CVS

PHYSIOLOGY ١

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Introduction to CVS

- First, we are going to have a **clinical case** since knowing the cardiovascular physiology is about solving symptoms and signs for a clinical case.

Let's see what a cardiac patient can complain of:

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:**

1. **severe weakness, fatigue, dry cough, weight gain and difficulty in breathing:**
   a. All these are cardiac symptoms. **Severe weakness** indicates that his heart is **unable to supply** enough **blood** or **O2** to the body tissues.
   b. **Dry cough** because of **some irritants** that irritate his **lung** causing cough.
   c. **Weight gain** (not because he's gaining fat or muscles), but because of **water retention**, water is retained in his body and **can't be execrated** and that's also why heart is failing.
   d. **Difficulty in breathing** happens also because of **water retention** in his lungs resulting in **impaired gas exchange**.
2. **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**.
3. **awakens at night feeling like he was suffocating:**
   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, thinking that the fresh air is what makes him better. **What makes him better is the action of gravity which pulls the fluid downward when he stands up.**

4. 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**.

5. the patient falls asleep while watching TV:

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

6. 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**.

7. 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 pump** (mechanical heart).

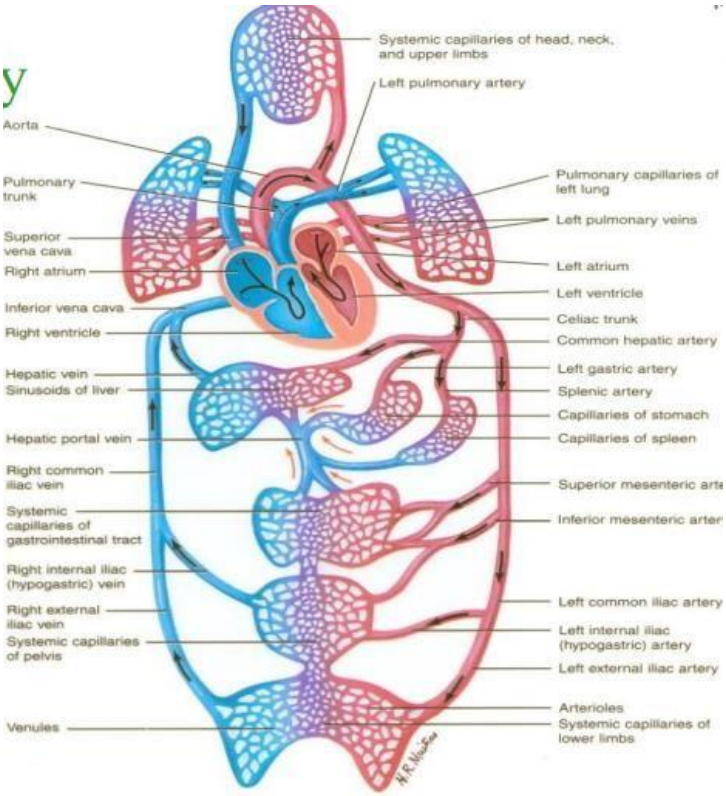
10:00

- **Cardio-vascular system**, from its name, consists of **cardiac part** (heart or pump) and **vascular part** (vessels) And if we include the **blood** it's called **circulatory system.**
- Vessels are two types:

-**Veins**: which brings blood **towards the heart.**

-**Arteries:** which takes blood **away from the heart.**

They are named according to the direction of blood inside them, **whether this blood is oxygenated / deoxygenated**.



General plan of circulation

- The vascular part of the system 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 **lungs to 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**, which forms the **aortic arch**, Aortic arch divides into three major (greater) arteries: (The **left subclavian** artery) + (**Left common carotid** artery) + (and the **brachiocephalic** artery on the **right** which divides into **right subclavian** and **right common carotid** arteries).
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

- **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 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 Linda Loma, California, Leonard Bailey, implanted a **baboon** (small animal) heart into a 12- day-old girl, she survived for **twenty days.**

- **In 1982,** in University of Utah, the first Total Artificial Heart was implanted in the chest a dentist Barney Clark by William DeVries. Clark 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**).

Anatomy of the heart

- The heart is in the **mediastinum**, and it is surrounded by an outer membrane that is continues with the lung tissue.

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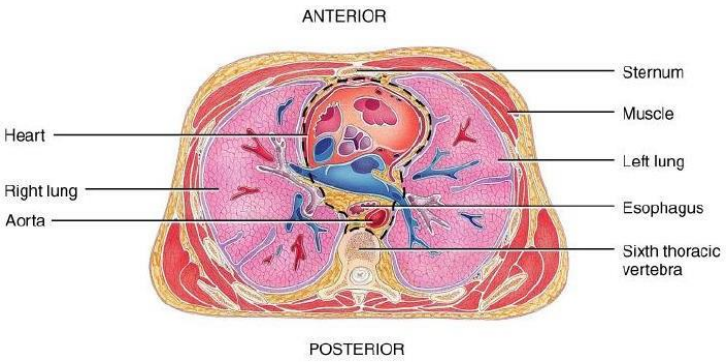
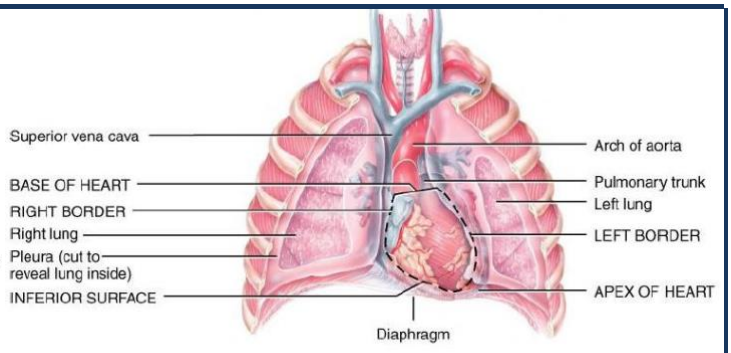
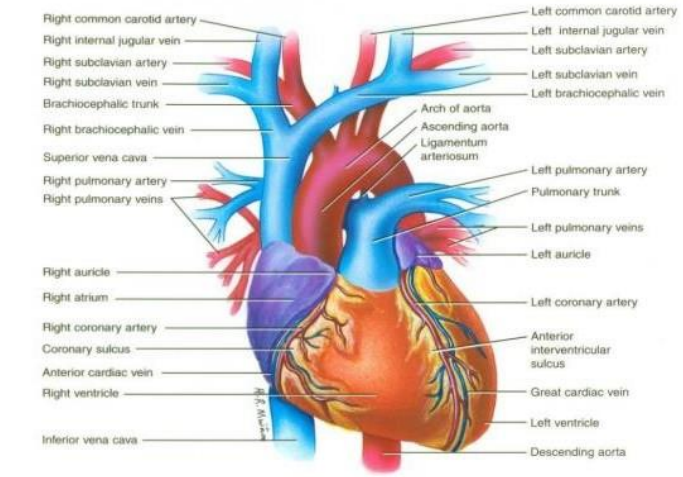


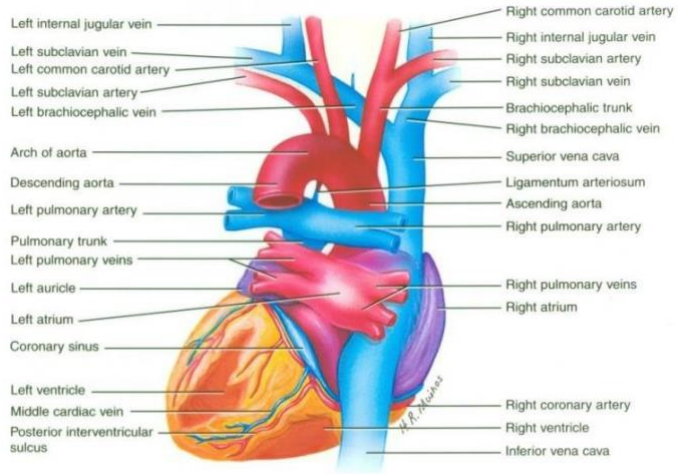
(a) Inferior view of transverse section of thoracic cavity showing the heart in the mediastinum



(b) Anterior view of the heart in the mediastinum

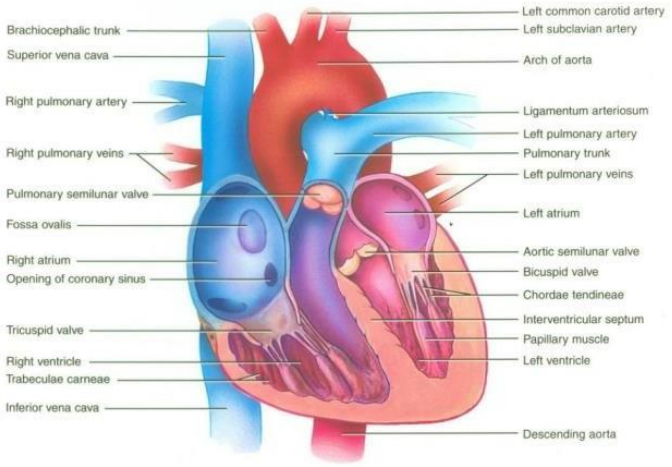


Anterior External View of Structure of Heart, Fig# 20.4a



Posterior External View of Structure of Heart, Fig# 20.4c

- 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 champers**: two Atria (upper champers) and two ventricles (lower champers), 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 <u>atrioventricular valve</u> (AV valve) to ensure unidirectional blood flow, on the **right** side (right atrium with right ventricle) it is called the **tricuspid valve**, while on the **left** side (left atrium with left ventricle) it is called the **bicuspid valve** (<u>mitral valve</u> الصمام الناجي).
- 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 <u>bi</u>cuspid valve), and three papillary muscles with three chorda tendineae at the right side (because we have <u>tri</u>cuspid)



Anterior View of Frontal Section of Structure of Heart, Fig# 20.4d

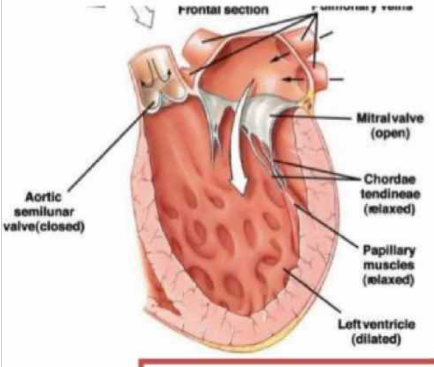
- The ventricles are also separated from the arterial system by **semilunar valves**, the rightventricle is separated from the pulmonary artery by **(pulmonary valve)**, the left ventricle is separated from the aorta by **(aortic valve)** and these valves function is to **prevent the back flow** of blood.
- **Cardiac Valves Open and Close Passively** according to the change in the **pressure,** theAV 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.

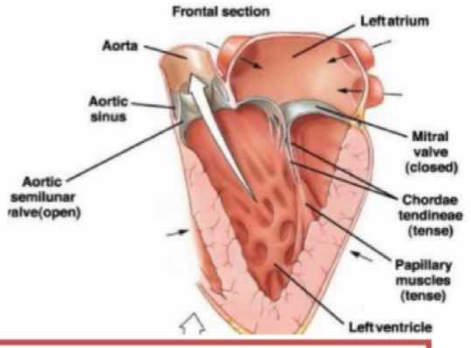
30:00

- **Importance of Chordae Tendineae:** the chorda tendineae is important in preventing

The **prolapse of the valve (valve incompetence**).

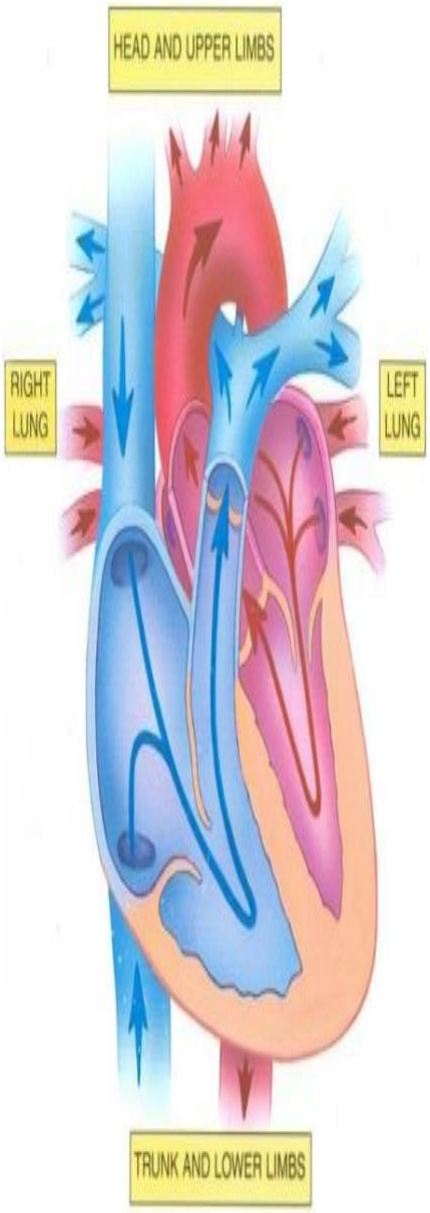
- Sometimes due to the **high pressure** inside the **ventricles**, the **AV valve** might **open** to the **atrium** resulting in what is called **valve incompetence** (valve collapse), and what **prevents** this from happening is the **chordae tendineae** that is attached to the **papillarymuscles**.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





Relaxed chorda tendineae	Contracted 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 (mitralvalve) to the **left ventricle** which pumps it to the **aorta** to start the **systemic circulation**.

Good luck