



CVS

Physiology

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Welcome to the 1st lecture of physiology, hope it's going to be fun and full of interesting information.

Also, it's short and simple, I promise ;)

-Introduction to CVS-

We'll start with a clinical case since knowing the cardiovascular physiology is about solving symptoms and signs for a clinical case.

A 54 years old man seen in the cardiology clinic complaining of **severe weakness, fatigue, dry cough, weight gain and difficulty in breathing**. He feels **severe shortness of breath while walking up the stairs** of his second-floor apartment. He still complains of lesser severity of symptoms at rest. He states he often **awakens at night feeling like he was suffocating**. He is now sleeping with three pillows under his head. Lately he has taken to fall asleep while he is sitting watching T.V. He also complains of having to **urinate 3-4 times per night**. He was hospitalized with **heart problem two months ago** and was told that the **efficiency of his heart is less than 30%** and he **needs??** And must **wait until??** On examination his weight is 95Kg, height is 165 cm, blood pressure was 140/85 mmHg, his heart rate 90 beats/min and regular, his resp. rate is 28/min and labored. Auscultation (**Listening to the heart sound using stethoscope**) of the heart reveals **abnormal heart sounds (also called murmurs)**.

Let's simplify the symptoms one by one:

-All these are cardiac symptoms.

1. Severe weakness:

Indicates that his heart is unable to supply enough blood or enough oxygen to the body tissues.

2.. Dry cough:

Because of some irritants that irritate his lung causing cough.

3. Weight gain:

You'll think it's because he's gaining fat or muscles, but it's because of **water retention**, water is retained in his body and can't be excreted and that's also why heart is failing.

4. Difficulty in breathing:

Also because of water retention in his lungs resulting in impaired gas exchange.

5. Severe shortness of breath while walking up the stairs:

Increased demand of oxygen and respiration when walking upstairs causing marked shortness of breath. However, being at rest state is less severe.

6. Awakens at night feeling like he was suffocating:

-This is called **paroxysmal nocturnal dyspnea**.

a. During sleep, the fluid accumulates in the lungs causing the feeling of suffocation thus, it makes gas exchange in the lungs harder.

b. The patient wakes up and opens the windows to get fresh air, then call his wife telling her Wallah what a nice weather I feel great! thinking that the fresh air is what makes him better. However, it's the action of gravity which pulls the fluid downward when he stands up.

7. Three pillows under his head:

Sleeping with three pillows creates better posture for the patient to breath because this will prevent the accumulation of fluids in the lungs.

8. Falls asleep while watching TV:

Caused by CO₂ narcosis (collection of CO₂) due to decrease gas exchange.

9. Urinate 3-4 times per night:

High amounts of fluid retention in the body thus accumulation of fluid in bladder in night and high filtration by the kidneys.

10. Efficiency of his heart is less than 30%: (will be discussed later in this course)

Usually, if the efficiency of the heart is **less than 45%** the surgeons will not operate any surgery on the patient. Rather, he needs?! **Cardiac transplant**, by waiting until?! Someone dies with a good heart.

-We need to comprehend that the heart is a **pump** in nature, and since it is a pump, we can change this pump, either by **cardiac transplant**, or by replacement with a **mechanical heart**.

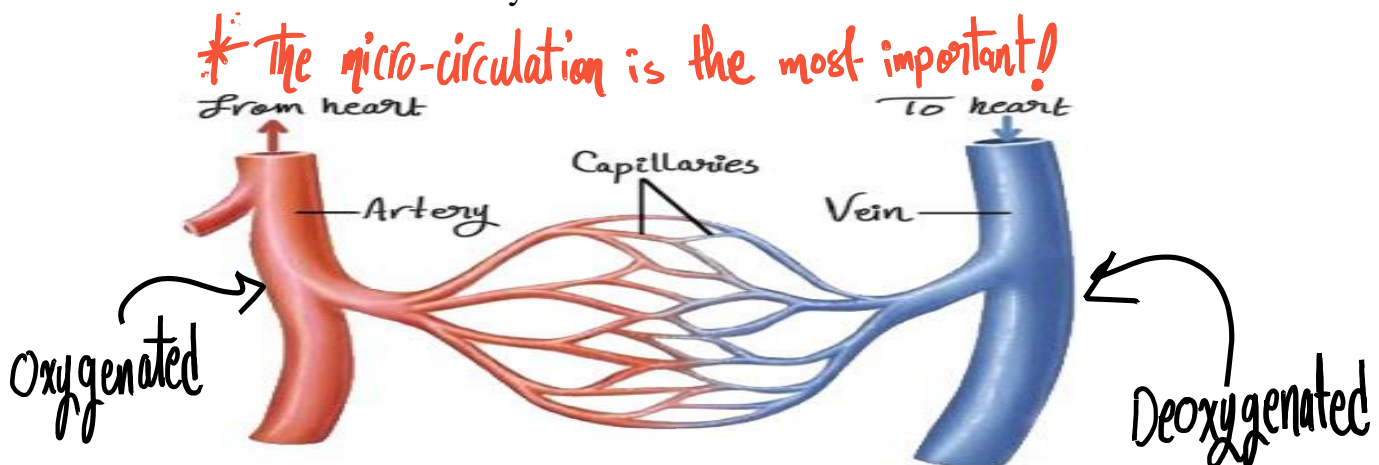
-Cardio-vascular system-

-From its name, consists of cardiac part (**heart**) and vascular part (**vessels**) and if we include the blood it's called **circulatory system**.

-Vessels are two types:

1. Veins: which brings blood towards the heart.

2. Arteries: which takes blood away from the heart.



-The vascular part consists of 2 circulations:

1. Lesser circulation (**pulmonary circulation**):

-The circulation that transport the **deoxygenated blood** from the heart to the lungs through pulmonary arteries and brings back **oxygenated blood** from the lungs to the heart through pulmonary veins.

2. Greater circulation (**systematic circulation**):

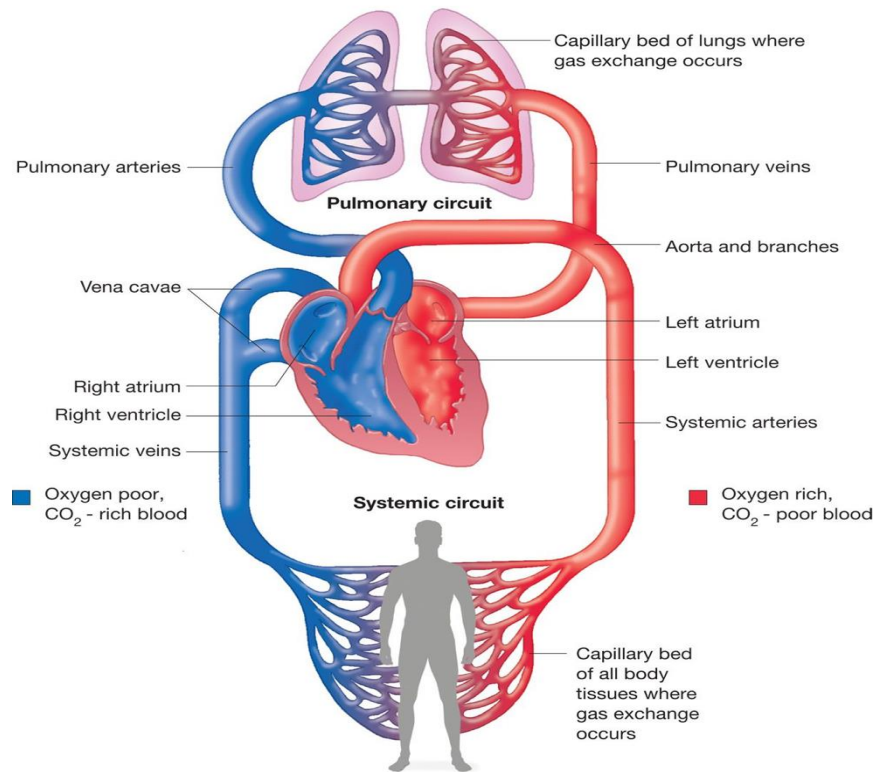
A. The circulation that transport blood to almost every part of the body.

B. The major big artery that takes blood away from the heart is the **aorta**.

-That forms the **aortic arch**, Aortic arch divides into:

#The left subclavian artery/ #Left common carotid artery on the left, #Brachiocephalic artery on the right which divides into **#Right subclavian artery/ #right common carotid artery**.

C. Aortic arch continues as **thoracic aorta** then **abdominal aorta** which gives the **celiac trunk, superior mesenteric and inferior mesenteric arteries** that supply the abdominal viscera.



-History of cardiac transplant- (Read only)

● In 1967, Christiaan Barnard in Cape Town, South Africa transplanted the **first Human Heart** removed from a 25-year-old woman who had died following an auto accident and placed it in the chest of Louis Washkansky, a 55-year-old man dying of **heart damage**. The patient survived for 18 days.

The problem was **Rejection** (Cyclosporine, the immune-suppressant drug that decreases rejection was not known yet).

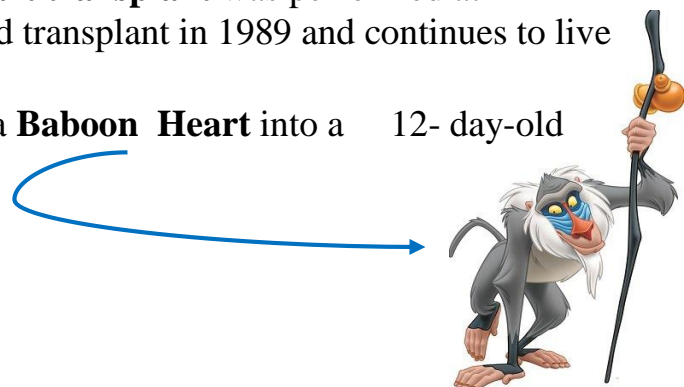
The heart was rejected because of the **incompatibility between tissues** of the recipient and the donor.

● In 1982, in University of Utah, the **first total Artificial Heart** was implanted in the chest a dentist Barney Clark by William DeVries. He survived for 112 days.

The problem was **blood clotting**. (The blood coagulates as a **defense mechanism** against foreign bodies, so they gave him an anti-coagulant -heparin or others- but he died from **severe GI bleeding**).

● In 1984, the world's **first successful Pediatric Heart transplant** was performed at Columbia on a four-year-old boy. He received a second transplant in 1989 and continues to live a productive life today.

● In 1984, in California, Leonard Bailey, implanted a **Baboon Heart** into a 12-day-old girl, she survived for twenty days.



-Anatomy of the heart-

-The heart is in the **mediastinum**, and it is surrounded by an outer membrane that is continuous with the lung tissue. The heart itself is **supplied by** the left and right coronary arteries which originate from the aorta and drained by the coronary veins.

- The heart is composed of 4 chambers: two Atria (upper chambers) and two ventricles (lower chambers) , **and they are not connected to each other.**

- **Atria are separated by the interatrial septum and ventricles are separated by the interventricular septum.** Each atrium is connected to its corresponding ventricle through atrioventricular valve (AV valve) to **ensure unidirectional blood flow.**

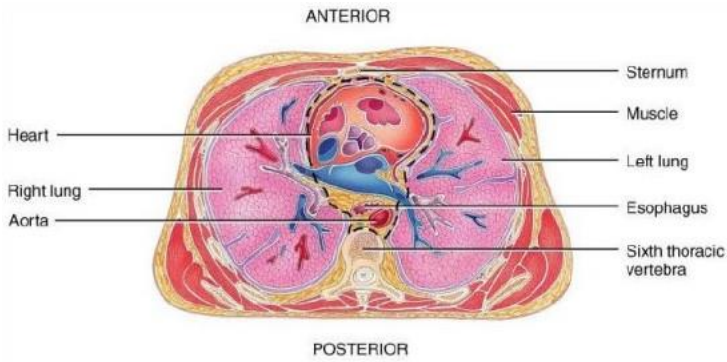
- **Atrial septal defect (ASD):** is a hole in the wall between the heart's two upper chambers. (Normally they are close after birth)
- **Ventricular septal defect (VSD):** is a hole in the wall between the two lower chambers.

Right atrium with right ventricle it is called the **tricuspid valve** .

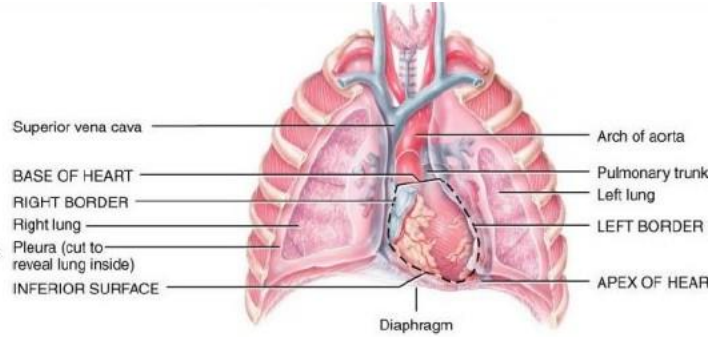
Left atrium with left ventricle it is called the **bicuspid valve (mitral valve).**

The edges of AV valves are attached to a tendinous structure called **Chorda tendineae**, which is inserted in muscles called papillary muscles (a part of the ventricular muscles) there are two papillary muscles with two chorda tendineae in the left side (because we have bicuspid valve), and three papillary muscles with three chorda tendineae at the right side (because we have tricuspid valve).

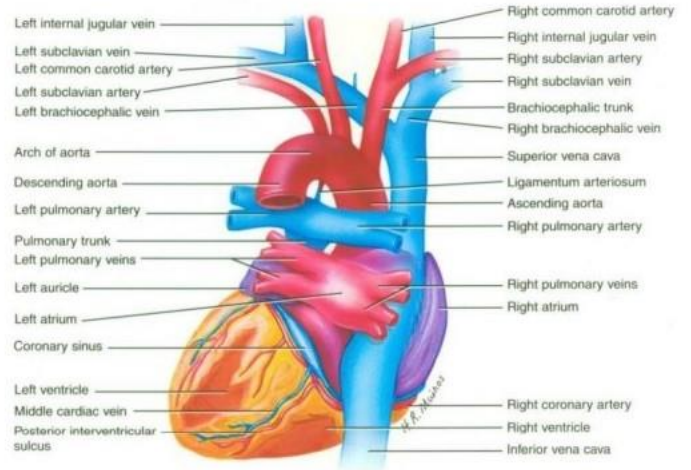
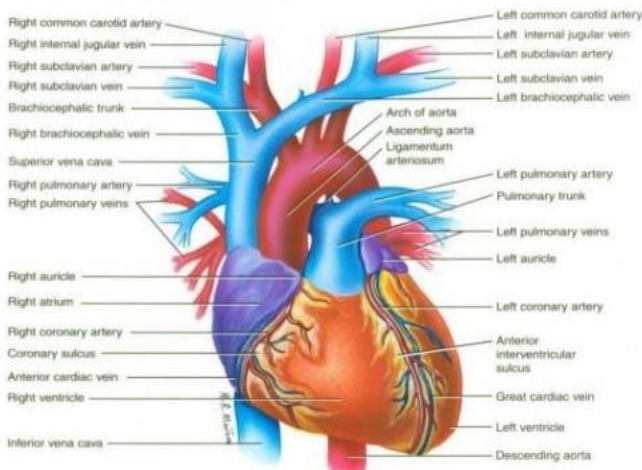
The ventricles are also separated from the arterial system by **semilunar valves**, the right ventricle is separated from the pulmonary artery by (pulmonary valve), the left ventricle is separated from the aorta by (aortic valve) and these valves function is to prevent the back flow of blood.



(a) Inferior view of transverse section of thoracic cavity showing the heart in the mediastinum



(b) Anterior view of the heart in the mediastinum



Cardiac Valves Open and Close Passively

according to the **change in the pressure**, the AV valves open when the pressure in the atria is higher than the pressure in the ventricles, and they close when the pressure in the ventricles is higher than the pressure in the atria, however the semilunar valves open when the pressure in the ventricles is higher than the pressure in the arteries (pulmonary trunk and aorta) and close when the pressure in the arteries is higher than the pressure in the ventricles.

Importance of Chordae Tendineae:

The chorda tendineae is important in **preventing the prolapse** of the valve (valve incompetence).

- Sometimes due to the high pressure inside the ventricles, the AV valve might open to the atrium resulting in what is called **valve incompetence** (valve collapse), and what prevents this from happening is the chordae tendineae that is attached to the

papillary muscles. As the muscle contracts, it pulls the chordae tendineae down with valves movement towards the ventricles.

- Valve prolapse results when there is abnormality in papillary muscles such as myocardial infarction, resulting in damage to papillary muscles and chorda tendineae.

Movement of blood in the heart:

Superior and inferior vena cava bring blood back **to the right atrium**, then it goes to the **right ventricle** through the tricuspid valve, then it will be pumped out through **pulmonary arteries to the lungs** in order to be oxygenated, then it will come back to **left atrium via pulmonary veins**, then through the bicuspid valve (mitral valve) to the **left ventricle** which pumps it to the aorta to start the systemic circulation.

