Cardiovascular System

Sheet 1

Subject | Physiology

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CVS is part of the human body, which affects mainly every system and every organ in the body. As you will see from the following clinical case which shows the **interrelation between different body systems**.

" 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 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 has to wait until??. On examination his weight is 95Kg, height is 165 cm, blood pressure was 140/85 mmHg (slightly high), 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"
Let's simplify the symptoms one by one:

- **Severe weakness**: CVS normally delivers oxygen to the tissues. No oxygen means no energy which in turn causes weakness.
- **Fatigue**: mainly when walking up stairs due to the lake of energy.

- **Dry cough**: heart pumps the fluids of the body, so if it does not function normally, fluids will accumulate causing **Edema**.
- When edema occurs in the lungs (pulmonary edema), the fluid will irritate the lungs resulting in **coughing** which is **dry (no sputum)** due to the absence of inflammation.
- **Weight gain:** due to the generalized edema (his weight is 95Kg).
- **Difficulty in breathing:** due to the pulmonary edema that impairs the gas exchange (rate is 28/min), as we know oxygen and carbon dioxide are transported by simple diffusion (since they are highly lipid soluble); fluid accumulation in lungs makes this diffusion abnormal.
- **Severe shortness of breath while walking up stairs:** due to the lack of oxygen and energy.

  Symptoms are not as severe when at rest; less oxygen required.
- **Awakens at night feeling like he was suffocating:** during sleep, the fluid accumulates in the lungs causing the feeling of **suffocation**. The patient wakes up and opens the windows to get fresh air thinking that the fresh air is what makes him better. Actually what makes him better is the action of gravity which pulls the fluid downward when he stands up.
  The patient's case has the medical name: "**Paroxysmal** (sudden, not continuous) **nocturnal** (at night) **Dyspnea** (shortness of breath)" (PND).
- **Sleeping with three pillows under his head:** More comfortable posture which reduces pulmonary edema(elevating the body elongates time needed for fluid accumulation) . It's called **orthopnea.**
- **The patient falls asleep while watching TV**: caused by CO_2 narcosis (CO_2 poisoning: characterized by somnolence and lethargy among other things).
- **Urinate 3-4 times per night:** due to the high amounts of fluid in the body thus high filtration by the kidneys (it is not always caused by renal failure)**.**
- **Efficiency of his heart is less than 30%:** it will be discussed later in this course. Normal efficiency is higher than 60% , this is important to decide whether operating on a patient is possible because patients with an efficiency lower than 40% can't have surgeries like appendectomy.
- **Needs??**If the heart gets impaired, we try to repair it, as much as we can, using drugs. But if these drugs are no longer useful, we will **need cardiac transplant.**

Wait until?? He needs to **wait until** someone dies with a good heart.

Introduction:

-CVS, from its name, consists of **cardiac part** (heart or pump) and **vascular part** (vessels). We will start this lecture by talking briefly about the **vascular part**, and then we'll introduce the **cardiac part**. But as a course, we will study the cardiac part in the first 10 lectures, then, we'll continue with the vascular part.

Vascular part (vessels):

-Vessels are two types:

1-Vein: which brings blood towards the heart.

2-Artery: which takes blood from heart.

They are named according to the direction of blood inside them, **regardless of their oxygenated or deoxygenated blood**, it doesn't matter, what matters is the **direction** of blood inside the vessel.

The major big artery that takes blood away from the heart is the aorta, which forms the aortic arch. The aortic arch goes from anterior back to the posterior, and then continues as thoracic aorta.

-Aortic arch divides into three major (greater) arteries which are the left subclavian (supplies the left upper limb) artery, left common carotid (head and neck) artery and the brachiocephalic artery on the **right** which divides into right subclavian (right upper limb) and right common carotid (head and neck) arteries.

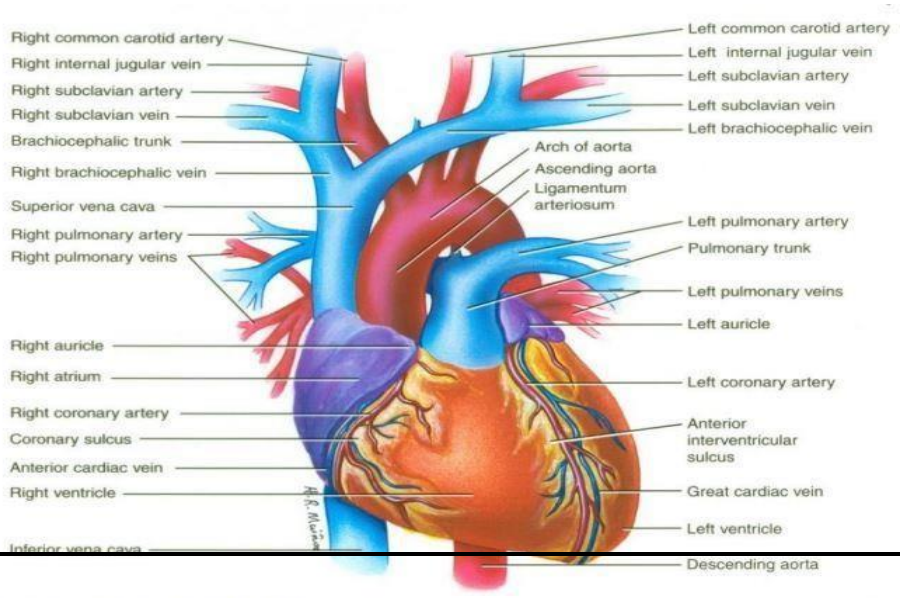
-Aortic arch-as we said- continues as thoracic aorta then abdominal aorta which gives the celiac trunk, superior mesenteric and inferior mesenteric arteries that supply the abdominal viscera.

- Major artery continues as a large artery then medium artery then small artery then arterioles (the suffix indicates that they are smaller than arteries) then capillary then the blood inside the capillaries will be collected into venules then small veins then medium veins then large veins that bring the blood to the right atrium of the heart through inferior (from the lower limbs and the lower body) and superior (from the upper limbs and upper body) vena cavae.

We have two types of circulations:

1-**Lesser circulation or pulmonary circulation** which brings the blood from the heart to the lungs to get oxygenated then the blood returns to the heart.
2-**Systemic circulation or greater circulation** (mentioned in the previous paragraph) which supplies every system in our body (even lung tissue itself, not to be oxygenated).

-The doctor mentioned some historical stories regarding the cardiac transplantation, let's go over them quickly (key words are in bold):
1-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 was not known** – **immunosuppressant** -decreased that).
2-In 1984, the world's **first** successful **pediatric heart transplant (less developed immune system)** 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.
3-In 1984, in Linda Loma, California, Leonard Bailey, implanted a **baboon heart (animal heart)** into a 12- day-old girl, she survived for twenty days. (The heart was rejected).
4-In 1982 in University of Utah, the **first Total Artificial Heart** was implanted in the chest of a dentist Barney Clark by William DeVries. Clark survived for 112 days-**The problem was blood clotting** (any foreign body may induce clot formation). They gave him **an anti-coagulant (heparin or others), but he died from severe GI bleeding**.



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

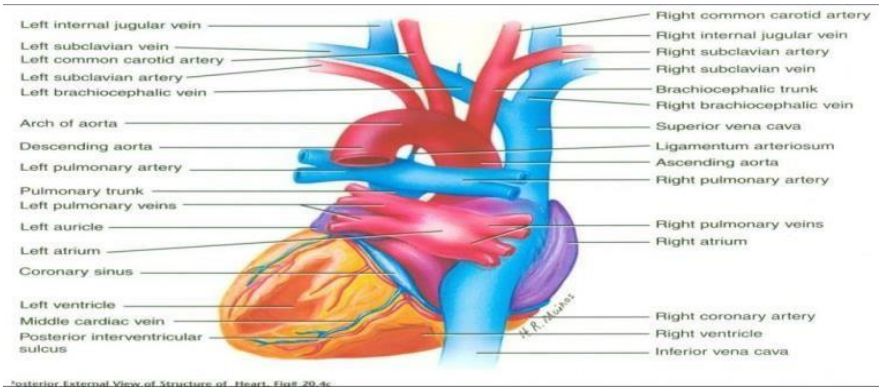
Anatomy of the cardiac part:

The heart is located in the **mediastinum,** and it is surrounded by a membrane which will be discussed later in anatomy.

The figure above shows an anterior view of the heart:

*Notice that the pulmonary arteries carry **deoxygenated (blue colour)** blood **away (since they are arteries)** from the heart.

*The heart itself is supplied by the left and right coronary arteries which originate from the aorta. They are very important physiologically and clinically since their blockage may cause ischemia (decrease in the blood flow) and MI (Myocardial infarction).

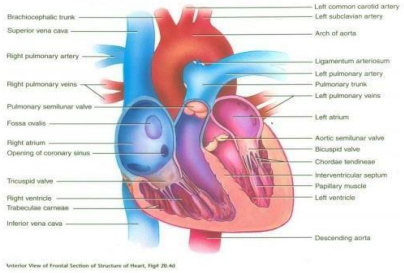


The following figure shows the posterior view of the heart:

-The heart is composed of 4 champers: two Atria (upper) and two ventricles (lower), 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); on the right side (right atrium with right ventricle) it is called **tricuspid valve** while on the left side (left atrium with left ventricle) it is called **bicuspid valve (mitral valve).**

-These valves are very important to **maintain unidirectional movement of the blood** (to prevent back flow of blood to the atria). AV valves open toward ventricles and close toward atria, so when the blood tries to go back from ventricles to atria, AV valve closes while when the blood tries to go from atria to ventricles, AV valve opens.



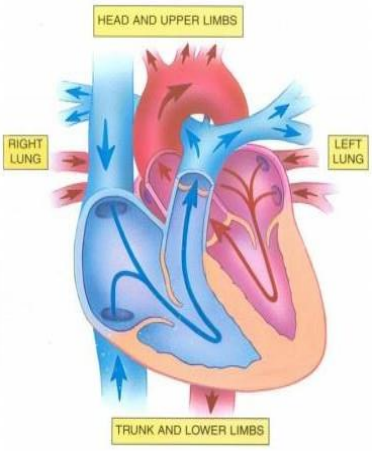
The opening and closing of AV valves are **passive processes** (according to blood pressure and doesn't require ATP) meaning that they don't close or open due to contraction or relaxation (keep this point in mind, it helps later), what occurs is that if the blood pressure in the atrium is higher than blood pressure in the ventricle, AV valve will open. While if the blood pressure in the ventricle is higher than the atrium, AV valve will close.

- The edges of AV valves are attached to a tendinous structure called **Chorda Tendineae,** which is inserted in a muscle called papillary muscle (a part of the ventricular muscles). This prevents prolapse. So, they contract when ventricles contract and they relax when ventricles relax.
- On the right side we have three papillary muscles attached to the tricuspid valve while on the left side we have two papillary muscles attached to the mitral valve.

When ventricles contract (the papillary muscle also does), the pressure inside them will be very high, so AV valves close to prevent blood from going back to the atria. Sometimes due to the high pressure inside the ventricles, the AV valve might open to the atrium resulting in what is called **incompetent valve (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.

- If a person has myocardial infarction, the papillary muscles are ineffective (cannot pull chordae tendineae toward the ventricles during their contraction), so AV valve will be pulled toward atrium and the blood gets back to atrium (this case is called **AV regurgitation (prolapse)** like: mitral prolapse and tricuspid prolapse)

-The exit of blood from heart is controlled by valves. Blood moves from the left ventricle to the aorta via the **aortic valve**, and the blood moves from the right ventricle to the pulmonary artery via the **pulmonary valve**, these valves have a semilunar structure and are thus called **semilunar valves**. SO, the function of semilunar valves is to **prevent back flow** from either aortic arch or pulmonary arteries into ventricles.



Additional pictures of the heart valves in different sections can be found in slides.

- Blood circulation in the heart:

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