

## ANATOMY / HISTOLOGY

☒ Sheet

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Number

Lab 2

Subject

The Heart

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Price:

# Anatomy Lab 2

## ❖ Topics :

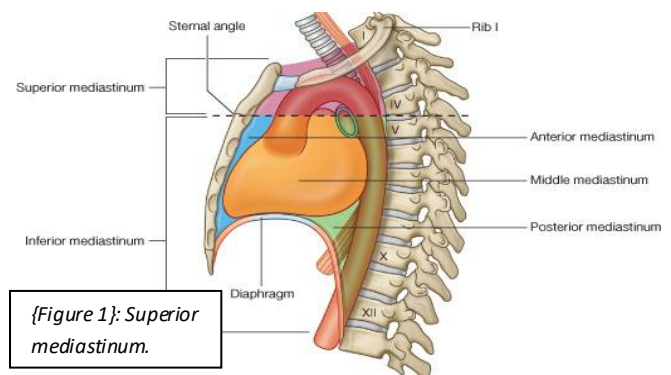
1. Superior mediastinum , Arch of aorta & its relations.
2. Valves of the heart .. AV & semilunar.
3. Interventricular septum.
4. Apex of the heart.
5. Phrenic nerve.

## ~ Remember:

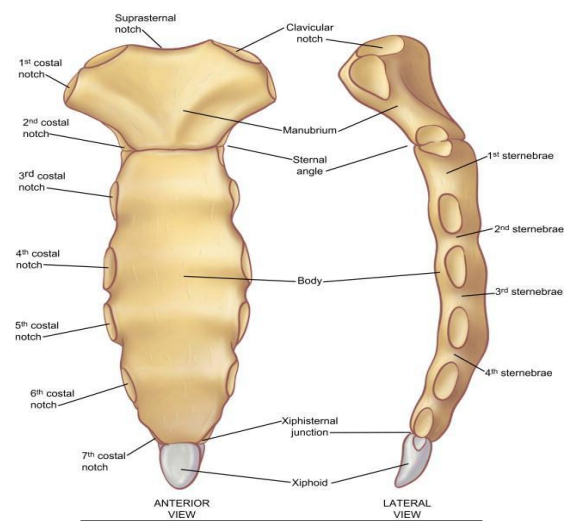
- Heart in relation to sternum :
  - The heart is inside the pericardium posterior to the body of sternum, this region 'posterior to the body of sternum' called **Inferior mediastinum**.
  - The region posterior to the manubrium called **Superior mediastinum**. the most important content in this region is the Arch of Aorta.

## • Superior mediastinum {figure1}:

- Anterior to it: Manubrium Sterni.
- Posterior: T1-T4 Vertebrae.
- Superior: Thoracic inlet.
- Inferior: Imaginary plane passing from sternal angle anteriorly to the lower border of the body of 4<sup>th</sup> thoracic vertebra posteriorly.



- Sternum: composed of manubrium “upper part”, body & xiphoid process .. {figure 2}

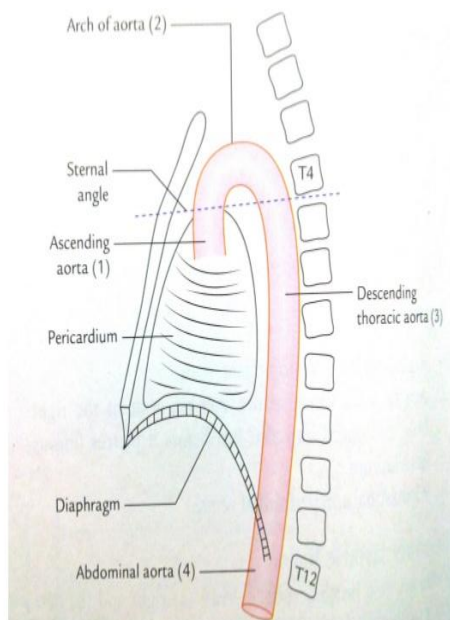


## ❖ Arch of Aorta & its relations \*Important\*:

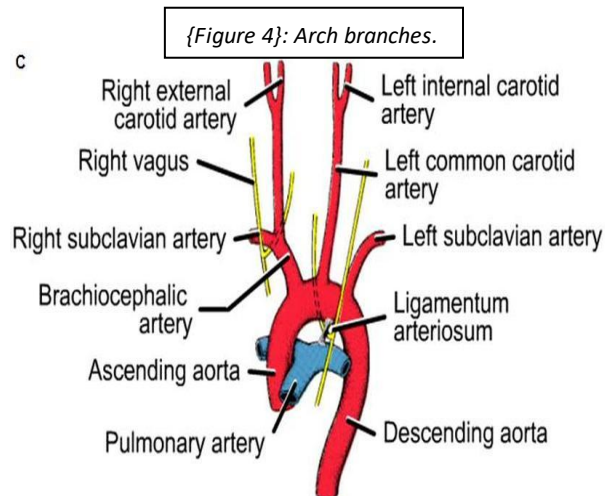
- Run upwards, backwards and to the left, across the left side of the bifurcation of trachea. Situated posterior to lower ½ of the manubrium sterni, it begins anteriorly behind the upper border of 2<sup>nd</sup> right sternochondral joint at the level of sternal angle.
- It ends posteriorly at the level of sternal angle, at the lower border of T4, the beginning & the end at the same level .. {figure3 }
- It's a continuation of ascending aorta; ascending aorta inside the pericardium "inferior mediastinum", while the arch of aorta is outside pericardium "superior mediastinum".
- It continues posteriorly as descending aorta! Ascending → Arch → Descending .. {figures 4&5 }

### Note:

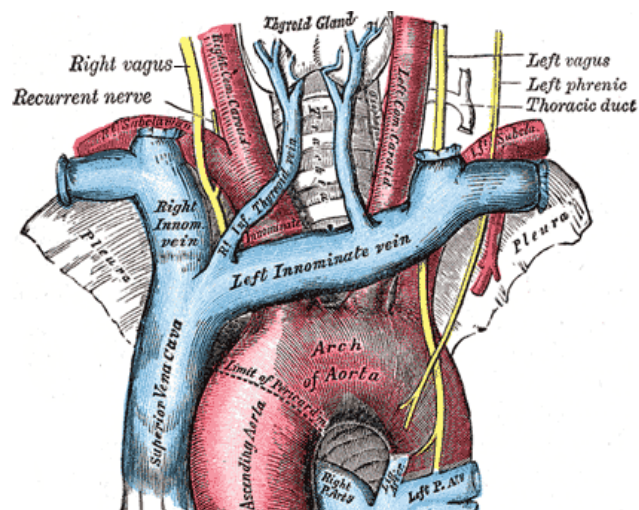
- Sternal angle {figure2}: angle between manubrium & body, at the level of 2<sup>nd</sup> rib, it's important landmark & it's a secondary cartilaginous joint (like intervertebral disk).



{Figure 3}: Ascending, Arch, Descending.



{Figure 4}: Arch branches.



{Figure5}: Superior relations.

## ❖ Relations of The Arch of Aorta:

### • **Superior “Above” to the arch {figure5}:**

- ✓ 5 structures (3 Arteries, 1 Vein, Thymus)

- 3 Branches of the arch of aorta: from anterior to posterior, brachiocephalic, left common carotid, left subclavian.
- Anterior to the lower part of these 3 branches is the left brachiocephalic vein “the 4<sup>th</sup> structure” which will join the right brachiocephalic vein and form Superior Vena Cava (S.V.C.).
- The 5<sup>th</sup> structure is remnants of thymus gland.

### ~ **Notes:**

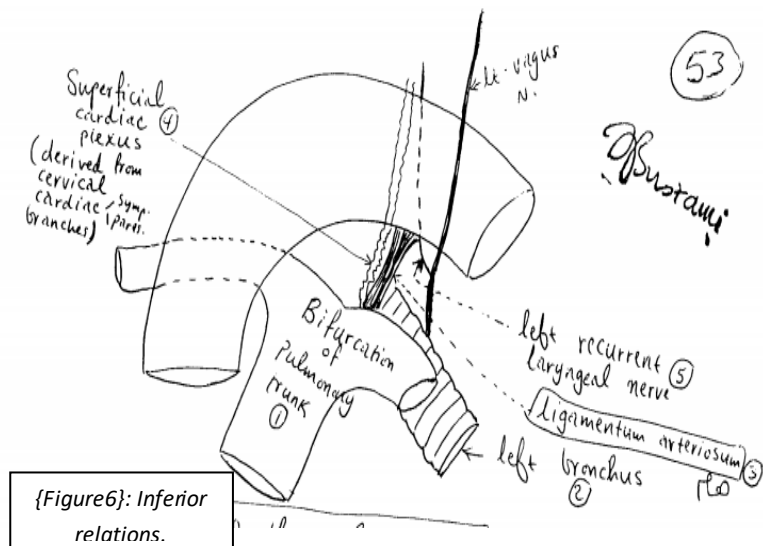
- S.V.C: its upper half is outside the pericardium, while lower half is inside the pericardium.
- Brachiocephalic artery gives 2 branches, right subclavian & right common carotid.
- Left common carotid bring blood to brain, head & neck.
- Left subclavian go to upper limb.

### • **Inferior “below” relations**

{figure6}:

#### 1. Bifurcation of the pulmonary trunk.

- ✓ Pulmonary trunk: is a blood vessel that carry blood from right ventricle to the lungs & it gives right pulmonary artery “right branch” to the right lung & left pulmonary artery “left branch” to the left lung.



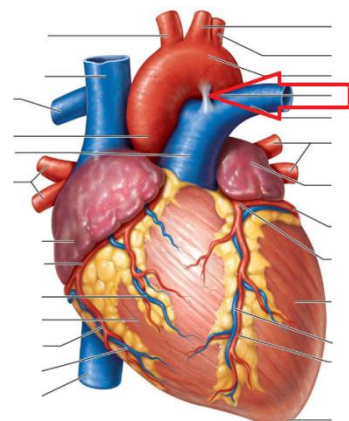
{Figure6}: Inferior relations.

#### 2. Left bronchus.

- ✓ Trachea divides to right & left bronchus.

#### 3. Ligamentum arteriosum... {figure7, notice the arrow}.

- This ligament was an artery in the fetus “Ductus arteriosus”, it was carrying deoxygenated blood.
- It extends between left pulmonary artery “at its beginning” to the end of the arch distal to the last branch (left subclavian).



{Figure7}: Ligamentum arteriosum.

- In the fetus this blood doesn't go to the brain, head & neck, the blood will go to the abdomen and lower limb; because this ligament "blood vessel in the fetus" opens at the end of the arch, at the beginning of descending aorta.
- If it opens in the middle of the arch, the blood will go to common carotid artery, to the head and brain; brain can't tolerate poorly oxygenated blood "venous blood".
- Anterior to ligamentum arteriosum 2 nerves: sympathetic & parasympathetic together form a plexus called superficial cardiac plexus(4<sup>th</sup> structure inferior to the arch of aorta), from this plexus give sympathetic & parasympathetic fibers supply the heart.
- Sympathetic supply atria & ventricles, while parasympathetic fibers supply **atria only** and don't supply ventricles.

**Q: Why** parasympathetic doesn't supply the ventricles?

Because sympathetic is excitatory, increase heart rate, increase force of contraction of ventricle "pumping power", anything that increases the force of ventricular contraction (increase myocardial contractility) has positive inotropic effect. However, parasympathetic "vagus" has inhibitory effect, if the vagus "parasympathetic" supply the ventricle will decrease its contraction, so NO parasympathetic to the ventricles, whereas sympathetic fibers supply both (atria & ventricles) and it's important because it strengthens the heart rate.

- Posterior to the ligament there is a branch from left vagus nerve which descends anterior to the arch and gives left recurrent laryngeal nerve(5<sup>th</sup> structure).

\* 5 Structures inferior: Bifurcation of the pulmonary trunk, Left bronchus, Ligamentum arteriosum, Superficial cardiac plexus, Left recurrent laryngeal nerve.

• **Anterior & to the left (superficial) relations {figure8} :**

- ✓ 5 Structures (3 Nerves, Vein, Plura & Lung)
  1. Left phrenic nerve.
    - Phrenic nerve supplies the diaphragm.
  2. Left vagus nerve.
    - Vagus nerve supplies the heart, lungs, then pierce the diaphragm and supply stomach & intestines.
  3. Left superior intercostal vein (deep to phrenic but superficial to vagus).
  4. 2 Cardiac nerves (symp.& parasymp.) to superficial cardiac plexus.
  5. Left plura & lung.



{Figure 8}: Ant. & Post. Relations.



• **Posterior & to the right (deep) relation {figure8}:**

1. Trachea (with deep cardiac plexus).
2. Oesophagus.
3. Left recurrent laryngeal nerve (in the groove between trachea & oesophagus), this nerve leaving the vagus and going back to the larynx.
4. Thoracic duct (on the left side of oesophagus).
5. Vertebral column “T4” 4<sup>th</sup> thoracic vertebra.

\* **Applied anatomy:**

If a patient had an aneurysm in the arch of aorta, this could press the trachea “posterior to the arch of aorta” and cause dyspnea (Shortness of breath), or it may press the oesophagus, the patient will suffer from dysphagia (Difficulty swallowing).

\***Aneurysm:** is a blood-filled balloon-like bulge in the wall of a blood vessel.

\* All these structures are in the superior mediastinum, posterior to the manubrium.

❖ **Valves of the heart:**

- The valves maintain unidirectional flow of the blood and prevent its regurgitation in opposite direction.
- There are two pairs of valves in the heart (pair of atrio ventricular (A-V) valves & pair of semilunar valves).

- **Atrio-Ventricular (A-V) valves {figure9}:**

- Tricuspid valve: on the right, it has 3 cusps (Anterior, Posterior, Septal).
- First cusp located on the septum between the two ventricles & called septal cusp, then there are the anterior & posterior cusps (3 cusps), all attached to papillary muscles.
- Bicuspid “mitral” valve: located on the left & it has two cusps (large anterior “aortic”, small posterior).
- AV valve is projected into the ventricular cavity, each cusp has atrial surface which is smooth “stream of blood” and free margins of ventricular surface which is rough “attachment of chordae tendinae”.

\* The cusps are folds of endocardium, strengthened by the intervening layer of fibrous tissue.

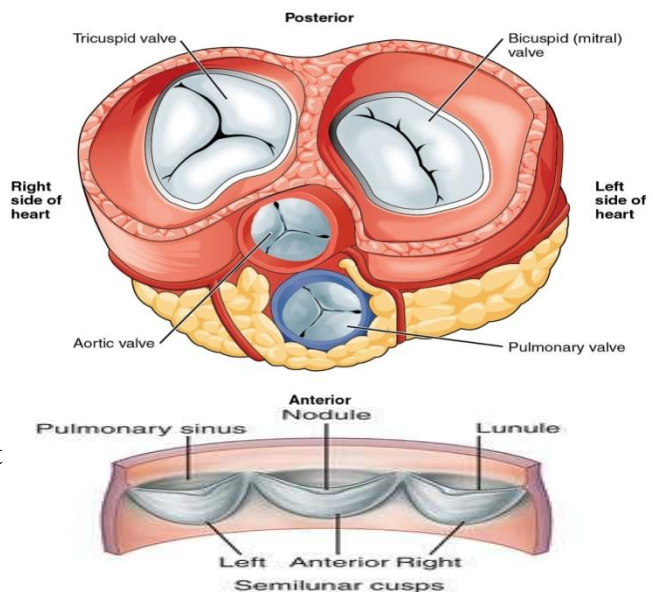
**Note:** Anterior cusp of bicuspid is subjected to 2 streams of blood, 1<sup>st</sup> from left atrium to left ventricle & 2<sup>nd</sup> from left ventricle to ascending aorta, so both atrial & ventricular surfaces are smooth “blood stream”.

- **Semilunar Valves {figure9}:**

- Include (aortic & pulmonary), each one has 3 semilunar cusps.
- Closed during ventricular diastole.
- Aortic valve: **1** Anterior cusp & 2 posterior cusps.
- Pulmonary valve: **1** Posterior cusp & 2 anterior cusps.

\* In the left ventricle there are 2 valves:

- 1<sup>st</sup> one is the Bicuspid located between left atrium and left ventricle in the entrance, it controls the blood flow from left atrium to left ventricle “inlet valve”. If a narrowing occur to it “mitral stenosis”, blood will accumulate in left atrium.
- 2<sup>nd</sup> valve in left ventricle is the semilunar aortic valve, it is located in the beginning of aorta exiting from the ventricle “outlet valve”.



{Figure9}: Heart valves.

**Note:** Papillary muscles in the posterior cusp of bicuspid are small, 2 to 3 and collectively we call them posterior papillary muscle.

- **How** the (A-V) valve close? how the semilunar valve open & close?
  - Bicuspid is an example of AV valve, so during diastole the heart is relaxed, ventricles are relaxed, and the way between atria & ventricles closed, bicuspid is closed.
  - Then blood will fill up the heart “atria”, right atrium from all the body except the lungs via S.V.C & I.V.C, left atrium receiving blood from lungs via 4 pulmonary veins “valve less”.
  - The blood will accumulate in atria. Thus, blood pressure will increase in the atria & become higher than ventricles; increasing of volume will lead to increasing in the pressure.
  - AV valve open, blood accumulate in ventricle, in this stage .. ending of diastole & beginning of systole.
  - Systole go through 2 stages:
    - ~ 1<sup>st</sup> stage: is contraction of ventricle called “isovolumetric contraction” in the early systole, the ventricle contracts without shortening of its fibers, thus **increasing the pressure inside the ventricle**.

Increasing the pressure inside the ventricle lead to closure of the valve, blood pressure will push the cusps toward the atrium, when the cusps touch each other the valve will close, no more movement.

\* Closure of AV valve is the first sound “Lub” at the beginning “early” systole.

\* If you put the stethoscope on patient chest , you will hear two sound of the heart (lub , dub).

~ 2<sup>nd</sup> stage “ejection”: The systole continue, pressure is increasing in the ventricle, pressure in the ventricle become higher than pressure in aorta, therefore semilunar valve will open & blood flow from ventricle to aorta.

- Then starts the diastole again, at early diastole little amount of blood will flow back to the ventricle. Back flow of the blood toward the ventricle will fill up the semilunar cusps, each cusp bulges down into a globular convexity towards the ventricular cavity, lead to closure of the valve, the 2<sup>nd</sup> sound “Dub”.

#### ~ **Conclusion:**

- Closure of AV valve “LUB” in early systole is due to increasing in the pressure inside the ventricles, because of Iso-volumetric contraction of the ventricles.
- Closure of semilunar valve “DUB” in early diastole is due to the little amount of blood that will flow back to the ventricle & fill up the semilunar cusps.
- \* Systole has 2 stages .. isometric contraction & ejection.

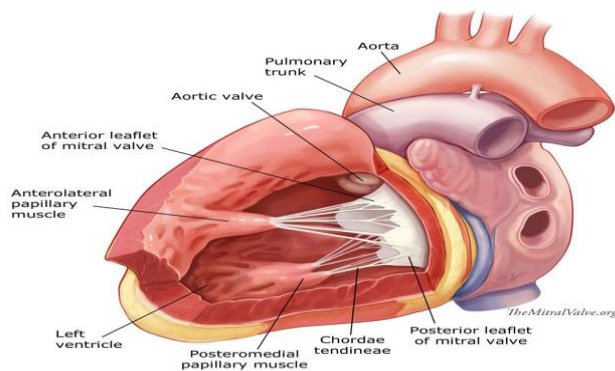
#### **Q:1) what** controls this movement of the valve?

- The **papillary muscles** .. *{figure10,next page}*, which prevent eversion of the free margins and limit the amount of ballooning of the cusps towards the cavity of the atrium.

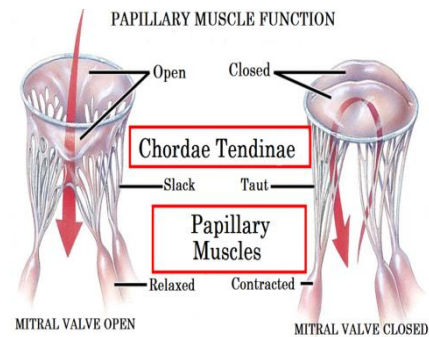
#### **2) How** the Atrio-Ventricular (A-V) valves are kept competent?

- By **active contraction** of the papillary muscles, which pull on the chordae tendinae during ventricular systole .. *{figure11}*.





{Figure10}: Papillary muscles + Chordae tendinae.



{Figure11}

### Notes:

**#Keep in mind:** Each papillary muscle is connected to the adjacent halves of two cusps.

**#Keep in mind:** Opening of the valve doesn't make any sound.

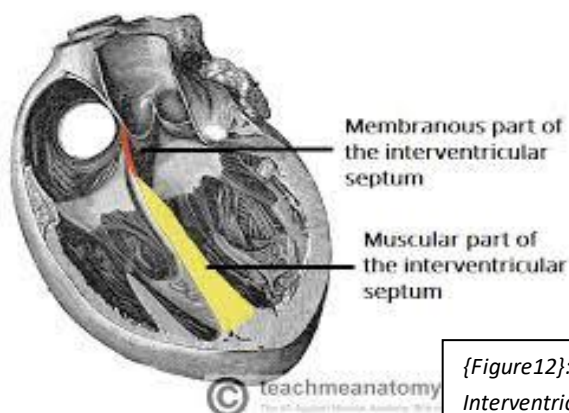
**#Remember:** Left ventricle will pump blood to the systemic circulation to all the body except lungs, while right ventricle will pump blood to the lung.

**#Remember:** To pump the blood from left ventricle the bicuspid valve should be closed, if this valve were open during systole, blood will go back to the atrium.

**#Remember:** There are two types of contraction .. 1<sup>st</sup> Isotonic: shorten of the fibers, shorten of the muscle (exert work), 2<sup>nd</sup> Isometric: the fibers doesn't shorten, the energy of the contraction increases the pressure, increase in tension (No external work).

### ❖ Interventricular septum {figure12}:

- Thick muscular part.
- Upper part of interventricular septum is thin membranous.
- The anterior part of the membranous part separates the two ventricle .. Interventricular Septum.
- Its posterior part intervenes between the aortic vestibule of left ventricle and right atrium .. Atrio-Ventricular Septum.



{Figure12}: Interventricular septum.

**Q:** The wall of the left ventricle is thicker than the wall of right ventricle .. **why?**

- Because The heart is pumping blood against resistance !

Ventricle pump blood to aorta, then blood will flow to aorta branches, then to small arteries, then to arterioles.

Arterioles are the smallest wall that has smooth muscles & contract, thus they narrow the arterioles and resist blood flow.

\* Arterioles are the major resistance vessels.

Blood pressure near the heart in the aorta almost 100 “93”, while blood pressure in the arterioles & capillaries “37” this decline helps to establish the pressure gradient that helps the flow of blood from the heart to the various organs downstream, blood will flow from higher pressure to lower pressure.

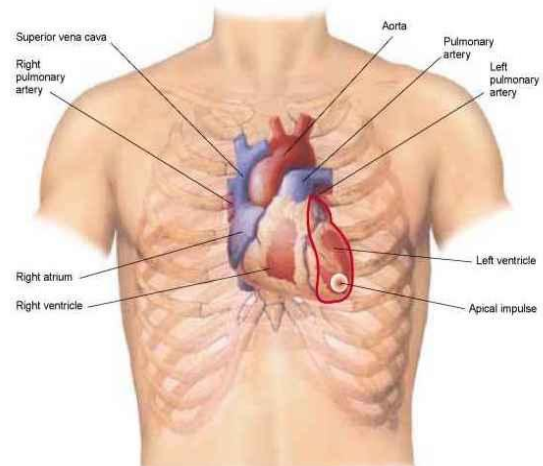
~ **Note:** The membranous part of interventricular septum is susceptible to congenital defects “perforation” Ventricular Septal Defect (VSD), if the perforation was large, blood will flow from left ventricle “higher pressure” to right ventricle “lower pressure”.

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### ❖ Apex of the heart:

- Formed by left ventricle.
- Directed downward, forward & to the left.
- Situated in the left 5<sup>th</sup> intercostal space, 9cm (3.5 inches) lateral to the midsternal line.
- Overlapped by the anterior border of the left lung.

~ **Note:** When the heart contracts “systole” the apex will hit the wall of chest “apex beat”; from this we can count the heart rate even it is covered by the lung.



{Figure13}: Apex of heart.

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### ❖ Blood supply of the heart \*discussed more later on in another lecture\*:

#### **Remember:**

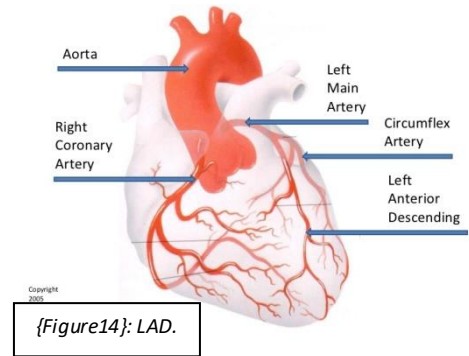
~ The heart is inside the pericardium with ascending aorta, pulmonary trunk & lower half of superior vena cava.

~ Ascending aorta coming from the left ventricle, outside the pericardium it continues as arch of aorta, then the arch become descending aorta.

~ Pulmonary trunk coming from right ventricle carry blood to the lungs.

- **Coronary Arteries:**

- Arise from the anterior & left posterior aortic sinuses.
- Left coronary artery: it's originated from left posterior aortic sinus, runs to the left in the left posterior coronary groove, where it terminates by anastomosing with the right coronary artery, it gives anterior interventricular branch (left anterior descending "LAD") .. {figure14}



**Q: What** blocks the coronary artery? A Thrombus ..

If the thrombus blocked the coronary artery, this will lead to a decrease in the blood supply to heart muscle. Thus, the part that is supplied by this artery may die "myocardial infarction", then heart muscle will become weak "coronary artery disease (CAD)".

**Q2:** A patient with CAD "coronary thrombosis", what is more dangerous, if he was young "Lad" or old "Dad"?

- Young. Because he doesn't have the anastomosis "Collateral circulation", the cardiac anastomosis present in "DAD" old.

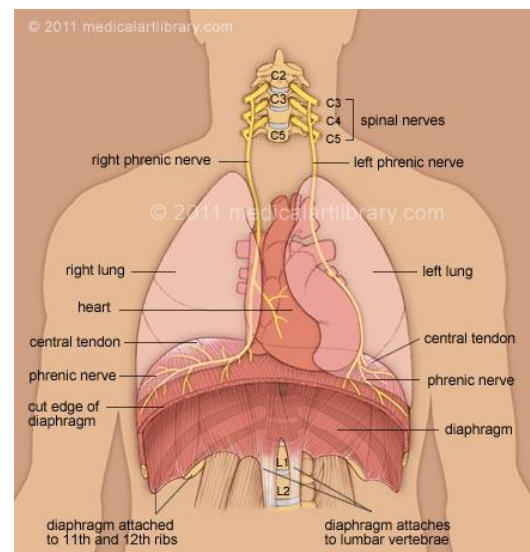
When we have a group of arteries that supply an organ such as left & right coronary arteries. If the left get blocked, the right could compensate this reduction in supply if there is anastomosis ! The two coronary arteries anastomose with each other, on the surface (insignificant) and in the myocardium "what we care about". However, this anastomosis "myocardium" is inadequate, only in old. Therefore, if a branch blocked in young person there will be no compensate "more dangerous".

\*Coronary Arteries: Are functional end arteries.

Functional end artery: is an artery that is the only supply of oxygenated blood to a tissue, with Ineffectual anastomoses.

## ❖ **Phrenic nerve .. {figure15}:**

- Value: C3,4,5 mainly 4.
- It's a spinal nerve: 3 types of nerve fibers "axons" .. sensory, motor & sympathetic.
- Muscles of diaphragm are skeletal "involuntary".
- Motor fibers move "contract" the diaphragm, if you cut the phrenic nerve this will lead to paralysis of corresponding dome of the diaphragm !
- Sensory bring sensation from pericardium, plura, peritoneum.
- Sympathetic supply smooth muscle & the glands, smooth muscles in walls of arteries in the diaphragm .. vasoconstrict & vasodilate them.



If the sympathetic act > vasoconstriction, if Not > vasodilatation.

- Pre-ganglionic sympathetic secretes acetylcholine “neurotransmitter”.
- Post-ganglionic sympathetic secretes nor-adrenaline.

\* Examples of spinal nerves: Ulnar, radial, median & sciatic.

#**Remember:** Not all skeletal muscles are voluntary, e.g. pharynx muscles are skeletal and involuntary (superior, middle & inferior constrictor muscles).

#Adrenaline secreted from adrenal medulla.

#Adrenal medulla secretes 80% adrenaline, 20% nor-adrenaline.

~ Left bronchus passes anterior to the oesophagus & descending aorta, inferior to the arch.

~ The left bronchus is very close to the oesophagus direct contact “nearest structure”.

\* Left atrium is not related directly to the oesophagus, there is pericardium and oblique sinus then the oesophagus.

- Applied Anatomy:

- Patient with dysphagia, the first diagnosis will be a problem “defect” in the oesophagus e.g. carcinoma, but you find nothing wrong in the oesophagus, then you should examine the bronchus, because the patient may have bronchogenic carcinoma, which will cause dysphagia.
- When bronchus pass anterior to the oesophagus it makes a constriction in the lumen of the oesophagus.

**Remember:** Oesophagus has 3 constrictions .. at the beginning, at the end & where the left bronchus passes.

~ These constrictions are important in endoscopy.

\*\*\*\*\*

~ I apologize if I made any mistake.

~ Good Luck </3