

Anatomy CVS

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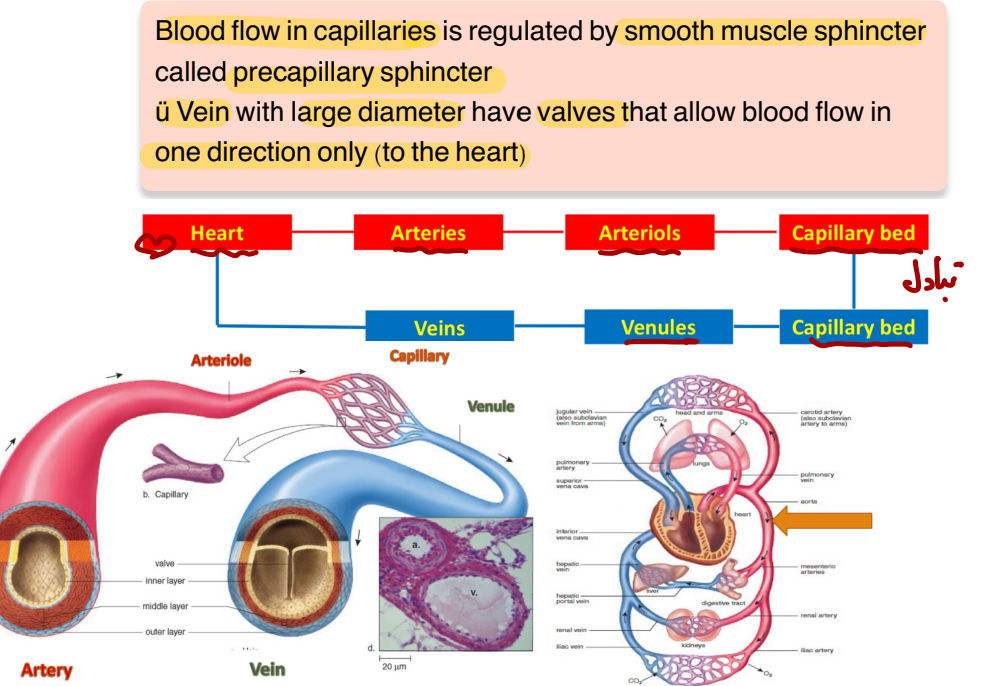
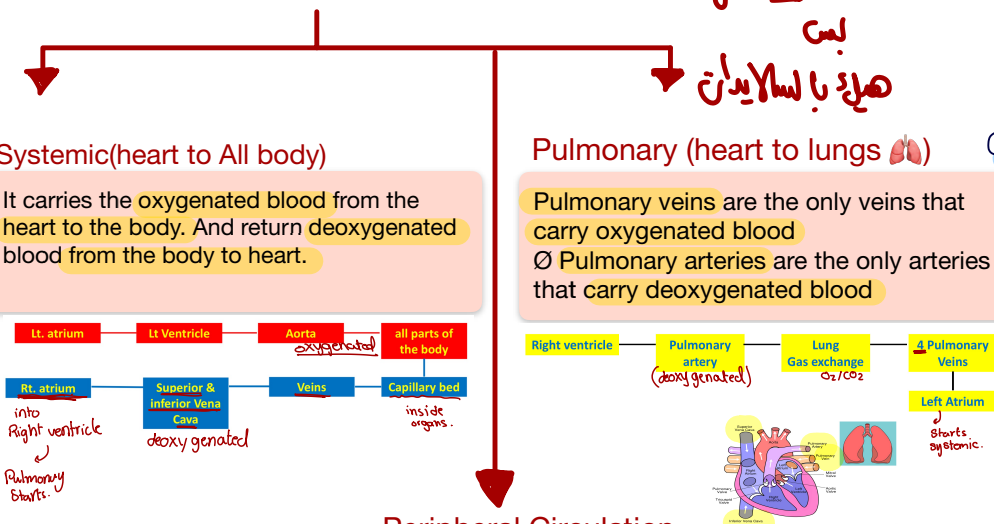
Lecture 1 Cardiovascular system anatomy

The function cardiovascular system is to carry oxygen and nutrients and to eliminate carbon dioxide and other waste products from the body.

Veins toward the heart.

Arteries away from the heart

3 circulations



Thoracic wall

Boundaries:
Anteriorly: sternum and costal cartilages
Posteriorly: vertebral column
On either side: ribs and intercostal spaces

Skeleton of thorax
This is an Osseo cartilaginous cavity composed of:
1- Sternum
2- Ribs
3- Costal cartilage
4- Thoracic vertebrae

Thoracic cavity
It is bounded by the thoracic cage, diaphragm. It extends upward into the root of the neck About one finger breadth above the clavicle on each side. It contains two pleural cavities containing lungs and mediastinum.

Arterial blood supply & venous drainage of thoracic wall

Arterial supply of thoracic wall

- Anterior wall:** 9 on each side, 2 in each space. Upper 6 from internal thoracic artery, 7,8,9 from musculophrenic artery.
- Posterior wall:** 11 on each side, one in each space. 1st, 2nd from superior intercostal artery, 3-11 from descending thoracic aorta.

Venous drainage of thoracic wall

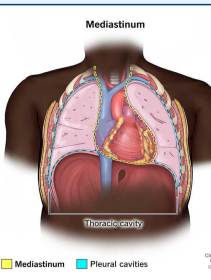
- Anterior wall:** Anterior intercostal veins drain into internal thoracic vein.
- Posterior wall:** Intercostal vein drains into brachiocephalic vein.

Internal Thoracic (Mammary) artery
Origin: branch of 1st part of subclavian artery.
Course: it descends vertically behind upper 6 costal cartilages and intercostal spaces.
Termination: opposite the 6th intercostal space into superior epigastric A. Musculophrenic A.

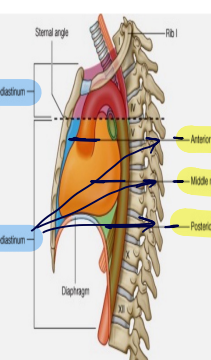
Vertebral venous plexus
is a valveless plexiform of veins.
Location: epidural space between the wall of the vertebral canal and the dura mater.
Communication: receives the basivertebral veins which lie within the vertebral bodies. Superiorly with the cranial dural sinuses. Inferiorly with the pelvic veins. It communicates with both the azygos and caval systems in the thoracic and abdominal regions.

Lecture 2 Cardiovascular system anatomy

Mediastinum It is the region between the two pleural cavities.



Boundaries:
Superior: Thoracic Inlet
Inferior: Diaphragm
Anterior: Sternum
Posterior: Vertebral column



Division:
Subdivisions
An imaginary line from sternal angle to lower border of 4th thoracic vertebra divide mediastinum into:
1. Superior mediastinum above the line
2. inferior mediastinum below the line.
Inferior mediastinum divided into:
- Middle mediastinum contains heart and pericardium
- Anterior mediastinum in front middle mediastinum
- Posterior mediastinum behind middle mediastinum

Superior mediastinum

Contents of superior Mediastinum

- Arch of Aorta and its branches
- Brachiocephalic veins and superior vena cava
- Thoracic duct
- Thymus
- Phrenic and vagus nerves
- Trachea
- Oesophagus

Boundaries:
- Anteriorly: manubrium sterni.
- Posteriorly: upper four thoracic vertebrae.
- Superiorly: thoracic inlet.
- Inferiorly: imaginary plane. On each side: mediastinal pleura.

Brachiocephalic vein (Right and left)

Brachiocephalic vein (Right and left)
Formation: By union internal jugular and subclavian veins
Beginning: Posterior to the sternoclavicular joint
Termination: 1st right costal cartilage
Both right and left Brachiocephalic veins joined together to form superior vena cava
N.B: The left Brachiocephalic vein is longer than the right Brachiocephalic vein WHY??
It passes from the left to the right side, anterior to the roots of the three major branches of the arch of the aorta

Tributaries of Brachiocephalic vein

Rt. Brachiocephalic vein	Lt. Brachiocephalic vein
Inferior thyroid vein	Inferior thyroid vein
Right vertebral vein	Left vertebral vein
Right internal thoracic vein	Left internal thoracic vein
Right first posterior intercostal	Left first posterior intercostal vein
	Left superior intercostal vein

Superior vena cava

Superior vena cava
Formation: By union the right and left Brachiocephalic veins
Beginning: 1st right costal cartilage
Termination: 3rd right costal cartilage as it enters the right atrium of the heart
It receives the venous return from the upper half of the body, above the diaphragm

Arteries of the superior mediastinum

I-Arch of the aorta
- Beginning: Right border of sternum at 2nd right costal cartilage
- Termination: Lower border 4th thoracic vertebra by becoming the thoracic (descending) aorta.
- Course: It arches superiorly, posteriorly and to the left, and then inferiorly.
§ It arches anterior to the right pulmonary artery and the bifurcation of the trachea.
§ It passes over the root of the left lung to become at the left side of the trachea and esophagus.
N.B The ligamentum arteriosum:
Ø It is the remnant of the fetal ductus arteriosus.
Ø It passes from the root of the left pulmonary artery to the inferior surface of the arch of the aorta

Lecture 2 Aortic arch

Relations

Anteriorly and to the left:

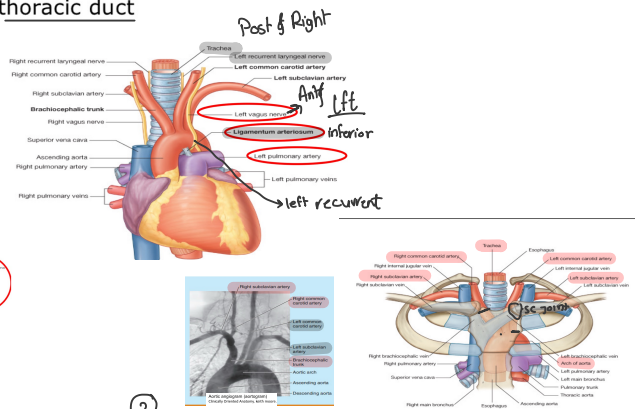
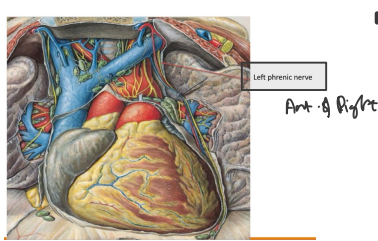
left phrenic, left vagus and left superior intercostal vein

Posteriorly and to the right:

Esophagus, trachea, left recurrent laryngeal nerve and thoracic duct

Inferiorly :

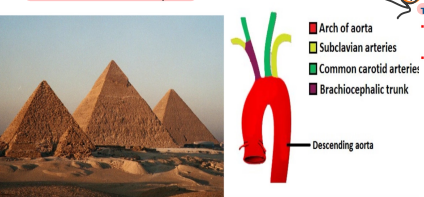
- ✓ Bifurcation of pulmonary trunk
- ✓ Ligamentum arteriosum.
- ✓ Superficial cardiac plexus
- ✓ left recurrent laryngeal nerve.
- ✓ Left main bronchus



Aortic arch branches

Three branches

1. Brachiocephalic trunk
2. Left common carotid artery
3. Left subclavian artery



The brachiocephalic trunk:
 It arises posterior to the manubrium, where it is anterior to the trachea and posterior to the left brachiocephalic vein.
 At the right sternoclavicular (SC) joint, it divides into the right common carotid and right subclavian arteries.

The left common carotid artery:

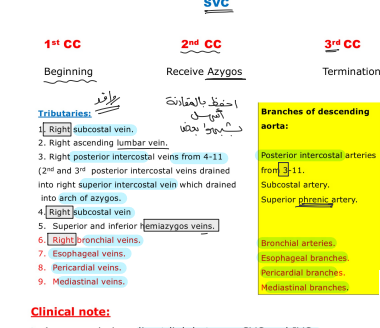
- It arises posterior to the manubrium
- It enters the neck by passing posterior to the left SC joint.

The left subclavian artery:

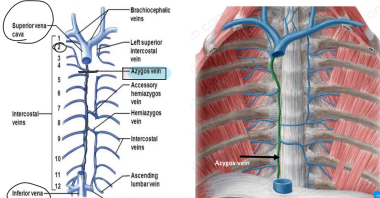
- It arises from the posterior part of the arch behind left common carotid artery
- It leaves the thorax and enters the root of the neck by passing posterior to the left SC joint.

② Posterior mediastinum. Azygos vein

Azygos Vein
Beginning:
 From the back of IVC opposite L2 (level of renal vein)
 Or by union of right subcostal and right ascending lumbar veins.
Course:
 It ascends through aortic opening of diaphragm.
 Then it ascends in posterior mediastinum till T4 where it arches forwards above right bronchus.
Termination: the back of SVC opposite right 2nd costal cartilage.



1st CC Beginning
2nd CC Receive Azygos
3rd CC Termination

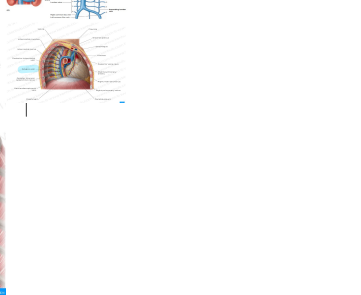


③ Superior hemiazygos

Superior hemiazygos
 It is a longitudinal venous channel that descends on the left side of vertebral body.
Termination:
 At the level of T7, it curves to right to end in azygos vein.
Tributaries:
 1. Left posterior intercostal veins from 4-6
 2. Left bronchial veins.

④ Inferior hemiazygos

Inferior hemiazygos vein
Beginning: From the back of the left renal vein opposite L2.
Termination:
 It is formed by union of left subcostal and left ascending lumbar veins.
 At the level of T8, it curves to the right to end into azygos vein.
Tributaries:
 1. Left posterior intercostal veins from 9-11
 2. Left subcostal and left ascending lumbar veins.



Nerves of the superior mediastinum

① Nerves of the superior mediastinum

1-Vagus Nerve

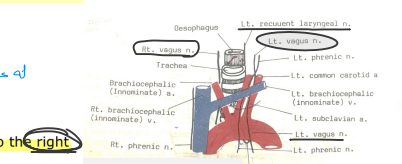
Right vagus nerve

- Passes on the right side of the trachea, then posterior to the right brachiocephalic vein, SVC
- It contributes to Rt. pulmonary, esophageal and cardiac plexuses
- It gives right recurrent laryngeal nerve, which hooks around the right subclavian artery and ascends between the trachea and esophagus to supply the larynx

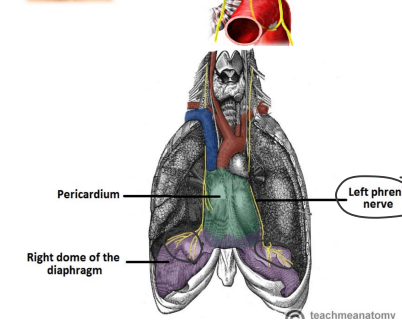
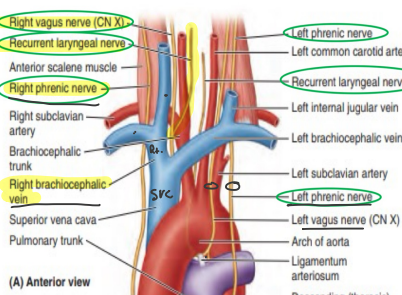
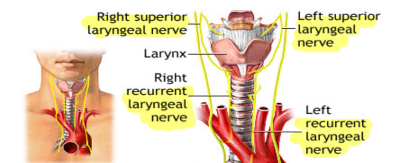
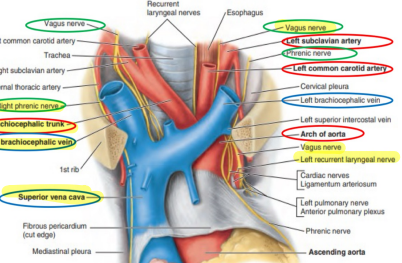
The left vagus nerve

- It enters the mediastinum between the left common carotid artery and left subclavian artery.
- It gives left recurrent laryngeal nerve which hooks around the arch of the aorta, lateral to the ligamentum arteriosum, and ascends in the groove between the trachea and the esophagus to supply the larynx

Both vagi are passing behind the root of the lung



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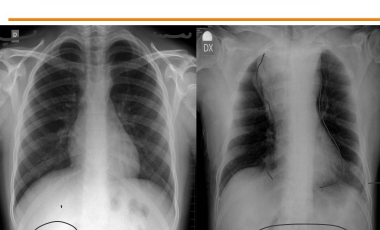
Mediastinal syndrome

Mediastinal syndrome

Definition: group of symptoms due to compression of the mediastinal contents by a space-occupying lesion. e.g. malignant tumour as lung cancer or non-Hodgkin's lymphoma

Symptoms:

- Dyspnea:** due to compression of trachea.
- Dysphagia:** due to compression of esophagus.
- Congestion of veins:** due to compression of SVC.
- Ischemia:** due to compression of branches of arch of aorta.
- Hoarseness of voice:** due to compression on left recurrent laryngeal nerve.
- Paralysis of hemi-diaphragm:** due to compression on phrenic nerve.



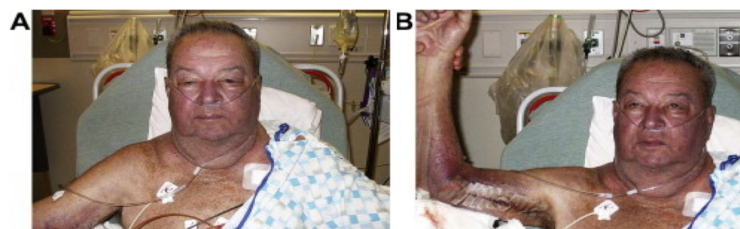
Normal Chest X ray vs Mediastinal syndrom

Superior vena cava syndrome

Superior vena cava syndrome (SVCS)

Due to obstruction of Superior vena cava
Manifestation
 Dyspnea and edema in the face and arms
Pemberton sign:
 Ask the patient to raise both arms above head, facial edema or cyanosis indicates SVCS

<https://www.youtube.com/watch?v=dz4CEkntWPM>



Front chest X-ray showing the overly short distal catheter (white arrow) and the dilation of the arch of the azygos vein (venous sheath) indicating the obstruction of the superior vena cava.

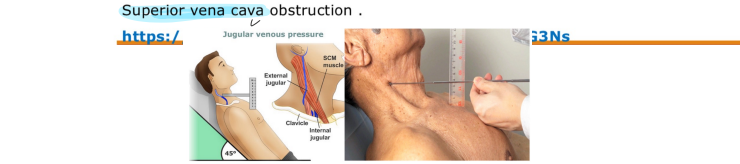
Jugular venous pressure

Jugular venous pressure (JVP)

- ✓ It provides an indirect measure of central venous pressure.
- ✓ The internal jugular vein connects to the right atrium without any intervening valves, thus acting as a column for the blood in the right atrium.

Difference between carotid and jugular pulse
 The jugular venous pulse is:
 Not palpable.
 Obliterated by pressure.
 Variable with respiration - it decreases with inspiration.

Causes of increased Jugular venous pressure
 Heart failure
 Constrictive pericarditis
 Pulmonary hypertension
 Superior vena cava obstruction.

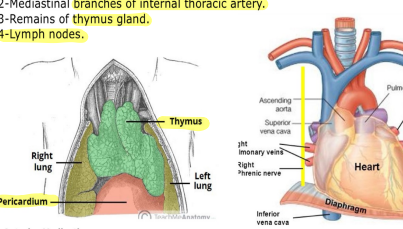


Inferior mediastinum



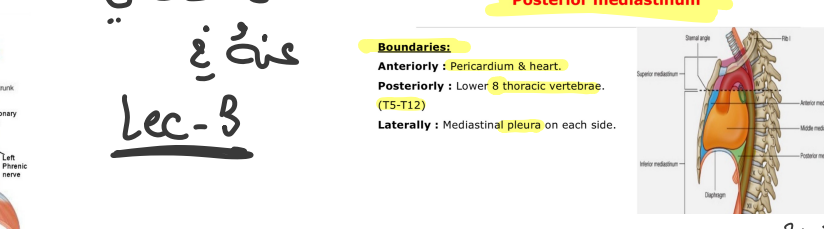
Anterior Mediastinum

It lies between pericardium and sternum.
Contents:
 1-Superior and inferior sterno-pericardial ligaments
 2-Mediastinal branches of internal thoracic artery.
 3-Remains of thymus gland.
 4-Lymph nodes.

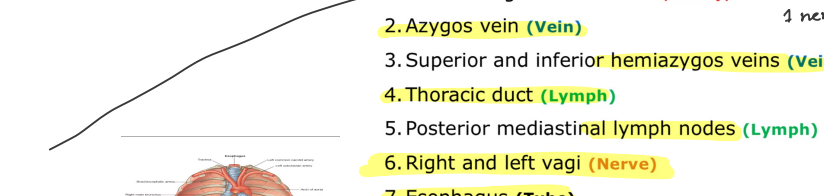


Posterior mediastinum

Boundaries:
 Anteriorly: Pericardium & heart.
 Posteriorly: Lower 8 thoracic vertebrae. (T5-T12)
 Laterally: Mediastinal pleura on each side.



Contents of posterior mediastinum:
 1. Descending thoracic aorta (Artery)
 2. Azygos vein (Vein)
 3. Superior and inferior hemiazygos veins (Vein)
 4. Thoracic duct (Lymph)
 5. Posterior mediastinal lymph nodes (Lymph)
 6. Right and left vagi (Nerve)
 7. Esophagus (Tube)



A 62 years old male patient has diagnosed as lung cancer. He is a heavy smoker, diabetic, and hypertensive. During a chemotherapy session for lung cancer, he complained of dyspnea for a week, and the doctor noticed edema in the face and arms. The doctor asked him to raise his hands above the head, and he noticed increased the edema.
What is your provisional diagnosis??



① Descending Thoracic aorta

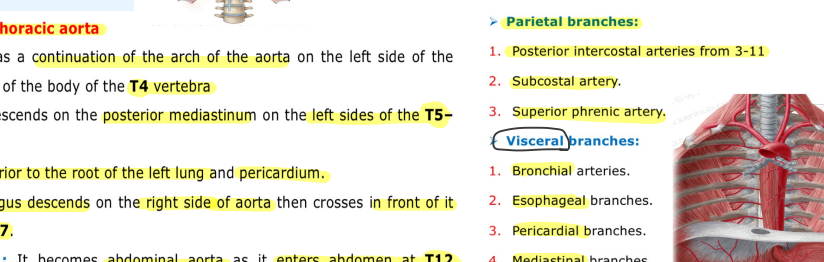
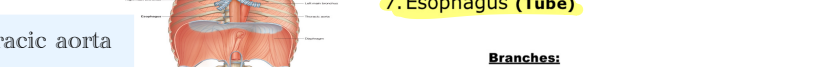
Descending thoracic aorta

Beginning: as a continuation of the arch of the aorta on the left side of the inferior border of the body of the T4 vertebra

Course: It descends on the posterior mediastinum on the left sides of the T5-T12 vertebrae

- It lies posterior to the root of the left lung and pericardium.
- The esophagus descends on the right side of aorta then crosses in front of it at level of T7.

Termination: It becomes abdominal aorta as it enters abdomen at T12 vertebra through the aortic hiatus in the diaphragm

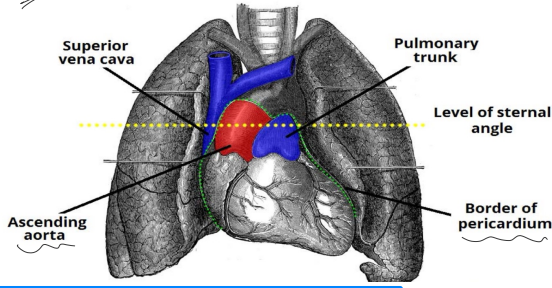


Inferior mediastinum

- Ant
- post
- middle.

Middle mediastinum

The middle mediastinum contains the **pericardial sac** which contains the heart and roots of its great vessels: ascending aorta, pulmonary trunk, and SVC; passing to and from the heart.



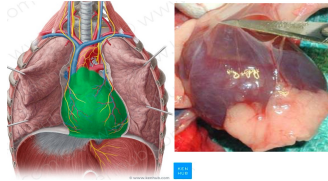
Pericardium

The pericardium is a closed fibrous membrane that covers the heart and the beginning of its great vessels

It is composed of two layers; The outer tough layer, the fibrous pericardium and inner serous layer.

Function of the pericardium

- 1-Restrict excessive movements of the heart.
- 2-Serve as a lubricated container in which the different parts of the heart can contract.

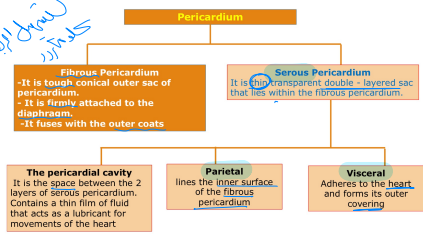
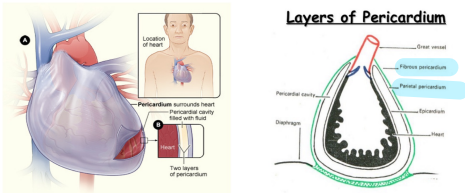
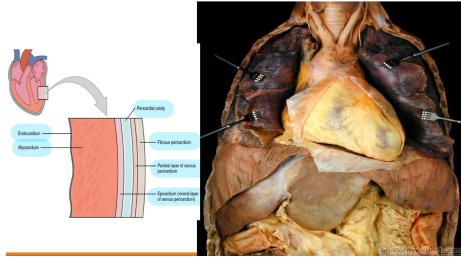


Layers of Pericardium

تذکرہ: لکتور شو جان (الکین)

I- The fibrous pericardium is the outer tough layer
Attachment:
Superiorly: Continuous with the tunica adventitia of the great vessels
Inferiorly: Continuous with the central tendon of the diaphragm, which is called **pericardiophrenic ligament**
Anteriorly: Attached to the posterior surface of the sternum by the **sternopericardial ligaments**
Posteriorly: Bound by loose connective tissue to structures in the posterior mediastinum.
 So, the heart is bonded in its place inside this fibrous sac.
N.B., The fibrous pericardium protects the heart against sudden overfill.

II- The serous layer is composed of two layers with a space in between
1- The parietal layer of serous pericardium: it lines the inner surface of the fibrous pericardium
2- Visceral layer: It is a reflection of parietal layer at the great vessels (aorta, pulmonary trunk and veins, and superior and inferior venae cava)
 The visceral layer of serous pericardium forms the epicardium, the outermost of three layers of the heart wall.
3- Pericardial sac: It is the space between the 2 layers of serous pericardium. Contains a thin film of fluid that acts as a lubricant for movements of the heart



PeriCardial sinuses

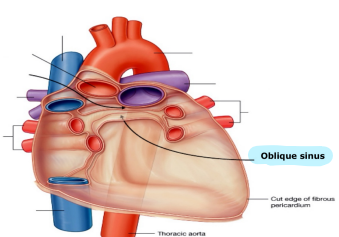
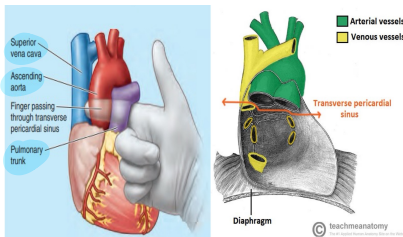
It is a reflection of pericardial parietal and visceral layers

1- Transverse sinus
Boundaries:

- Anterior: Ascending aorta and pulmonary trunk.
- Posterior: SVC.
- Inferior: Atria of the heart

2- Oblique sinus
Boundaries:

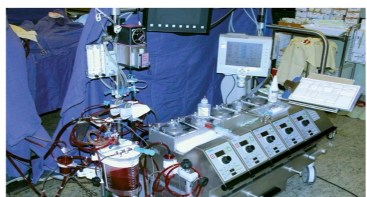
- Anterior: Visceral pericardium covering back of left atrium.
- Posterior: Parietal pericardium covering esophagus.
- Superior: Reflection of visceral to become parietal pericardium.
- Inferior: Opened and continuous with pericardial cavity.
- Laterally: Pericardial reflection surrounding pulmonary veins and IVC.



REED ONLY

Clinical importance of The transverse pericardial sinus
 In cardiac surgery, After the pericardial sac is opened anteriorly, a finger can be passed through the transverse pericardial sinus posterior to the ascending aorta and pulmonary trunk.

By passing a surgical clamp or a ligature around these large vessels, inserting the tubes of a coronary bypass machine, and then tightening the ligature, surgeons can stop or divert the circulation of blood in these arteries while performing cardiac surgery, such as coronary artery bypass grafting.

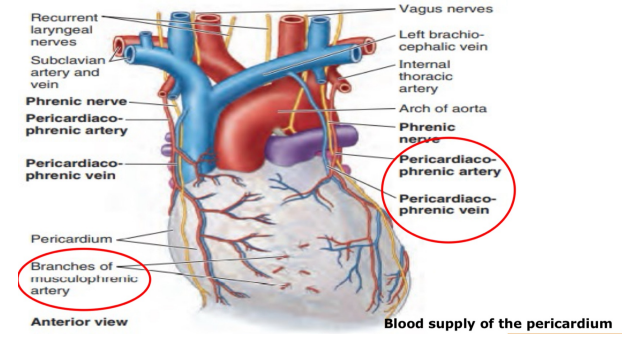


Arterial supply of the pericardium

1. **Pericardiophrenic** artery, which is slender branch of the internal thoracic artery (the main blood supply)
Smaller contributions of blood come from
2. **Musculophrenic** artery, a terminal branch of the internal thoracic artery.
3. **Bronchial, esophageal, and superior phrenic** arteries, branches of the thoracic aorta.
4. **Coronary arteries** (visceral layer of serous pericardium only).

Venous drainage of the pericardium

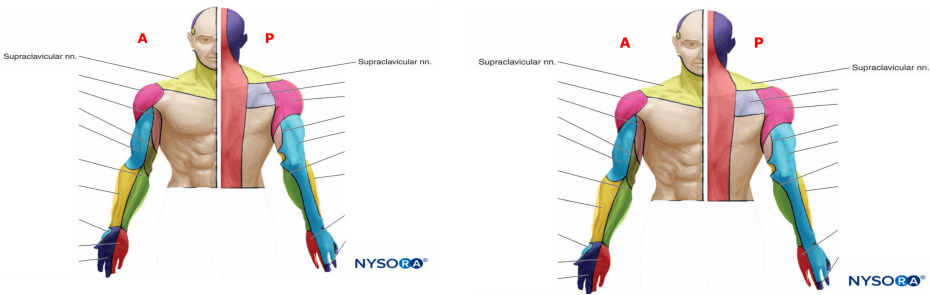
Pericardiophrenic veins, tributaries of the brachiocephalic (or internal thoracic) veins



Nerve supply of the pericardium

- The fibrous pericardium and the parietal layer of the serous pericardium are supplied by the **phrenic nerves (C3-C5)**
- The **visceral layer** of the serous pericardium is innervated by branches of the sympathetic trunks and the **vagus nerves**.
- Pericardial pain sensations is referred to the skin of the ipsilateral supraclavicular region, top of the shoulder of the same side, (C3-C5 dermatomes)
- C3-C5 dermatomes is supplied by supraclavicular nerves

vagus
 left - Anterior to Esophagus
 Right - Posterior Esophagus

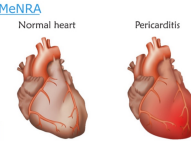


Pericarditis

Is inflammation of pericardial sac, which cause chest pain
 Pericarditis pain usually occurs behind the breastbone (sternum) or on the left side of the chest.
 The pain may:

- Spread to the left shoulder and neck
- Get worse when coughing, lying down or taking a deep breath
- Get better when sitting up or leaning forward

https://www.youtube.com/watch?v=5_EkYuMeNRA



A 25 years old male patient came to emergency by a penetrating wound in chest wall. The knife reached the heart and there was a sever bleeding. He died shortly. What is the common cause of death?

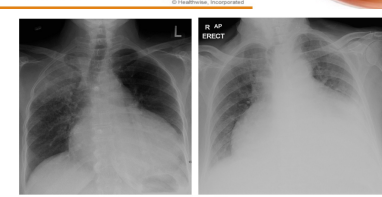
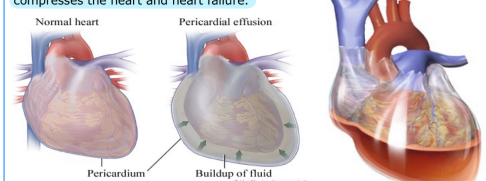


Pericardial effusion

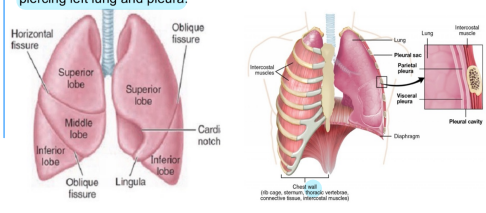
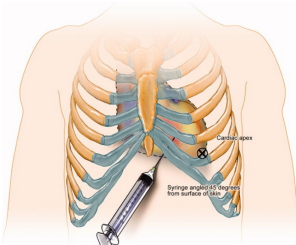
Means increase the fluid between the parietal and visceral layers of the pericardium

Cardiac tamponade

Is a rapid accumulation of excess fluid within the pericardial sac, which leads to compresses the heart and heart failure.

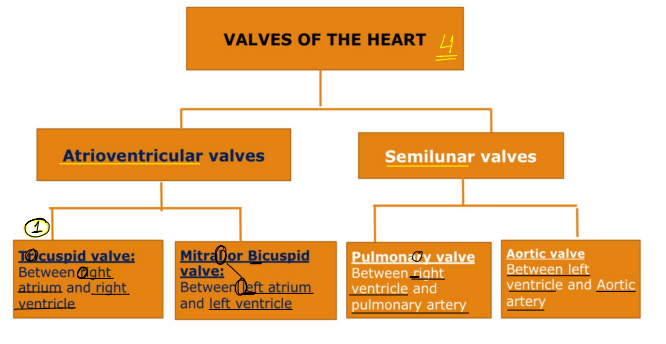


Pericardiocentesis: pericardial effusion is usually removed by inserting a needle in the left 5th or 6th intercostal spaces close to the sternum to avoid piercing left lung and pleura.



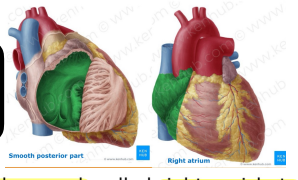
The Heart composed of 4 chambers :-

- Two Receiving chambers (Atria)
 - Right Atrium/Left Atrium
- Two Discharging chambers (Ventricles)
 - Right Ventricles/Left Ventricles



Heart chambers

1 Right atrium



The right atrium has a small muscular pouch called **right auricle** to increasing the capacity of the atrium

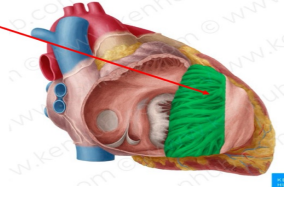
The right atrium has

A. Smooth posterior part and **rough anterior part**

B. Septal wall, which separates the right atrium from the left atrium

Smooth posterior part (The sinus venarum)
It receives superior and inferior venae cavae and coronary sinus openings

Rough Anterior part muscular anterior wall composed of **pectinate muscles** (L. musculi pectinati).



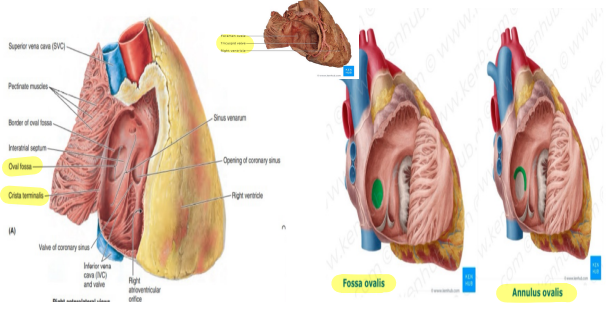
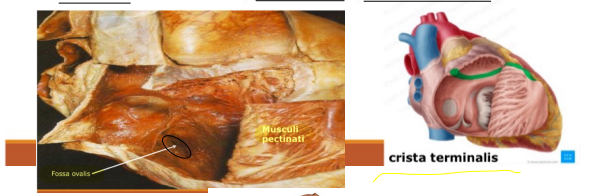
The smooth and rough parts are separated by

Externally by a shallow vertical groove, the **sulcus terminalis** or terminal groove

Internally by a vertical ridge, the **crista terminalis** or terminal crest

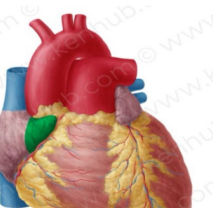
The interatrial septum

- It has an oval depression called **fossa ovalis**, which is a remnant of the oval foramen (L. foramen ovale) in the fetus.
- The fossa ovalis is surrounded by **annulus ovalis** (limbus fossa ovalis).



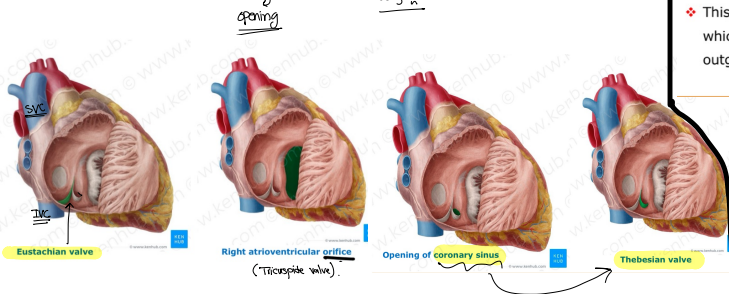
The right auricle

- It is a conical muscular pouch that projects from Rt. atrium
- It increase the capacity of the atrium
- It overlaps the ascending aorta
- Cardiac surgeon used it as point of entry



Openings of the right atrium:

- SVC Opens at the level of right **3rd costal cartilage**
- IVC Opens at the level of right **5th costal cartilage**
- It has a valve called **Eustachian valve** or valve of the inferior vena cava, which is located anterior to the orifice
- Coronary sinus**
- It opens between the orifice of the inferior vena cava, the fossa ovalis and the vestibule of the atrioventricular opening.
- It has a valve called **Thebesian valve**
- Anterior cardiac veins.**
- Venae cordis minimi.**
- Right Atrioventricular orifice** which is guarded by **Tricuspid valve**



2 Right ventricle



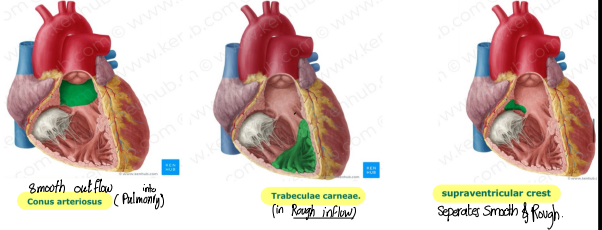
It has

1- Smooth outflow part which is called the **conus arteriosus** (infundibulum), which leads into the pulmonary trunk

2- Rough inflow part which receives blood from the right atrium through the right atrioventricular orifice which is guarded by Tricuspid valve.

It has numerous muscular **irregular structures** called **trabeculae carneae**.

BOTH parts are separated by A thick muscular ridge called the **supraventricular crest**

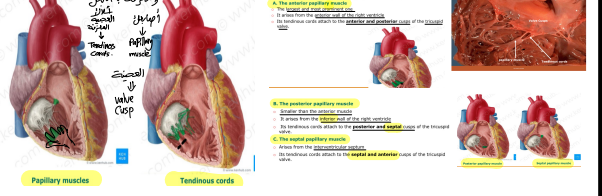


Trabeculae carneae

Trabeculae carneae has three patterns according to their attachments to the ventricular walls

- Attached throughout their length forming **RIDGES**
- Attached by both ends forming **BRIDGES**
- Attached by one end and the other end is free forming **PAPILLARY MUSCLES**

The papillary muscles are attached to **tendinous cords** called **chordae tendinae** which are attach to the free edges and ventricular surfaces of the tricuspid valve cusps.

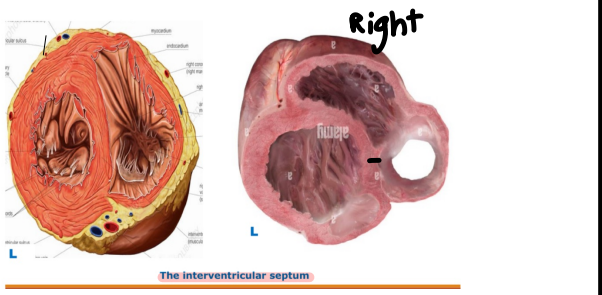


The septo marginal trabecula (moderator band)

- It is a curved muscular bundle that traverses the right ventricular from the inferior part of the interventricular septum (IVS) to the base of the anterior papillary muscle.
- It carries part of the right branch of the atrioventricular (AV) bundle (a part of the conducting system of the heart) to the anterior papillary muscle
- This shortcut across the chamber seems to facilitate conduction time, allowing coordinated contraction of the anterior papillae

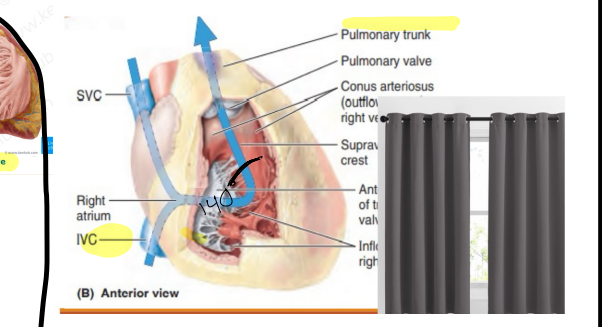
The interventricular septum (IVS)

- It composed of muscular and membranous parts
- It is obliquely placed partition between the right and left ventricles forming part of the walls of each.
- Because of the much higher blood pressure in the left ventricle, the **muscular** part of the IVS, bulges into the cavity of the right ventricle.
- Superiorly and posteriorly, The membranous part of the IVS is formed from membranous part of fibrous skeleton of the heart
- On the right side, the septal cusp of the tricuspid valve is attached to the middle of this membranous part of the fibrous skeleton.
- This means that inferior to the cusp, the membrane is an **interventricular septum**, but superior to the cusp it is an **atrioventricular septum** separating the right atrium from the left ventricle.



Blood flow through the right ventricle

- The right atrium contracts when the right ventricle is relaxed
- Thus blood is forced into the **right ventricle**, pushing the cusps of the tricuspid valve aside like curtains
- The inflow of blood into the right ventricle (inflow tract) enters posteriorly
- When the ventricle contracts, the outflow of blood into the pulmonary trunk (outflow tract) superiorly and to the left
- Consequently, the blood takes a U-shaped path through the right ventricle, changing direction about 140°.
- This change in direction is accommodated by the **supraventricular crest**, which deflects the incoming flow into the main cavity of the ventricle, and the outgoing flow into the conus arteriosus toward the pulmonary orifice.



3 Left atrium



1. The left atrium forms most of the base of the heart.

2. Behind it lies the fibrous pericardium separates it from the esophagus

3. It is smaller in size but has thicker wall than right atrium

4. The left atrium extends behind the right atrium, thus the right atrium is anterolateral to the right part of the left atrium.

It has

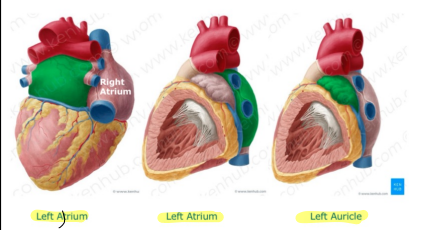
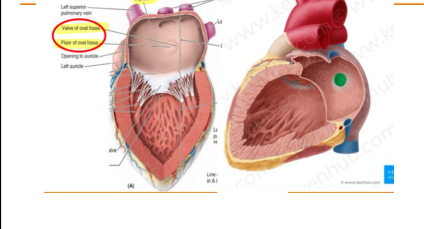
1- Rough part
The left auricle, its wall lined with pectinate muscles
It represents the remains of the left part of the primordial atrium

2- Smooth part
It represent the absorption of the future 4 pulmonary veins.

- The interatrial septum shows a semilunar edge indicates the oval fossa
- The surrounding ridge is the valve of the oval fossa

Openings of the left atrium

- The four pulmonary veins
- The left atrioventricular orifice which is guarded by mitral valve



Openings of left ventricle

- Right atrioventricular orifice which is guarded by the mitral valve (ostium venosum)
- An outlet region, guarded by the **aortic valve** (ostium arteriosum)

The left atrioventricular orifice admits atrial blood during **diastole**, flow being towards the cardiac apex.

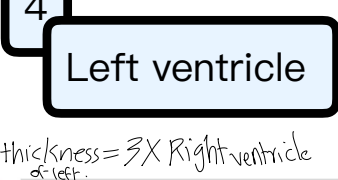
After closure of the mitral cusps, and throughout the **ejection phase of systole**, blood is expelled from the apex through the **aortic orifice**

The bloodstream undergoes two right angle turns, which together result in a **180° change in direction**.

This reversal of flow takes place around the anterior cusp of the mitral valve



4 Left ventricle



Thickness = 3X Right ventricle of left.

The thickness of its wall is three times than that of the right ventricle

The left ventricle is a conical cavity, so it is longer than that of the right ventricle

It has :-

1- Inflow rough part:
It contains **trabeculae carneae** which are more numerous than right ventricle

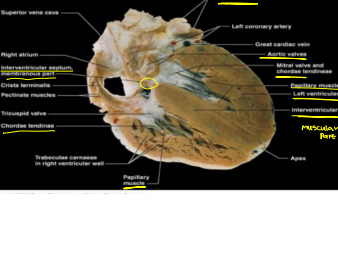
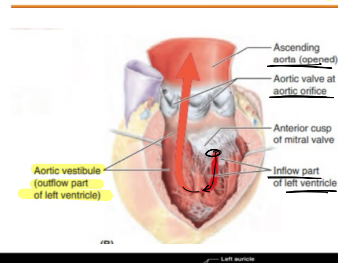
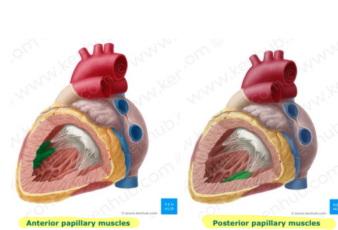
2- Inflow smooth part:
It contains **two papillary muscles**:
1- **Anterior papillary muscles**: arise from sternocostal surface
2- **Posterior papillary muscles**: arise from diaphragmatic surface
The papillary muscles are attached to **chordae tendinae** which are attach to the free edges and ventricular surfaces of the mitral valve cusps.

2- Smooth outflow part:
It called the **aortic vestibule**
It is a smooth-walled, non muscular
It is located **supero-anterior**
It leads to the **aortic orifice** and **aortic valve**

Both parts are separated by **subortic curtain** and anterior leaflet of the mitral valve

Openings of left ventricle

- Right atrioventricular orifice which is guarded by the mitral valve (ostium venosum)
- An outlet region, guarded by the **aortic valve** (ostium arteriosum)

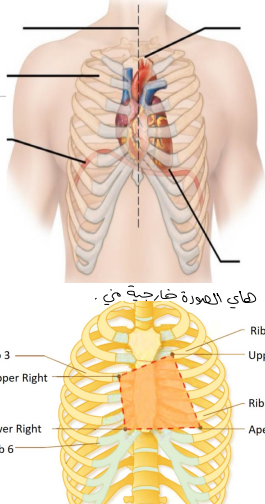
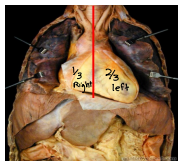


Online

The heart

- It is a **muscular pump** that propels blood to various parts of the body.
- Lies within the **pericardium** in the middle mediastinum.
- 1/3 of the heart lies to the **right** & 2/3 to the **left** of the median plane.
- The **walls** of the heart are composed of **three layers** from **outside** :

- Epicardium
- Myocardium which is the **cardiac muscle**
- Endocardium



Cardiac cycle

REED ONLY

- The cycle begins with a period of **ventricular elongation and filling (diastole)**
- And ends with a period of **ventricular shortening and emptying (systole)**.
- Two heart sounds are heard with a stethoscope: a **lub (1st)** sound as the blood is transferred from the atria into the ventricles
- And a **dub (2nd)** sound as the ventricles expel blood from the heart.
- The heart sounds are produced by the **snapping shut of the one way valves** that normally **keep blood from flowing backward** during contractions of the heart.

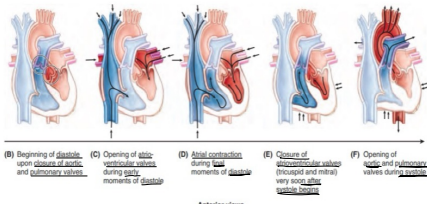
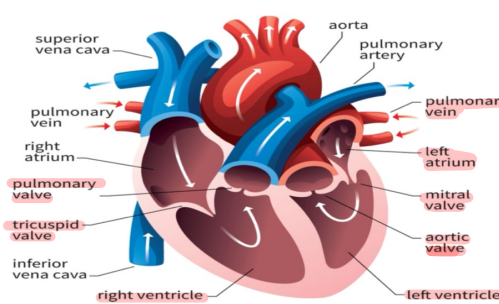
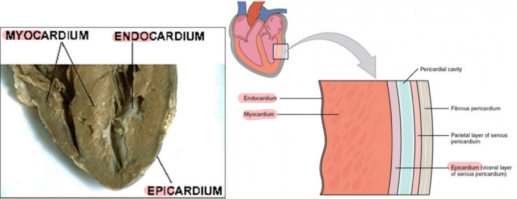


FIGURE 1.49. Cardiac cycle. The cardiac cycle describes the complete movement of the heart or heartbeat and includes the period from the beginning of one heartbeat to the beginning of the next one. The cycle consists of diastole (ventricular relaxation and filling) and systole (ventricular contraction and emptying). The right heart (blue side) is the pump for the pulmonary circuit; the left heart (red side) is the pump for the systemic circuit.

diastole → closure of aortic & pulmonary. (beginning).
→ opens tricuspid & mitral.
systole → opens aortic & pulmonary valves. (beginning).
→ closure of tricuspid & mitral.

- The wall of each heart chamber consists of three layers, from **superficial to deep**

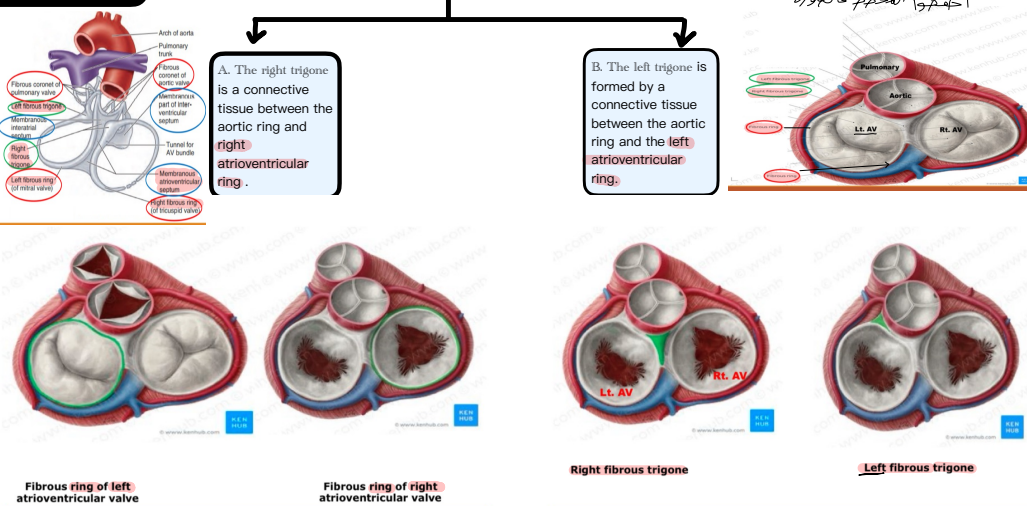
- Endocardium** : a thin internal layer (endothelium)
- Myocardium** : a thick middle layer composed of **cardiac muscle**.
- Epicardium** : a thin external layer (mesothelium) formed by the **visceral layer of serous pericardium**



Fibrous skeleton of heart

The cardiac muscle fibers are anchored to the **fibrous skeleton** of the heart. It is formed of **dense collagen fibers**. It composed of:

- Fibrous rings** (L. anuli fibrosi) that surround the **orifices of the valves**
- Fibrous trigone** (right and left) formed by connections between the rings
- Membranous parts of the interatrial and interventricular septa.**



Functions of cardiac skeleton

- Separates** of the atria from the ventricles
- Acts as an **electrical insulator** between the atria and ventricles
- Acts as **Framework** for the **attachment** of myocardial fibers
- Provides **attachment** points for **valve leaflets and cusps**
- Maintains **valve** orifices open and prevents them from being overly distended

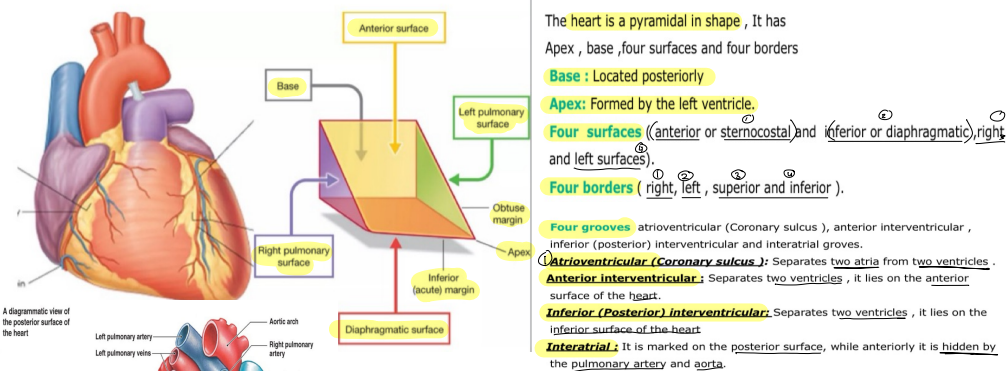
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- The heart is **related posteriorly** **Vertebral coulmn**
- The heart is **posterior** **Sternum**
- The heart is **anterior** **Vertebral coulmn**
- The heart is **related anteriorly** **Sternum**

Choices are
A.Sternum
B.Vertebra coulmn



External Morphology of the Heart



The heart is a **pyramidal in shape**, It has Apex, base, four surfaces and four borders
Base : Located **posteriorly**
Apex : Formed by the **left ventricle**.
Four surfaces (anterior or sternocostal) and (inferior or diaphragmatic), right and left surfaces).
Four borders (right, left, superior and inferior).
Four grooves atrioventricular (Coronary sulcus), anterior interventricular, inferior (posterior) interventricular and interatrial grooves.
Atrioventricular (Coronary sulcus) : Separates **two atria** from **two ventricles**.
Anterior interventricular : Separates **two ventricles**, it lies on the **anterior** surface of the heart.
Inferior (Posterior) interventricular : Separates **two ventricles**, it lies on the **inferior** surface of the heart.
Interatrial : It is marked on the **posterior surface**, while anteriorly it is **hidden** by the **pulmonary artery and aorta**.

Base / Apex / surfaces.

The apex of the heart :

- It is formed by the **infero-lateral part of the left ventricle**.
- It lies in the **left 5th intercostal space, 9 cm** (a hand's breadth) from the median plane.
- It is the site **mitral valve auscultation** (موقع سماع صوت التمام).

The base of the heart

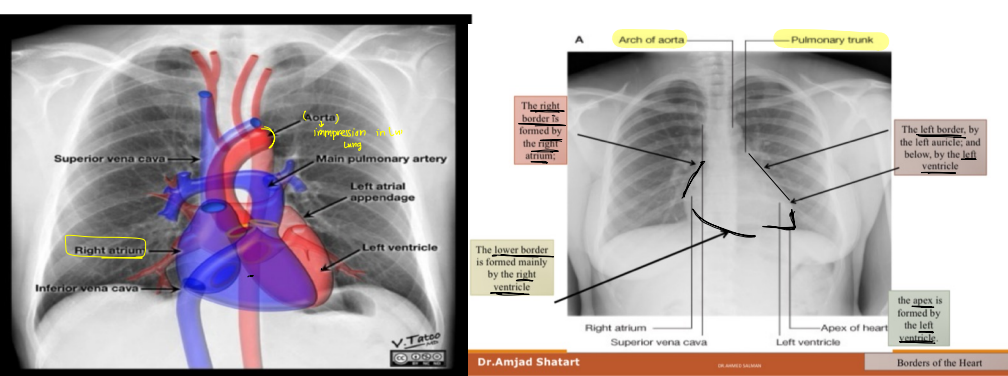
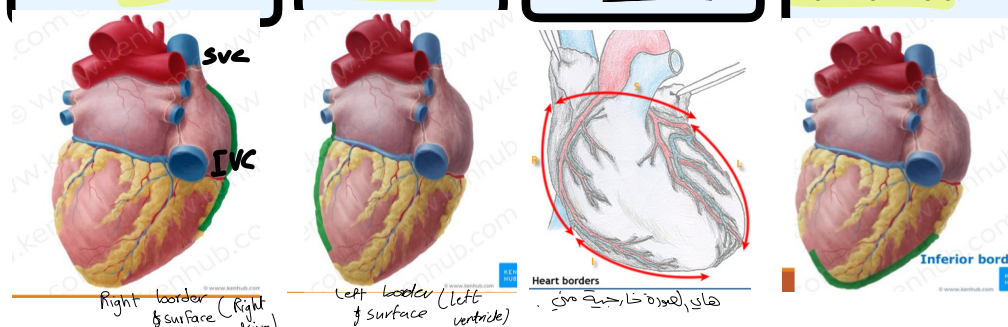
- It is located **posteriorly** (opposite the apex)
- It is formed mainly by the **left atrium**, with a lesser contribution by the right atrium.
- The base is related posteriorly to bodies of **T6-T9** in erect position. BUT it lies opposite **T5-T8** in recumbent position
- It is separated from the vertebrae by the pericardium, oblique pericardial sinus, esophagus, and descending aorta.

Anterior (sternocostal) surface , formed by **Right atrium** (mainly).
Ventricular part : consists of **Right ventricle (2/3)** and **Left ventricle (1/3)**.
 Both ventricles are separated by **posterior interventricular groove** which contains: 1. Posterior interventricular artery. 2. Middle cardiac vein.
 This surface is separated from the base of the heart by atrioventricular (coronary) sulcus, which contains: 1. The right coronary artery 2. The circumflex branch of the left coronary artery 3. The coronary sinus 4. The small cardiac vein

Diaphragmatic (inferior) surface : it is related mainly to the central tendon of the diaphragm, it consists of **Left ventricle (2/3)**, **Right ventricle (1/3)**.
 Both ventricles are separated by **posterior interventricular groove** which contains: 1. Posterior interventricular artery. 2. Middle cardiac vein.
 This surface is separated from the base of the heart by atrioventricular (coronary) sulcus, which contains: 1. The right coronary artery 2. The circumflex branch of the left coronary artery 3. The coronary sinus 4. The small cardiac vein

Borders

- Right border** : formed by the **right atrium** and extending between the **SVC** and the **IVC**.
- Left border** : formed mainly by the **left ventricle** and slightly by the **left auricle**
- Superior border** : is formed mainly by the **left atrium** and completed by the **right atrium**.
- Inferior border** : is formed mainly by the **right ventricle** and slightly by the **left ventricle**.



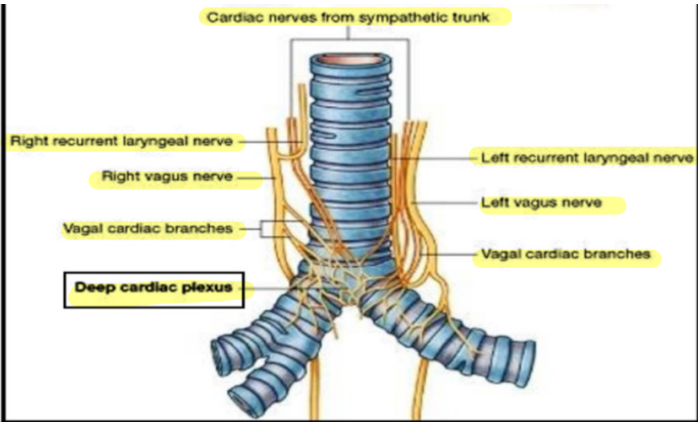
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 بالتوفيق جميعاً
 لا يلقى اليأس بأرواح المؤمنين

Lecture 6

Nerve supply

Heart Innervation

- ❖ The heart is supplied by **autonomic nervous system** through **cardiac plexus**
- ❖ The cardiac plexus is divided into **superficial and deep parts**
- ❖ The cardiac plexus is located on the **anterior surface of the bifurcation of the trachea**
- ❖ It is formed of both **sympathetic and parasympathetic fibers** as well as **visceral afferent fibers**



The sympathetic supply (fight or flight)

- Pre-ganglionic fibers from cell bodies in the **intermediolateral cell columns (IMLs)** of the superior five or six thoracic segments of the spinal cord
- Pre-ganglionic fibers relay at **cervical and superior thoracic ganglia** of the sympathetic trunks.
- Post-ganglionic fibers traverse **cardio-pulmonary splanchnic nerves** and the cardiac plexus to end in the SA and AV nodes
- Sympathetic stimulation causes **increased heart rate, impulse conduction, force of contraction and increased blood flow** through the coronary vessels to support the **increased activity**.

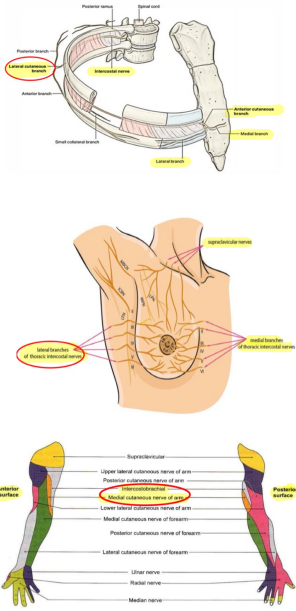
The parasympathetic supply (Rest & Digest)

- Pre-ganglionic fibers from the **vagus nerves** relay in cardiac plexus and nerve cells in atrial wall and interatrial septum near the SA and AV nodes and along the coronary arteries
- Parasympathetic stimulation **slows the heart rate, reduces the force of the contraction, and constricts the coronary arteries**, saving energy between periods of increased demand.

SAVE ENERGY

Cardiac Pain

- The nature of the pain varies, from a mild discomfort to a severe crushing pain
- The heart is insensitive to touch, cutting, cold, and heat; however, ischemia and the accumulation of metabolic products stimulate pain endings in the myocardium
- The afferent pain fibers run with **thoracic cardiac branches of the sympathetic trunk**.
- These sensory fibers enter the spinal cord through the posterior roots of the upper four thoracic nerves (T1-T4)
- The pain is not felt in the heart, but is referred to the skin areas supplied by the upper four thoracic nerves
- The skin areas supplied by the upper four intercostal nerves and by the **intercostobrachial nerve (T2)** are therefore affected.
- The **intercostobrachial nerve** communicates with the medial cutaneous nerve of the arm and is distributed to skin on the medial side of the upper part of the arm
- Pain felt on the left side of chest, left side of neck, left shoulder and medial side of left arm
- Intercostobrachial nerve is the lateral cutaneous branch of the second intercostal nerve**

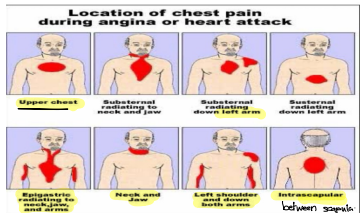


Myocardial infarction involving the inferior wall or diaphragmatic surface of the heart often gives rise to discomfort in the epigastrium. The afferent pain fibers run with the sympathetic nerves and enter the spinal cord in the posterior roots of T7, T8, and T9. This gives a referred pain to epigastric region

RESPECT ANY EPIGASTRIC PAIN ESPECIALLY IN HIGH RISK PATIENT

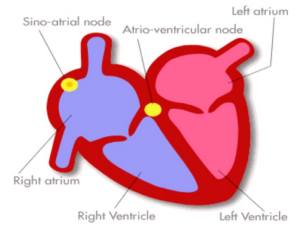
Is the heart pain can felt in the right side, both sides, or the back?

Synaptic contacts may also be made with connector neurons, which conduct impulses to neurons on the right side of comparable areas of the spinal cord.



The conducting system of the heart

- It is formed of modified myocardial fibers called **purkinje fibers** that are responsible for **initiation, conduction and maintenance** of cardiac muscle
- Atria contract first and together, to be followed later by the **contractions of both ventricles together**
- The slight delay in the passage of the impulse from the atria to the ventricles allows time for the atria to empty their blood into the ventricles before the ventricles contract.



It consists of:
 - The sinoatrial node (S.A.)
 - The atrioventricular node (A.V.)
 - The atrioventricular bundle
 - Right and left terminal branch

SA node

- 1- Sinoatrial (S.A.) node**
- Is the **pacemaker** of the heart
 - It **initiates and regulates** the impulses of the heart contractions
 - It is an ellipsoid band of modified myocardial fibers and associated fibroelastic connective tissue
 - It extends from the anterolateral aspect of the opening of the superior vena cava into the upper part of the **crista terminalis**

AV node

- 2- Atrio ventricular (A.V.) node**
- It is a collection of nodal tissue but it is smaller than the SA node
 - It lies on the right side of the lower part of the interatrial septum just above the septal leaflet of the tricuspid valve close to the opening of the coronary sinus
 - Its anatomical landmarks are the boundaries of the triangle of Koch
 - It receives the impulse from the SA node through intermodal tract and distributes the signal to the ventricles through the AV bundle (of His)

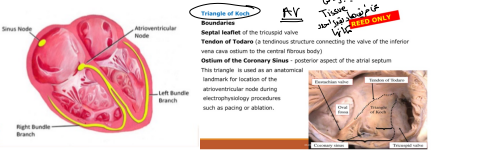
AV bundles

- 3- Antioventricular (AV) bundle**
- Is a short bundle of modified myocardial fibers which begins from A.V. node and passes through fibrous skeleton of heart along membranous part of the interventricular septum
 - It divides into right and left bundles at the junction of the membranous and muscular parts of the IVS
 - These branches proceed on each side of the muscular IVS deep to the endocardium and then ramify into subendocardial branches (Purkinje fibers) which extend into the walls of the respective ventricles.

Internodal tracts

Internodal conduction tracts: These are fine bundles of modified myocardial fibers connecting the sinoatrial (S.A.) node with the atrioventricular (A.V.) node. They are arranged as follows:

- Anterior internodal tract:** It arises from the upper end of the S.A. node and passes in front of the superior vena caval opening and it divides into two bundles:
 - A. A bundle penetrating the interatrial septum to reach the wall of the left atrium and is called **Bachmann's bundle**.
 - B. The other bundle descends on the right side of the interatrial septum to reach A.V. node.
- Middle internodal tract:** It arises from the postero superior aspect of the S.A. node and curves posteriorly behind the orifice of the Superior vena cava to reach the A.V. node
- Posterior internodal tract:** It arises from the postero inferior aspect of the S.A. node and descends through the crista terminalis and the valve of inferior vena cava to reach A.V. node



Artificial Pacemaker

An artificial pacemaker is a small electrical device commonly fitted to monitor and correct heart rate and rhythm. It is inserted into the chest under the left clavicle, with wires connected to the heart via the venous system.

The most common indication for a pacemaker is bradycardia. Once inserted, the pacemaker monitors the heart rate, and only fires if the rate becomes too slow. Pacemakers can also be used to treat some tachycardias, certain types of heart block and other rhythm abnormalities.

Commotio Cordis

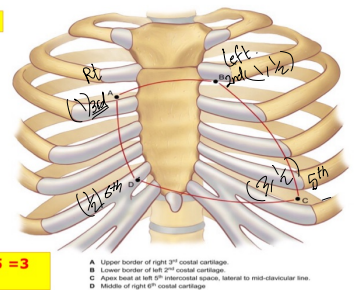
This condition results in ventricular fibrillation and sudden death. It is caused by a **blunt non penetrating blow** to the anterior chest wall over the heart. It occurs most commonly in the young and adolescents and is often sports-related.

Surface Anatomy

Surface anatomy of the heart

- Point A:** Upper border of right 3rd costal cartilage (1 inch) from midline.
- Point B:** Lower border of left 2nd costal cartilage (1.5 inch) from midline.
- Point C (apex):** in the left 5th intercostal space (3.5 inches) from midline.
- Point D:** on the right 6th costal cartilage (1/2 inch) from midline.

2+3=5



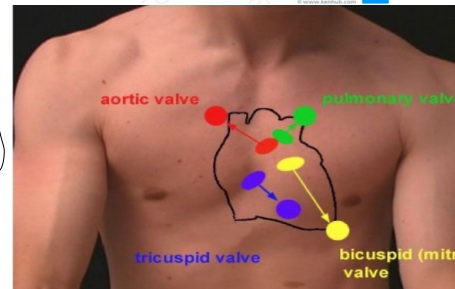
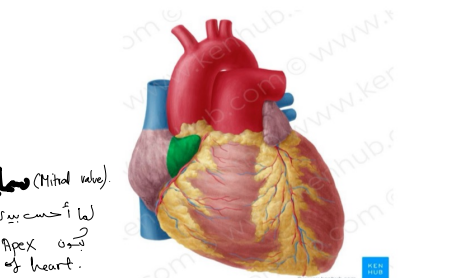
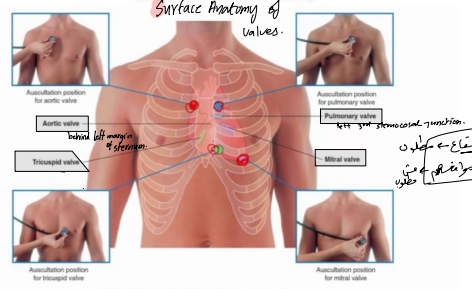
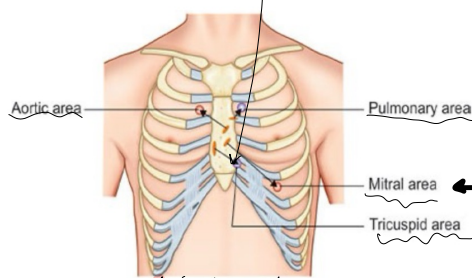
5th -> 3rd -> 2nd -> 5th inter
 1/2 1 1/2 3 1/2

Heart Auscultation

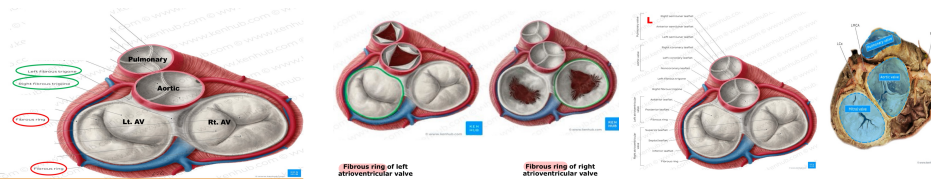
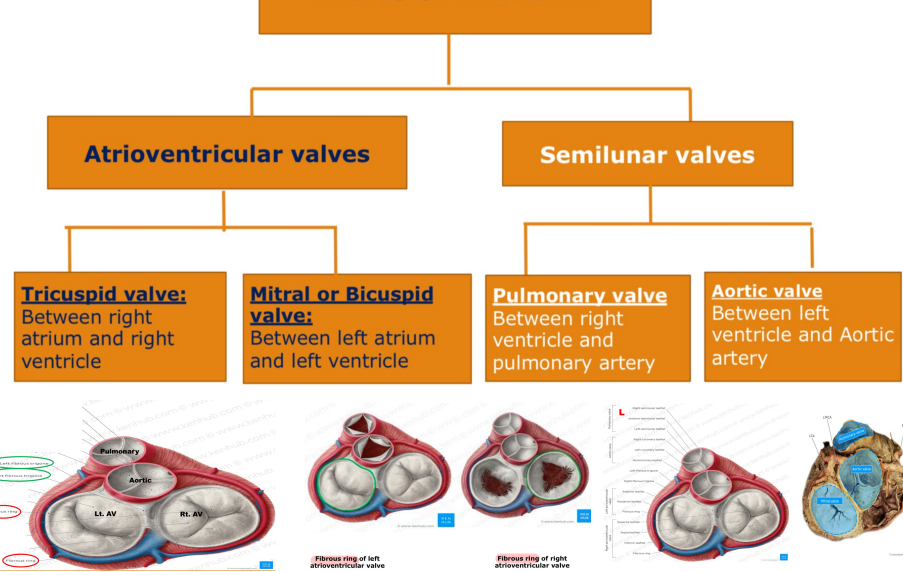
- Pulmonary valve:** left 2nd sternocostal junction.
- Aortic valve:** right 2nd sternocostal junction.
- Mitral valve:** apex of the heart.
- Tricuspid valve:** xiphisternal joint.

Surface anatomy of Cardiac valves

- Pulmonary valve:** on the left 3rd sternocostal junction.
- Aortic valve:** Behind left margin of sternum opposite to 3rd intercostal space.
- Mitral valve:** Behind left half of sternum opposite to the left 4th costal cartilage.
- Tricuspid valve:** on the midline of the sternum opposite the 4th intercostal space.



VALVES OF THE HEART



Atrioventricular valves

Tricuspid valve

It guards the right Atrioventricular orifice
It composed of :

1-Tricuspid valve orifice and annulus

- The orifice is surrounded by the tricuspid valve annulus which is a collagenous fibrous ring
- It gives attachment to the cusps or leaflets of the tricuspid valve.
- The fibrous ring keeps the orifice constant, large enough to admit the tips of three fingers.

2- Tricuspid valve cusps (leaflets) *3 cusps*

- Three in number: anterior, posterior and septal.
- The base of the cusps are attached to the tricuspid fibrous annulus of the heart skeleton
- The margins of the cusps are fused together forming valve commissures.
- Each cusp or leaflet is formed of a double layer of endocardium enclosing a collagenous fibrous lamina.
- The anterior cusp is the largest while the septal one is the smallest.

3- Chordae tendineae

- These are strong collagenous fibrous threads which spring from the apical parts of the papillary muscles or directly from the septal wall.
- They get attached to the margins and ventricular surfaces of the leaflets of the tricuspid valve.
- Each papillary muscle sends its chordae tendineae to two adjacent leaflets

Anterior papillary muscles their chordae tendineae are attached to the adjacent parts of the anterior and posterior leaflets.

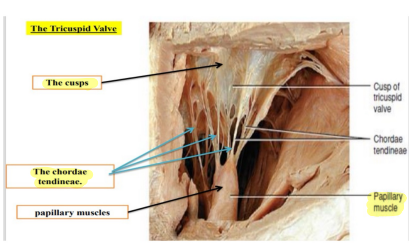
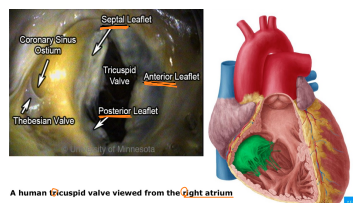
Posterior papillary muscles their chordae tendineae are attached to the adjacent parts of the posterior and septal leaflets.

Septal papillary muscles: their chordae tendineae are attached to the adjacent parts of the septal and anterior leaflets.

Blood supply of the cusps

- Valve cusps are normally avascular
- Small blood vessels and smooth muscle can be found only in the base of the cusp.
- The surfaces of the valve are exposed to blood, and the cusps are thin enough to allow nutrients and oxygen to diffuse from the blood.
- Rheumatic fever causes inflammation of the heart valves (valvulitis)
- Inflammation induces angiogenesis in the valve and vascularization in the normally avascular layers of the valve.
- This inflammation can lead to progressive replacement of elastic tissue by irregular masses of collagen fibers, causing the valve to thicken.
- The valves become rigid and inflexible, which affects their ability to open and close

Inflammation of the heart valves → Vasculogenesis → Replacement of elastic tissue by collagen fibers → Valve thickening → valves become rigid and inflexible



Mitral valve

- It guards the left atrioventricular orifice between left atrium and left ventricle
- The mitral orifice is narrower than tricuspid orifice
- It has two cusps : *2 Cusps*
- The anterior is larger and directed anterior and to the right
- The posterior is smaller and directed posterior and to the left

Mitral Valve Prolapse (Floppy valve syndrome)

How the atrioventricular valves work

- When the ventricle contracts, the papillary muscles contract and prevent the cusps from being forced into the atrium and turning inside out as the intraventricular pressure rises.
- To assist in this process, the chordae tendineae of one papillary muscle are connected to the adjacent parts of two cusps
- On closure of an AV valve, the narrow border between the free edge of each cusp presses against that of the next, resulting in a secure, watertight closure

- Papillary muscles begin to contract before contraction of the right ventricle, tightening the tendinous cords and drawing the cusps together.
- Because the cords are attached to adjacent sides of two cusps, they prevent separation of the cusps and prevented from prolapsing (being driven into the right atrium) as ventricular pressure rises.
- Thus, regurgitation of blood (backward flow of blood) from the right ventricle back into the right atrium is blocked during ventricular systole by the valve cusp

How AV valves work?

Semilunar valves

Each consists of three pocket like cusps of approximately equal size

The arterial wall has three dilated pouches called sinuses or Valsalva (The aortic sinuses pulmonary sinuses)

The blood in the sinuses and the dilation of the wall prevent the cusps from sticking to the wall of the vessel, which might prevent closure

At the center of the free margin of each cusp is a small fibrous nodule called the **nodulus Arantii**

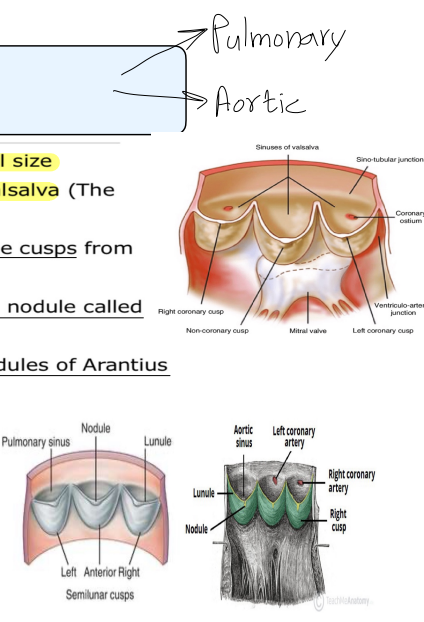
Along the entire free edge of the cusp, on each side of the nodules of Arantius there is a thin, halfmoon-shaped area called the **lunula**

1- The pulmonary valve

It guards the orifice between right ventricle and pulmonary artery.
It consists of three semilunar cusps (Anterior, right and left)

2-The Aortic valve

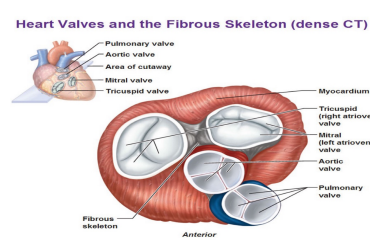
It guards the orifice between left ventricle and aorta
It consists of three semilunar cusps (Posterior right and left.)
Just superior to right and left cusps in the aortic sinus there are the openings of the right and left coronary arteries, respectively



Mechanism of Heart Valves

The Atrioventricular (AV) Valves

- When the ventricles contract, forcing blood against atrioventricular valve cusps
- Papillary muscles contract and , tightening the tendinous cords and drawing the cusps together and preventing valve flaps from everting into atria
- Because the cords are attached to adjacent sides of two cusps, they prevent separation of the cusps and their inversion when tension is applied to the tendinous cords



Function of the Atrioventricular Valves

At this point, you hear the first heart sound, with the mitral sound slightly before the tricuspid

(b) AV valves closed; atrial pressure less than ventricular pressure

- Ventricles contract, forcing blood against atrioventricular valve cusps.
- Atrioventricular valves close.
- Papillary muscles contract and chordae tendineae tighten, preventing valve flaps from everting into atria.

The Semilunar Valves

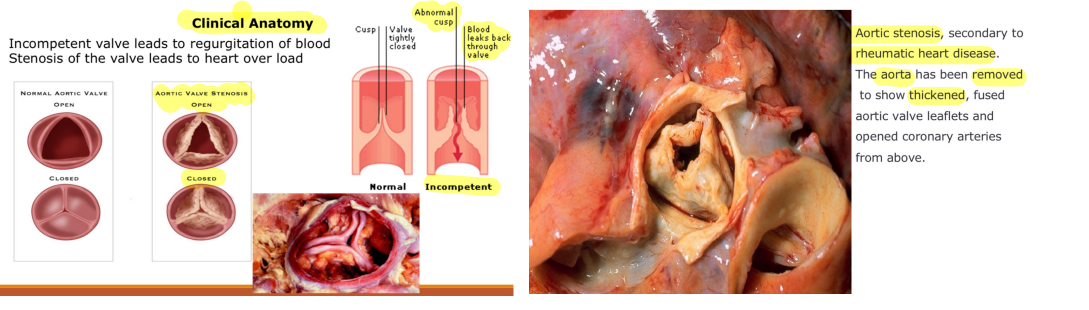
- As ventricles contract and intra ventricular pressure rises, blood is pushed up against semilunar valves, forcing them open.
- After relaxation of the ventricle (diastole), the elastic recoil of the wall of the pulmonary trunk or aorta forces the blood back toward the heart.
- The blood filling the cusps of semilunar valves and forcing them to close
- They come together to completely close the orifice and preventing any blood from returning to the ventricle

Function of the Semilunar Valves

When semilunars close, you hear 2nd heart sound, with aortic slightly before pulmonary

(a) Semilunar valves open

(b) Semilunar valves closed



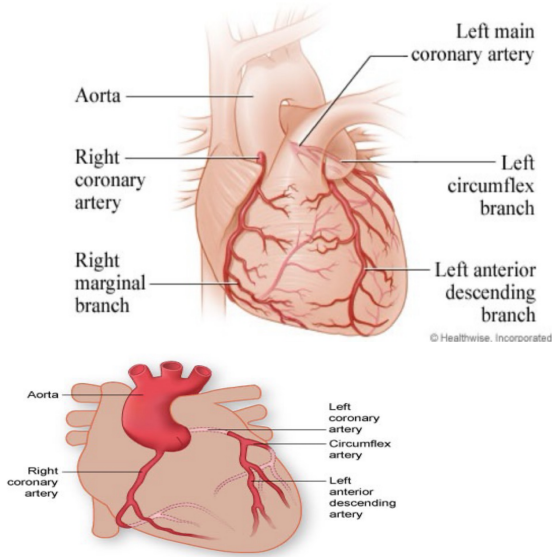
- Wear your headphones and ENJOY
- Mitral stenosis**
<https://www.youtube.com/watch?v=5oCPTz04pUY>
 - Mitral valve prolapse**
https://www.youtube.com/watch?v=sH_KmHHR70
 - Aortic regurgitation**
<https://www.youtube.com/watch?v=uZysrKXHJMM>
 - Aortic stenosis**
<https://www.youtube.com/watch?v=pgDWz1JybzE>



كلمة معطاه

Confidential

Blood Supply of heart



Interventricular septum

Membranous
Muscular

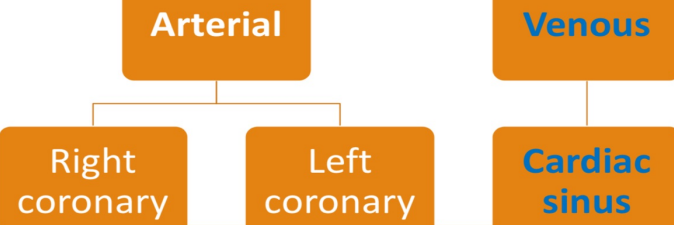
Sternocostal surface

Anterior 2/3

Posterior 1/3

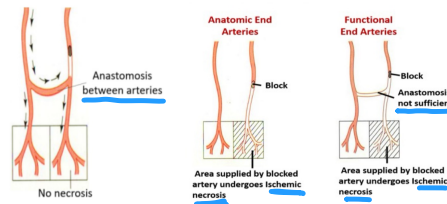
Diaphragmatic surface

Blood Supply of the heart



Coronary arteries

- The branches of the coronary arteries are generally considered to be functional end arteries
- So, arteries that supply regions of the myocardium lacking sufficient anastomoses from other large branches to maintain viability of the tissue when occlusion occurs
- The endocardium and some subendocardial tissue located immediately external to the endocardium receive oxygen and nutrients by diffusion or microvasculature directly from the chambers of the heart

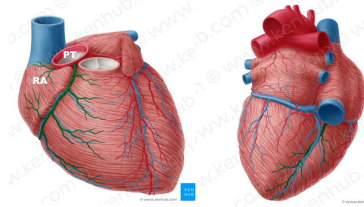


Variations in the Coronary Arteries

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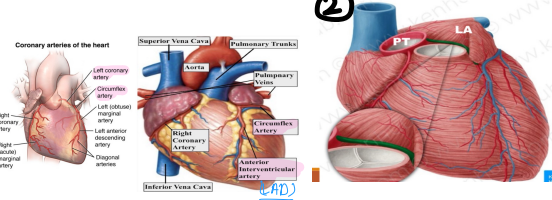
Variations in the blood supply to the heart do occur, and the most common variations affect the blood supply to the diaphragmatic surface of both ventricles. Here the origin, size, and distribution of the posterior interventricular artery are variable. In right dominance, the posterior interventricular artery is a large branch of the right coronary artery. Right dominance is present in most individuals (90%). In left dominance, the posterior interventricular artery is a branch of the circumflex branch of the left coronary artery (10%).

Coronary Artery Anastomoses
Anastomoses between the terminal branches of the right and left coronary arteries (collateral circulation) exist, but they are usually not large enough to provide an adequate blood supply to the cardiac muscle should one of the large branches of either coronary artery usually leads to myocardial death (myocardial infarction), although sometimes the collateral circulation is enough to sustain the muscle.



The left coronary artery (LCA)

- It originates from the left aortic sinus of the ascending aorta
- It passes between the left auricle and the left side of the pulmonary trunk
- It has short stem, it is divided into the anterior interventricular or left anterior descending (LAD) and circumflex artery



The right coronary artery (RCA)

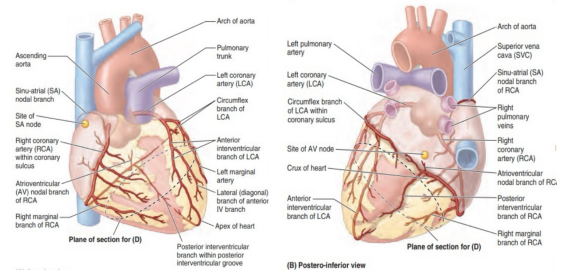
Arises from The right aortic sinus of the ascending aorta
It runs along the right AV sulcus, embedded in fat.

Branches

- Sinoatrial (SA) nodal artery**: It encircles the base of SVC to supply SA node
- Atrioventricular (AV) nodal artery**: It supplies AV node
- Inferior (Posterior) interventricular branch**, which descends in the posterior IV groove toward the apex of the heart.
This branch supplies adjacent areas of both ventricles and posterior third of IV septum.

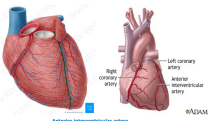
The RCA supplies :

- The right atrium.
- Most of right ventricle.
- Part of the left ventricle (the diaphragmatic surface).
- Part of the IV septum, usually the posterior third.
- The SA node (in approximately 60% of people).
- The AV node (in approximately 80% of people)
- The LBB also receives small branches.



1-Anterior interventricular artery (IV)

- Clinician name it as **left anterior descending (LAD)**
- It runs downward in the anterior interventricular groove to the apex of the heart, then it passes around the apex of the heart to enter the posterior interventricular groove and anastomoses with the terminal branches of the right coronary artery.
- In one third of individuals it ends at the apex of the heart
- The anterior IV branch supplies adjacent parts of both ventricles and the anterior two thirds of the IVS via IV septal branches
- In many people, the anterior IV branch gives rise to a lateral branch (diagonal artery), which descends on the anterior surface of the heart

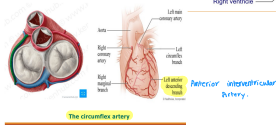


2-The circumflex artery

- It is the same size as the anterior interventricular artery
- It winds around the left margin of the heart in the atrioventricular groove.

Branches

- Left marginal artery**, is a large branch that supplies the left margin of the left ventricle down to the apex.
- Anterior ventricular and posterior ventricular branches** supply the left ventricle.
- Atrial branches** supply the left atrium

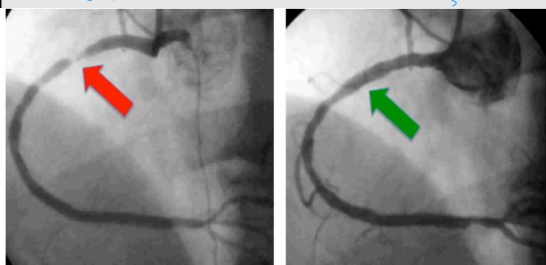


The LCA supplies :

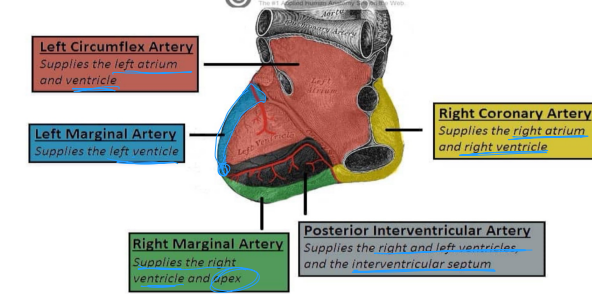
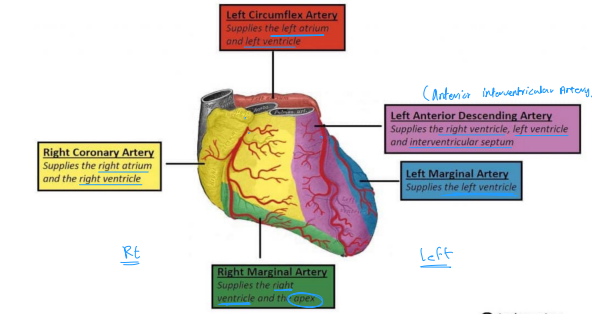
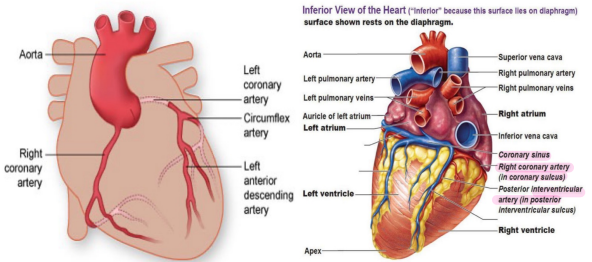
- The left atrium.
- Most of the left ventricle.
- Part of the right ventricle.
- Most of the IVS (usually its anterior two thirds), including the AV bundle of the conducting system of the heart, through its perforating IV septal branches.
- The SA node (in approximately 40% of people)
- Right Bundle Branch
- Left Bundle Branch

Arterial Supply to the Conducting System

- The **sinoatrial node (SA)** is usually supplied by the right but sometimes by the left coronary artery.
- The **atrioventricular node (AV)** is supplied by the right coronary artery.
- The **RBB** of the atrioventricular bundle is supplied by the left coronary artery
- The **LBB** is supplied by the right and left coronary arteries



Example of coronary angiogram of a 55 year old gentleman with chest pain. Image on the left shows the right coronary artery with a severe narrowing (red arrow). Image on the right was taken after angioplasty and stenting showing resolution of the narrowing.



تم بعد الشد
انتهت مادة المير اناتومي ...

Venous drainage of the heart

The heart is drained mainly by veins that empty into the coronary sinus and partly by small veins that empty directly into the right atrium

Veins of the heart are

- Coronary sinus
- Anterior cardiac veins (drain the upper part of the anterior surface of the right ventricle . These veins empty directly into the right atrium)
- Vena cordis minimi (Thebesian veins)
It drain subendocardial portion of myocardium into heart chambers

A. The coronary sinus

Is the main vein of the heart, is a wide venous channel
It runs from left to right in the posterior part of the coronary sulcus
It runs between left atrium and ventricle.

It receives :

- Great cardiac vein:**
 - It begins at the apex of the heart and ascends in the anterior interventricular groove
 - It receives left marginal vein which ascends on the left border of the heart.
- Middle cardiac vein:**
 - It also begins at the apex of the heart and runs in the posterior (inferior) interventricular groove
- Small cardiac vein**
- Posterior vein of left ventricle**
- Oblique vein of the left atrium**

