinum – between the posterior surface of the fibrous pericardium and the vertebral column.
2) Three compartment model
    a) used by many clinicians
    b) no division into superior and inferior mediastinum; rather anterior, middle, and posterior compartments extend from the superior thoracic aperture to the diaphragm.
        i) anterior mediastinum – between the posterior surface of the sternum and the anterior surface of the fibrous pericardium and brachiocephalic veins.
        ii) middle mediastinum – the region occupied by the heart and pericardium and all of the structures superior to the heart; includes the brachiocephalic veins, trachea, primary bronchi, and the aortic arch and its branches.
        iii) posterior mediastinum – between the posterior surface of the fibrous pericardium, trachea, and primary bronchi and the vertebral column; includes descending thoracic aorta, esophagus, azygos venous system, and thoracic duct.

Clinical Notes: 1) Mediastinal subdivisions - The division of the mediastinum into subregions is useful in describing mediastinal abnormalities and in the fact that certain thoracic masses have a predilection to occur in particular subregions of the mediastinum. 2) Widened mediastinum – term used to describe a broader than normal radiopacity in the mediastinum as observed in a PA or AP chest film; usually reflects bleeding in the mediastinum as may occur from an aortic tear. 8 cm is typically considered the upper limit of normal mediastinal width in an adult at the level of the aortic arch.

Great Vessels

"Great vessels" - a collective term for the large arteries and veins located in the mediastinum.

Brachiocephalic (Innominate) Veins

1) Left brachiocephalic vein
    a) forms in the root of the neck behind the left sternoclavicular joint from the union of the left internal jugular vein and the left subclavian vein
    b) venous return from the left side of the head & neck and left upper limb
    c) descends behind the manubrium to the right side of the mediastinum
2) Right brachiocephalic vein

a) forms in the root of the neck behind the right sternoclavicular joint from the union of the right internal jugular vein and the right subclavian vein
b) venous return from the right side of the head & neck and right upper limb
c) takes a near vertical descent through the superior mediastinum

Venae Cava

1) Superior vena cava (SVC)
   a) forms posterior to the costal cartilage of the 1st rib from the union of the right and left brachiocephalic veins
   b) descends vertically to enter the right atrium at the level of the right 3rd costal cartilage
   c) receives the azygos vein
2) Inferior vena cava (IVC)
   a) traverses the caval foramen (opening) of the diaphragm and enters the right atrium

Clinical Note: Superior vena cava syndrome – a collection of clinical symptoms resulting from a reduction in blood flow through the SVC; the most common etiology is extrinsic compression of the SVC by tumors. The SVC is especially vulnerable to compression and obstruction due to its thin walls and low intravascular pressure. SVC compression leads to increased venous pressure in the upper thorax, head, and neck that is characterized in part by distention of the veins in the neck and edema (abnormal accumulation of fluid in the interstitial spaces) and plethora (excess of blood leading to a reddish complexion) in the upper limbs, head, neck and thorax.

Pulmonary Blood Vessels

1) Pulmonary trunk
   a) originates at the pulmonary orifice of the right ventricle
   b) projects superiorly, posteriorly, and to the left to the concavity of the aortic arch where it bifurcates into the left and right pulmonary arteries
2) Left and right pulmonary arteries
   a) project laterally to the hilum of their corresponding lung
   b) ligamentum arteriosum - a prominent band of connective tissue that is the remnant of the fetal ductus arteriosus; connects the underside of the aortic arch with the root of the left pulmonary artery
3) Superior and inferior pulmonary veins
   a) two per lung (right and left superior, right and left inferior)
   b) project from the hila of the lungs to the left atrium

Clinical Note: Patent ductus arteriosus – failure of the ductus arteriosus to close within a few months of birth to create the ligamentum arteriosum; results in a continual shunting of high pressure oxygenated blood in the aorta into the lower pressure deoxygenated blood of the pulmonary trunk, which in turn feeds the pulmonary circulation of the lungs. The condition can result in irreversible damage to the pulmonary circulation if not corrected.

Thoracic Aorta

1) Ascending aorta
   a) originates at the aortic orifice of the left ventricle and rises (ascends) obliquely to the right to the level of the sternal angle
   b) branches - right and left coronary arteries
2) Arch of the aorta (aortic arch)
   a) the curved (arched) continuation of the ascending aorta
   b) arches posteriorly and to the left
   c) continuous with the descending thoracic aorta at the level of the sternal angle
   d) branches (listed in order of origin)
      i) brachiocephalic artery – blood supply to right side head & neck and right upper limb

   ii) left common carotid artery – blood supply to left side head & neck
   iii) left subclavian artery – blood supply to left upper limb
3) Descending thoracic aorta
   a) begins at the distal end of the arch of the aorta adjacent to the vertebral column
   b) descends the posterior mediastinum, moving toward the midline, to the aortic hiatus
   c) branches
      i) posterior intercostal arteries
      ii) pericardial, esophageal, and bronchial arteries

Clinical Notes: 1) Aortic aneurysm (aneurysm – a permanent, localized dilation of an artery) - can occur anywhere along the thoracic aorta. An aneurysm at the proximal end (root) of the ascending aorta often produces aortic regurgitation (retrograde blood flow into the left ventricle) due to its distortion of the aortic valve. Expanding aortic aneurysms can cause tracheal and bronchial compression, SVC syndrome, and compression of the left recurrent laryngeal nerve. 2) Coarctation of the aorta – a congenital narrowing of the thoracic aorta; usually occurs just distal to the origin of the left subclavian artery near the junction of the aortic arch and the descending thoracic aorta. Clinical manifestations vary widely from complete cardiovascular shutdown in infancy to asymptomatic hypertension in adulthood. 3) Traumatic aortic rupture (transection) – the most common injury of the great vessels, accounting for about 15% of all fatalities in automobile accidents. Usually a transverse tear of the aortic wall near the proximal end of the descending aorta just after the origin of the left subclavian artery and near the aortic attachment of the ligamentum arteriosum; in rapid deceleration the heart and aortic arch continue forward while the descending aorta remains tethered to the stationary vertebral column (speculation that the tear occurs in part from the pull of the ligamentum arteriosum on the aorta). 4) Dissection of the aorta (Aortic dissection) – progressive separation of the layers of the aortic wall by a column of blood, creating a “false aortic lumen” within the wall of the artery that is connected to the “true aortic lumen” by a tear in the intima of the vessel wall. Combined with the incidence of aortic aneurysms are the 15th leading cause of death in the U.S..

Azygos Venous System

1) General features
   a) a vertical system of veins
   b) azygos means “unpaired” or “lacking a mate”
   c) highly variable “system” of veins
2) Azygos vein
   a) originates below the diaphragm by the union of the right subcostal vein and the right ascending lumbar vein, the latter of which anastomoses with the IVC
   b) the single azygos vein resides on the vertebral bodies near the midline
   c) joins the SVC after arching over the root of the right lung
3) Hemiazygos and accessory hemiazygos veins
   a) their presence is variable
   b) if present they drain the left side of the posterior thoracic wall
   c) lie on the vertebral bodies to the left of the azygos vein
4) Tributaries of the azygos system of veins
   a) posterior intercostal veins
   b) pericardial, esophageal, and bronchial veins

Clinical Note: Alternate routes of venous return to the heart - venous compressions typically occur gradually over time (e.g. an enlarging aneurysm compressing the SVC) which gives collateral venous channels time to expand and facilitate alternative venous flow patterns. The azygos venous system forms an important collateral venous circulation when blood flow through the IVC or SVC is obstructed. The veins of the azygos venous system are devoid of valves, which permits blood to flow in either direction based on blood pressures within adjoining veins. The azygos vein is connected to both the SVC (its termination) and the IVC via the right ascending lumbar vein (part of its origin). Hence a collateral venous route to the right atrium of the heart is formed with compression of the SVC, i.e.

blood flows from the SVC to the azygos vein to the ascending lumbar vein to the IVC to the right atrium.

Major Nerves of the Thoracic Cavity

Phrenic Nerves

1) derived from C3, C4, and C5
2) function
   a) sole motor innervation to the diaphragm (each supplies its corresponding half of the diaphragm)
   b) conducts sensory afferents (pain) from mediastinal and diaphragmatic parietal pleurae and from the fibrous and serous parietal pericardium
3) traverse superior thoracic aperture, pass anterior to the roots of the lungs, and descend the pericardium to the diaphragm
4) travel with the small pericardiacophrenic blood vessels, which supply blood to the pericardium and the central region of the diaphragm

Clinical Notes: 1) Paralysis of the phrenic nerve(s) – The most common cause of paralysis of the phrenic nerve(s) is injury during cardiac surgery; other causes include external trauma (e.g. gunshot wound, birth injury) and compression or invasion by neighboring diseased structures (e.g. tumors of the mediastinum). A unilateral paralysis reduces ventilation function by about 25% in adults and older children, which is well tolerated. A temporary bilateral paralysis may require mechanical ventilation of the patient. 2) Diaphragmatic pacing – rhythmic electrical stimulation of the phrenic nerve with resulting rhythmic contraction of the diaphragm; requires an intact phrenic nerve and a structurally sound diaphragm (e.g. not used on patients with muscular dystrophies). Most commonly used in sleep apnea and spinal cord injuries above the C3 level. 3) Phrenic nerve block – a potential complication in other nerve block procedures, e.g. about 50% of patients subjected to a supraclavicular approach for a brachial plexus nerve block have a concurrent temporary block of the phrenic nerve on the same side.

Vagus Nerves

1) the 10th cranial nerves – the principle parasympathetic nerves of the body
2) traverse the superior thoracic aperture, pass posterior to the roots of the lungs, lie on the anterior and posterior surfaces of the esophagus, traverse the esophageal hiatus
3) function
   a) motor innervation to thoracic viscera (e.g. SA node)
   b) sensory innervation to thoracic viscera (e.g. touch of the cough reflex)
   c) somatic (voluntary) innervation to muscles of the larynx responsible for speech
      i) laryngeal motor nerves branch from the vagi as the recurrent laryngeal nerves
         (1) left recurrent laryngeal nerve branches from the left vagus near the aortic arch
         (2) right recurrent laryngeal nerve branches from the right vagus in the lower neck

Clinical Note: Damage to the left recurrent laryngeal nerve – the thoracic position of the left recurrent laryngeal nerve renders it susceptible to surgical injuries (e.g. repair of a coarctation of the aorta), compression injuries from neighboring structures (e.g. an aortic aneurysm), and invasive diseases (e.g. bronchogenic carcinoma). Damage to the left recurrent laryngeal nerve leads to left vocal cord paralysis and a resulting hoarseness in the voice.

Sympathetic Trunks

1) typically 10 to 11 sympathetic chain ganglia per side in the thorax
2) ganglia lie near the heads of the ribs
3) function
   a) send postganglionic fibers to the intercostal nerves (vasomotor, sweat glands, and arrector pili innervation of the thoracic wall)

b) upper 5 or 6 thoracic ganglia provide postganglionic efferents to thoracic viscera (e.g. SA node); sensory afferents (e.g. pain fibers from the heart) pass through the ganglia.
c) thoracic splanchnic nerves
   i) three in number named the greater, lesser, and least splanchnic nerves
   ii) are preganglionic sympathetic efferent and visceral sensory afferent fibers that pass through the lower 6 or 7 thoracic ganglia and enter the abdomen to provide motor and sensory innervation to abdominal viscera.

Clinical Notes: 1) Thoracic sympathectomy – surgical ablation of portions of the thoracic sympathetic trunk; used in the treatment of palmar and axillary hyperhidrosis (excessive and clinically significant sweat production on the palms of the hands or axillae) in which the goal is to interrupt the sympathetic innervation to the sweat glands. 2) Thoracic splanchnicectomy - surgical ablation of the thoracic splanchnic nerves; used as a treatment for intractable pain associated with certain abdominal diseases (e.g. pancreatic cancer). While the pain fibers originate in abdominal viscera, they are collectively together and more easily exposed within the thorax where the splanchnic nerves form.

Thymus

1) anatomical position (4 compartment model) – upper anterior mediastinum and anterior portion of the superior mediastinum; often extends into the lower neck.
2) function - helps to establish the immune system (T-lymphocyte production)
3) diminishes greatly in size during puberty; replaced largely with fat and connective tissue and henceforth referred to as the thymic remnant

Clinical Note: Thymoma - a class of thymic tumors, may be benign or malignant, usually presenting between the ages of 40 and 60 with no sex predilection; very rare in children. Thymomas are the most common mediastinal tumors in adults, comprising 21% of all mediastinal masses.

Esophagus

1) a thick-walled muscular tube that is continuous with the hypopharynx (laryngopharynx) in the neck and the stomach in the abdomen
2) position
   a) descends the superior mediastinum immediately posterior to the trachea and anterior to the vertebral column
   b) passes directly posterior to the left atrium of the heart
   c) deviates slightly to the left and anteriorly in the posterior mediastinum to reach the esophageal hiatus of the diaphragm
3) upper 1/3 is striated (voluntary) muscle, middle 1/3 a mixture of striated and smooth (involuntary) muscle, lower 1/3 entirely smooth muscle
   a) esophagus does not exhibit spontaneous peristalsis; a peristaltic wave of contraction is initiated voluntarily by the act of swallowing and then spreads to the smooth muscle
   b) LES (lower esophageal sphincter) - circular layer of tonically contracted smooth muscle in the distal esophagus near its entrance into the stomach
4) blood supply
   a) from vessels of the neck, thorax (esophageal branches of the descending thoracic aorta), and abdomen (esophageal branches of the left gastric artery).
   b) thoracic and abdominal esophageal veins form a portal-systemic anastomosis (areas of the circulatory system where veins draining directly into the systemic circulation anastomose with veins that drain into the hepatic portal circulation of the liver)
5) nerve supply
   a) striated muscle innervated by 11th cranial nerves - voluntary act of swallowing

b) smooth muscle innervated by vagus nerves - relaxes the LES during swallowing
c) sensory afferents conduct esophageal pain, which is felt posterior to the sternum and may be confused with cardiac pain

Clinical Notes: 1) Esophageal varices – unnaturally enlarged, tortuous esophageal veins due to sustained increased portal venous pressure (portal hypertension) in the portal vein of the liver, as may occur with compression of the portal vein (e.g. tumor) or diseases of the liver (e.g. cirrhosis). The varices reflect the venous drainage of the lower 1/3 of the esophagus by tributaries of the portal vein and the anastomoses that exist between those tributaries and veins of the middle 1/3 of the esophagus that drain into the azygos vein of the systemic circulation. If significant, esophageal varices are susceptible to rupture (resulting in hemorrhage) from the pressures and abrasions of swallowing. 2) The anatomical relationship of the esophagus to the left atrium is exploited in transesophageal echocardiography (creation of cardiac images based on the capturing of ultrasound echoes) where the requisite instrumentation is placed in close proximity to the heart by passing it down the esophagus, which resides immediately posterior to the left atrium. 3) Esophageal mobility - the esophagus is mobile within the mediastinum (not tightly tethered to neighboring structures) and diseases of neighboring structures may shift its typical near midline position.

Thoracic Duct

1) largest lymphatic vessel of the body
2) begins in the abdomen at the cisterna chyli, a dilated sac-like confluence of lymphatic vessels just inferior to the diaphragm on the right posterior abdominal wall
3) ascends through the aortic hiatus and follows the course of the esophagus into the root of neck where it joins the left brachiocephalic vein
4) carries all of the lymph that originates from below the diaphragm and from the left side of the thorax, the left side of the head and neck, and the left upper limb.

Clinical Note: Chylothorax - the accumulation of chyle (a fat and protein rich, milky-white form of lymph) within the thoracic cavity. While congenital chylothoraces, non-traumatic chylothoraces (e.g. structural breakdown of the thoracic duct wall as a result of invasion of the duct by a tumor), and traumatic chylothoraces (e.g. rupture of the thoracic duct by a vertebral body fracture in an automobile accident) do occur, the most common cause of chylothorax is injury to the thoracic duct during intrathoracic surgery. The clinical manifestations of chylothorax are those of pleural effusion which results when the accumulated chyle in the mediastinum ruptures through the mediastinal parietal pleurae. The fluid is drained by thoracentesis and the diagnosis is made by analysis of the fluid. Treatment may be non-operative with repeated thoracenteses and dietary management to reduce the amount of lymph flowing from the intestines, seeking a spontaneous closure of the site of leakage, or operative closure of the rupture site.

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