# Cardiovascular system
# Physiology
# Sheet (1)

In any patient the most important thing is the cardiorespiratory system, if any patient comes to you with a car accident for example the first thing that you should check as a doctor is his cardiorespiratory system then you move on to the other things.

Cardiovascular system: We are going to deal with the cardiac part alone and the vascular part alone. We study the normal physiology so we can be able to identify and deal with the abnormal.

Now looking at this 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 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, his heart rate 90 beats/min and regular, his resp. rate is 28/min and labored.
Auscultation of the heart reveals abnormal heart sounds

- It was revealed that this patient is a man, this might make a difference physiologically or it might not. We see the symptoms that the patient has, he suffers from a **dry cough** because this is not respiratory problem and not an infection therefore nothing would come out. **Weight gain**, this is not real weight gain, more of fluid retention due to the fact that the heart is failing blood will be stagnant (accumulating in the system, not moving). All these symptoms would make us think that the problem is in the

patient's lungs but it is not. His lungs are filled with fluid that doesn't allow the blood to be oxygenated therefore all the tissues will receive inadequate amount of oxygen that explains why he suffers from **fatigue.** The patient suffers from **shortness of breath**, which we call dyspnea. This symptom was only noticed while he is walking up the stairs it might be due for the extra energy requirement. The **suffocation at night** is because the patient is hungry for oxygen due to the fluid that is filling his lungs so this wakes him up at night. This relieves him because when the patient is in upright posture due to gravity the fluid will go down now the lung gets ventilated, if he goes back to his sleeping position he would wake up again with the same problem in few hours. We call this *paroxysmal nocturnal dyspnea (DNP),* paroxysmal because this comes as attacks and nocturnal because it comes at night. The patient also **sleeps with three pillows** under his head we call this *orthopnea*, which means he needs to raise his head when he is sleeping; this is due to the fluid too. This fluid retention makes the patient **urinate 3 or 4 times at night**, he doesn't have a problem in his kidneys this is due to the heart as well. When the patient was hospitalized two months ago he was told that the efficiency of his heart is 30%. The efficiency we call it *ejection fraction*. So this patient needs a heart transplant, but heart transplant is the last resort. At the beginning we use pharmacology, like digitalis to increase the strength of the heart, also diuretics to decrease the fluid. If all these ways do not work then we inform the patient that he needs a heart transplant. Heart transplant is not a big deal these days but it is still a problem. The heart is usually taken from a person who died by a car accident. Now we do regular examination for the patient, we find his weight, height, blood pressure, and we listen to the sounds of his heart- (called *cardiac auscultation)* using stethoscope. Normally we hear two heart sounds S1 and S2, some people can hear four sounds (S1, S2, S3 and S4). Nowadays due to technological advancement we can have a recording of the sounds of the heart using *phonocardiogram*.

Now, the aim of today's lecture is to get introduced to the cardiovascular system, its physiology and main functions.

This system is made up of the heart and tubes which are vessels that are used for transport (oxygen, hormones, waste, glucose…) Also it regulates body temperature through the blood system. Any problem in the cardiovascular system might affect any other system.

Last thing is to comprehend the pumping nature of the heart. The heart is a pump, it has other functions but this is the main one.

Now lets talk about the vascular part that is the vessels (tubes). The cardiovascular system is the first system that develops in the embryo.

The embryo started as a one-cell zygote, it was in direct contact with the fluid and obtained the nutrients needed easily. However when it becomes multicellular the cells in the middle are too far from the fluid, so in order to obtain the nutrients needed they developed channels (vessels). The vessels transport the blood anywhere in the body however it needs a pump that is the heart.

Now if you included the blood with this system, you call it *circulatory system* not cardiovascular. The cardiovascular system is just the heart and the vessels. The vessels are made up of two parts one part is very short, from the heart to the lung and from the lung back to the heart that's why it is called *lesser circulation* or *pulmonary circulation.* There is another circulation that comes from the heart to almost every other part in the body; this one is called *greater circulation* or *systemic circulation.*

We have in our body large vessels and they keep getting smaller until we reach what it is known as capillaries. These vessels are two kinds either we call them arteries or veins. The artery is called an artery because it takes blood away from heart whether this blood is oxygenated or deoxygenated. The vein on the other hand brings blood to the heart. So the direction of the movement of the blood is responsible for calling the vessel an artery or a vein.

Now let starts talking about the large vessels coming out of the heart, it is the *aorta.* Then this aorta divides into 3 mains vessels:

a) Left subclavian artery
b) Left common carotid artery
c) Right brachiocephalic artery

The brachiocephalic instantly divides to: *right subclavian and right common carotid.* Then the aortic arch comes from the anterior to the posterior and runs in the thorax as *thoracic aorta.* This is a big artery, after that comes smaller, then medium sized artery, small sized artery, then we come to the arterioles now the arterioles are subdivided into too many capillaries. The capillaries are connected into venules, the venules collect into small veins, those collect into medium sized veins, then large veins, at last we have superior and inferior vena cava that go to the heart. This is for the *systemic circulation.*

However the *pulmonary circulation* same thing, we have the largest artery pulmonary trunk then its subdivided into right and left pulmonary artery then medium sized artery, small artery, arteriole then at last pulmonary capillaries. So you have the same subdivisions like in the systemic circulation the only difference is that the pulmonary circulation is shorter so it's under less pressure therefore the walls of the arteries are thinner. Then when the blood comes from the lungs to the heart it comes through veins, starting with venules, small veins, medium sized veins and large veins, which are the pulmonary veins. The difference between pulmonary veins and superior and inferior vena cava is that the systemic veins contain *deoxygenated* blood while the pulmonary veins contain *oxygenated* blood. The same applies for the arteries; the aorta contains *oxygenated* blood while the pulmonary arteries contain *deoxygenated* blood.

The capillary circulation is the microcirculation here is where the exchange of substances takes place. You have to know that concentration for example glucose and the partial pressure of oxygen in the aorta and the arteriole it is the same however when you come to the venule it is totally different.

Heart is the pump, and we know if we have a problem with it we can change it. However, if you have a problem a disease in the microcirculation you can't change it.

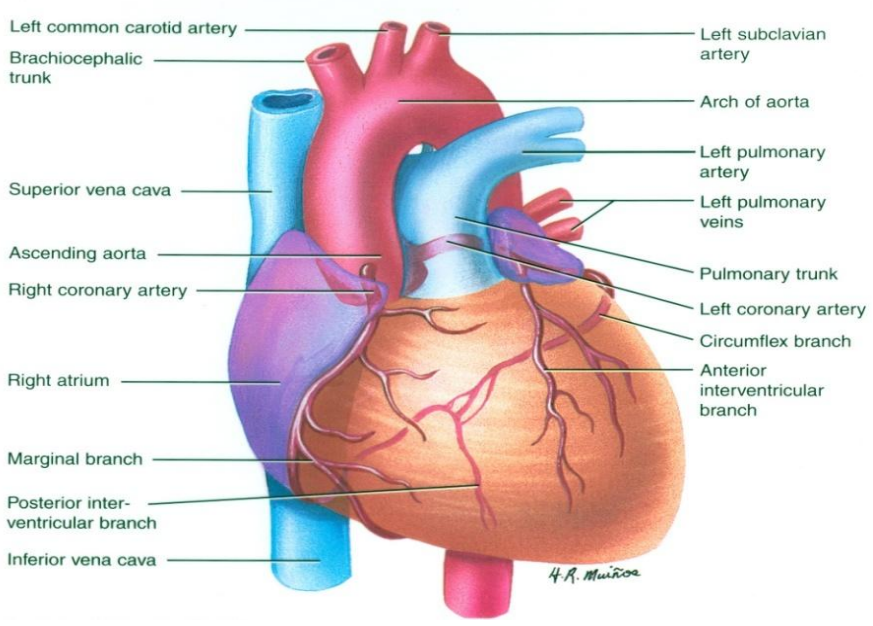
Now we come to the heart, as we mentioned before if there is any problem we try to fix it, our last resort is a heart transplant. The first

ever human cardiac heart transplant was done in 1967 in Cape Town, South Africa it was done by Professor Christiaan Neethling Barnard.

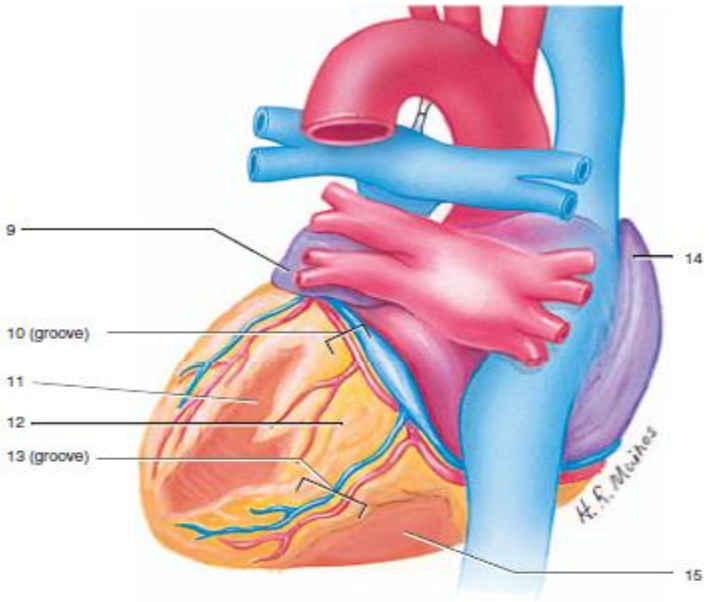
At that time cyclosporine the immunosuppressant was not known which caused the patients to die from organ rejection, however now when preforming a heart transplant, the patient is given cyclosporine directly or any other immunosuppressant drug.

They tried using once animal's heart rather than humans to a patient but the patient did not survive also due to rejection. After that they tried using an artificial heart in 1982, the patient died due to GI bleeding because it's a foreign body, it initiated clot formation that is why the patient must receive anti-coagulants. They stopped using artificial hearts after that and they tried other ways. From all those examples we comprehend that the heart is a pump and this pump can be fixed or replaced.

The location of the heart is in the chest in the mediastinum. In the anterior view of the heart we can see the aortic arch, vessels, pulmonary artery, and on the surface we can see the coronary vessels. The coronary vessels are superficial just the retinal vessels (which are usually tested in patients who have problems like diabetes).



Now in the posterior view of the heart we see the 4 pulmonary veins also pulmonary artery, the aortic arch coming from anterior to posterior, the superior and inferior vena cava, the coronaries are seen as well.




(b) Posterior view

When opening the heart we see that it consists of 4 chambers; two upper chambers called atria and two lower chambers called ventricles. The two atria are separated from each other by *interatrial septum,* also the two ventricles are separated from each other by *interventicular septum.* The atria and its corresponding ventricle (on the same side) are separated from each other by an *AV valve* (atrioventricular valve), the valve on the left is different than the one on the right. The valve on the right has three cusps that's why it's called *tricuspid valve* while the valve on the left has two cusps so its called *bicuspid valve (mitral valve)*.

Now these valves open and close passively according to the change in pressure, if the pressure in the atria is higher than that in the ventricle the AV valve opens but if the pressure in the ventricle is higher it closes. The valves direct the blood movement in one direction.

When the blood is leaving from the heart it is also controlled by valves called *semilunar valves;* the valve that separates the left ventricle from the aorta is called semilunar aortic valve while the one that separates the right ventricle from the pulmonary artery called pulmonary valve.

These valves open toward the arterial system and close towards the ventricles according to the pressure, if the pressure in the ventricles is higher than that in the arterial system they open while if the pressure is lower in the ventricles than in the aorta and pulmonary artery they close.

What is important about these AV valves is that their edges are connected to tendinous structure called *chordae tendineae.* These chordae tendineae are inserted in papillary muscles. These muscles are part of the ventricles, which means when the ventricles contract they contract as well also when it relaxes the muscles relaxes. So when the pressure inside the ventricles is high they close, however when the pressure is too high the valve might open toward the atria but what prevents that is when the ventricles contract , the papillary muscles pull the chordae tendineae towards the ventricles so they prevent the incompetence of the valve.

If there is myocardial infarction for example, then the papillary muscle would not pull the chordae tendineae down the pressure inside, the ventricles will push the blood back to atria this is called *atrioventricular valve regurgitation.* This is abnormal, you would hear sounds murmurs we call it AV incompetence or valve prolapse.

Remember the chordae tendineae doesn't open and close the valve. This depends upon the PRESSURE. The papillary muscles provide the tension.

In case of the semilunar valves we have what's called by *pulmonary or aortic regurgitation*.

The movement of the blood; the blood comes to the right atrium from the superior and inferior vena cava then goes to the right ventricle. From there through the pulmonary trunk it goes to the lungs. It comes back from the lungs to the left atrium, then left ventricles, leaves the ventricles through the aorta to all systems.

Good luck ☺

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