Human Physiology
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Week - 03
Lecture - 04

Welcome to another new class in human physiology. In the last class, we discussed the anatomy of the heart. We also discussed different heart-related diseases and cardiomyocytes, or heart muscles. Finally, we saw how the electrical activities of the heart get generated. So, in this class, we will discuss various circulations of our body. So, let us start with that.

So, what would be the different contents for today's class? So, we will discuss the circulatory system. And then we will discuss cardiac circulation, we will discuss peripheral circulation, and we will also discuss splenic circulation. And in between, we will also discuss blood pressure; we will look at the different types of heartbeat, which are called systolic and diastolic. Finally, we will also see what happens in our body in cases of hypertension or hypotension.

We will also see a little bit about the ECG. So, today's class will be very interesting; let us stay with it. So, what is the circulatory system generally called? The circulatory system generally ensures the delivery of oxygen to our cells and tissues. And if you see, it has mostly two components: one is the cardiac circulation, and the second is the peripheral circulation. So, both the circulatory system and it ensure proper blood flow, not only from the lungs to the heart or from the heart to the lungs.

Basically, it carries the oxygenated blood from the lungs to the heart, and eventually, that oxygenated blood is supplied to all the cells and tissues, mostly in our upper and lower extremities. And once cellular respiration and cellular activities are done, the cells will release carbon dioxide and other metabolic wastes. So, the deoxygenated blood eventually comes back to the heart from the tissues and cells. And again, the role of the heart is to pump deoxygenated blood back to the lungs for further oxygenation. So, this is basically the circulation system closely functioning with our respiratory systems as well.

And a well-functioning circulatory system ensures physiological homeostasis and overall good health. The main key component of our circulatory system, the primary one, is the heart, and what is the role of the heart? The heart basically acts as a pump. So, in the last class, we saw how the cardiac muscles actually work and how they generate electrical activity. And with the electrical activities and continuous pumping and rhythmic beats, it basically acts to pump out the blood across various parts of our body. So, the heart is the primary and key component of the whole circulatory system.

And then the next one is the artery. What do arteries do? Arteries basically carry oxygenated blood from the heart to the various parts of our body. So, arteries generally carry oxygenated blood from the heart to other parts of our body. So, as you see, there is a heart, and from this heart, these arteries will carry the oxygenated blood. So, O2-rich blood is sent to different parts of our body, both in the lower extremities and in the upper extremities.

And once cellular respiration and other activities are done, the cells will produce carbon dioxide, and this carbon dioxide or the deoxygenated blood, in the same way, needs to go back

to the heart. So, the deoxygenated blood needs to come back to the heart again, and it is carried by the veins. And finally, the fourth component is the small capillaries. They are the smallest blood vessels, and what is basically their function? They function basically in terms of gas and nutrient exchange. So, in our next class, we will thoroughly discuss the blood capillary and also see how capillary action occurs.

So, blood vessels in terms of deoxygenated blood come from different parts of our body, and they enter the right atrium of our heart. The process involves two major blood vessels, or you can also say two different veins: one is the superior vena cava, which carries deoxygenated blood from the upper extremities of the upper body. So, if I consider our upper body, the superior vena cava carries deoxygenated blood from the upper extremity to the right atrium of the heart. In the same way, the inferior vena cava carries deoxygenated blood to the right atrium from the lower extremities of the body. So, the inferior vena cava carries blood from the lower extremities of the body, and what does it carry? It carries deoxygenated blood.

In the same way, it carries deoxygenated blood from the upper extremity like the superior vena cava. And then there is another artery called the pulmonary artery. You can see this is the pulmonary artery, and what is the function of the pulmonary artery? Basically, the pulmonary artery acts to move blood from the ventricle to the lung. So, what is happening when the blood eventually comes to the right atrium, after which it goes to the right ventricle, and this blood then eventually moves out using the pulmonary artery, where it goes to the lungs for the next round of oxygen perfusion. So, basically, it gets perfused with oxygen and again reaches the oxygen concentration.

Then let us see how the blood flows. So basically, our body tissues generate deoxygenated blood, right? This deoxygenated blood will go to the right atrium by the superior vena cava. We discussed the superior vena cava and the inferior vena cava. So, they will come by different types of vena cava or veins to the right atrium, and once they reach the right atrium, there is this tricuspid valve, the tricuspid AV valve. So, from the right atrium, the deoxygenated blood will go to the right ventricle, and from the right ventricle, it will be pumped out by the pulmonary arteries to the lungs.

So, eventually it will pump back out to the lung for oxygenation. Then once it reaches the lung, the lung has alveoli that will take the oxygen from the air, and oxygen will eventually get bound to the RBCs or hemoglobin and be perfused into the blood. So, in the lungs, our deoxygenated blood will further get perfused with oxygen and become oxygenated. And then, from this oxygenated blood through the pulmonary vein, it will eventually enter the left atrium of our heart. So, through the pulmonary veins, this oxygenated blood will enter the left atrium, and in between the left atrium and the left ventricle, there is this bicuspid valve.

So, oxygenated blood will slowly move from the left atrium to the left ventricle, and once it is moved to the left ventricle, eventually, through the aorta, the oxygenated blood will be pumped out to the various parts of our body and organs. So, eventually the heart's role is to transfer this oxygenated blood from the left ventricle to different cells, organs, and tissues for their cellular function. This is the whole route of how coronary circulation occurs. Now, let us discuss heartbeat. Heart sounds are generally produced by the mechanical activity of the heart during each cardiac cycle.

And you can see that this sound is produced by the flow of blood during cardiac cycles, as well as by the contraction of the cardiac muscle along with the closure of the heart valves. So, all

three of these together—like the flow of blood, contraction of the cardiac muscle, along with the closure of the valves—make the heart sound like a "lub" and "dub." Therefore, heart sounds are generally referred to as "lub" and "dub." Right, and how it can be heard if a doctor uses a stethoscope; he or she can clearly hear the "lub" and "dub" sounds of the heart or the heartbeat. The study of heart sounds has very important diagnostic value, especially in clinical practice, because any alteration of the regular sound can indicate certain cardiac diseases that may be causing the irregularities of the heartbeat and the sound.

Now let us discuss blood pressure, okay? So what is blood pressure? Blood pressure is basically a force that is exerted on our blood capillaries or arteries, okay? So basically, in the wall of the blood artery, the pressure generated by the heart is called blood pressure, and it is basically of two types: one is systolic pressure, and systolic pressure is basically referred to as the top number. So, whenever the heart beats or contracts, the amount of pressure it exerts into the arteries of the blood vessels is called systolic pressure, which is the top number. Alternatively, the diastolic pressure is when the heart is at rest, and during these two heartbeats, the amount of pressure the blood flow is exerting on the capillaries is called diastolic pressure. So, it is the bottom number, and as you can understand, the systolic pressure is always higher compared to the diastolic pressure because it is generated when the heart is actively in a pumping state. Now, let us see what the normal blood pressure is.

So, in the case of normal blood pressure, the top number is usually about 90 to 120, which is the systolic number, and in cases of normal blood pressure, the diastolic or bottom number is about 60 to 80. And in case, for example, if our blood arteries have a clogging of thrombus or due to cholesterol, fat, or lipid deposition, the arteries get narrower; then the exertion of pressure from the blood to the arteries will be much greater, causing high blood pressure, and this situation can also lead to hypertension. So, in cases of hypertension what will happen the top number can be more than 140. So, it can be like 140 to like 190 in cases of hypertension right the top number can be more than 140 to 190. And the bottom number also you can see the bottom number can be also 90 to 100.

So, in case it is detected that your top number is more than 140 or even your bottom number is more than 90, that is a serious concern, and you are probably experiencing a condition called hypertension or high blood pressure. And this is a significant physiological challenge because many times what happens is that hypertension or high blood pressure goes undetected. And if there is high blood pressure, you can think of it like this: our arteries and blood cells want to move in very high pressure, significantly high pressure. What will you do? It will exert a lot of force on all these walls that can cause systemic damage, which can affect our arteries, and it is very detrimental; in cases of long-term situations like hypertension, it can lead to cardiac ischemia or even stroke. Finally, in cases of low blood pressure, what we will experience is that the low blood pressure measurements you see will have a top number of about 70 to 90, which means the systolic number will be about 70 to 90, and the bottom number will be around 50 to 60.

So, if you experience a systolic blood pressure of about 70 to 90 and a diastolic blood pressure of about 50 to 60, this is also a serious concern because it is a condition called hypotension where blood flow is significantly slow. A slower or lower amount of blood flow can lead to a reduced delivery of oxygen and nutrients to our cells, tissues, and organs, which can create a hypoxic situation, and the cells can be deprived of proper nutrition and other ions. Hopefully you understood what systolic blood pressure is, what diastolic blood pressure is, and what the different conditions like hypertension and hypotension are. These are very important to monitor

all the time, and it is always recommended that once a year we should go and check our blood pressure, and if we have equipment that can be with us in our home, that is very good. You can always measure your blood pressure once a month, so that you know if it is controlled or if you have any serious condition in your body.

The blood pressure generated by the fetus is called fetal blood pressure because it depends on the fetus; that fetal blood pressure only contributes to the blood circulation from the fetus and not from the mother's heart, which actually contributes to the fetus's blood circulation. So, it is very important to know that the mother's heart is not the main responsible for the blood circulation to the fetus; it is the fetus's heart that plays the most important role. And you can see that for about 20 weeks of gestation, there is this measurement of around 30 millimeters of mercury, which is the blood pressure generated in the fetus. And it slowly increases to about 45 millimeters per hertz when the fetus is about 40 weeks old. And once the infant is born, the systolic and diastolic pressure are primarily generated by the heart, which creates these two functions: both the top number and the bottom number.

As you can see, the systolic number is about 65 to 95 millimeters of mercury, and the lower number of the diastolic number is about 30 to 60 millimeters of mercury. This table also has different age groups, and it includes both the systolic and diastolic numbers, which you can read for your information. Okay, and then in the case of persistent hypertension, for example, if our body experiences a prolonged condition of high blood pressure, as I said, it will rupture the blood vessels, and it can also cause a lot of blood loss; it can cause strokes and other deadly diseases. So, there are different medications for hypertension. Some of the categories briefly let us discuss, for example, one category of beta blocker drugs like atenolol or betaxolol; these are used to help reduce the heart rate.

So, as the heart rate decreases, the blood pressure will also slow down. So, what do beta blockers do? They reduce the heart rate or the heartbeat; in this way, they reduce blood pressure. Then there are other classes of drugs called diuretics, and as you know, diuretics increase urination, right? So, diuretics increase urination, and if urination is increased, it will remove a lot of sodium and water from the blood, causing blood pressure to drop. Then there are other classes of drugs, which are angiotensin-converting enzyme inhibitors, or ACE inhibitors. So, angiotensin-converting enzyme inhibitors cause a condition of widening of blood vessels, or vasodilation.

So, if the blood vessels get wider or vasodilation occurs, the blood pressure will drop because the blood can flow easily and reduce the BP. And then the fourth class of drugs is the calcium channel blocker, and as you know, calcium is very important for muscle contraction, even for heart muscle contraction. So, this calcium channel blocker will ensure that a low amount of calcium is accepted, which will cause slower contractions, and in this way, the heart rate will slow down and the blood pressure will also become lower. So these are a few classes of drugs you can use in cases of hypertension. As you can see, as we already said, hypotension is a cause when blood pressure falls, and that is very detrimental because if the heart pressure falls, the blood will not be able to circulate properly through our body.

And there can be many cases, like causes, for this low blood pressure or hypotension. It can be like sepsis, it can be hemorrhage, it can be the effect of different toxins, or even hormonal abnormalities, right? Or it can be the effect of different steroids as well. So, various things can eventually cause a situation of low blood pressure or hypotension. And in these cases, a doctor may also prescribe certain therapies to improve your blood pressure from low back to normal.

Then finally, let us see what ECG is, right? So basically, ECG, or electrocardiography, is the technique by which the electrical activities of the heart are studied.

So in the last class, you remember we discussed the electrical activity, right? When there is initial depolarization followed by initial repolarization, then the plateau of depolarization, and finally, a final repolarization step. So, if you remember, we discussed the initial depolarization and said that it happens due to fast sodium ion channels, and the voltage was about plus 20 millivolts. If you remember, then there is this stage where the initial repolarization happens. Right, and if you remember what happens during the initial repolarization, like potassium efflux happening, in this case, the sodium influx occurs, and then in the plateau stage, where a sustained amount of depolarization happens, calcium channels are involved. Finally, there is the final repolarization step where again the potassium efflux channels are involved.

So, all these together generated an action potential or electrical activity, and that measurement is done by electrocardiography, or ECG. So, basically, an electrocardiograph or electrocardiography is an instrument to measure the electrical activity of the heart. And then, an electrocardiogram is the record or graphical representation of the electrical activities of the heart that occur before the onset of mechanical activity. ECGs are recorded mostly in 12 leads. There are about 3 bipolar limb leads and 3 augmented unipolar limb leads along with 6 unipolar precordial leads.

So, lead means various sensors, basically. There will be about 12 leads or 12 electronic sensors that will be attached to our chest, measuring all the electrical pulses and activities that will eventually generate an electrocardiogram or a graphical representation. So, you see we will just briefly discuss the different waves of the ECG. So, the first one is the P wave, right? It is caused by the atrial depolarization and has a duration of about 0.01 seconds. And what is the amplitude in terms of millivolts? It is about positive 0.

1 to 0.01, okay? So, 0.01 to about 0.01 millivolts is the amplitude. So, what you can see here is this P wave initially in the ECG graph, and after the P, you will see this QRS type of graphical representation. So, how is this QRS complex generated? This generates due to ventricular depolarization and atrial repolarization. So, the QRS complex, or the graphical representation of the electrical activity, is generated due to ventricular depolarization and atrial repolarization. And what is the onset of the duration? It is about 0.

08 to 0.1 seconds, right? And then the T wave, which is generated after the QRS complex, is generated due to ventricular repolarization, okay. So, the T wave is generated due to ventricular repolarization. for about 0.2 seconds and the amplitude is also about 0.

3 millivolts. So basically, you will see mostly three types of important nodes. One is the P wave, then the second is the QRS wave, and the third is the T wave. The P wave is generated due to atrial depolarization, isn't it? Then the QRX complex or the wave is generated for the ventricular depolarization, along with atrial repolarization, and finally the T wave, which is generated for the ventricular repolarization. So, this three-wave pattern is very clear to us, and then in between, there are a few intervals; for example, the PR interval, where you will see both atrial depolarization along with conduction through the AV node. You will also see the ST segment or ST interval; this is basically like an isoelectric nature.

And also, you will see this QT type of interval, which is generated due to the ventricular depolarization and ventricular repolarization. So, these are like in between P and QRS and T;

we can experience PRST and QT type intervals or segments. So, basically, the ECG will try to monitor the electrical activities by representing our electrical activity in this graphical demonstration, and in cases of any abnormality, we may see changes from the normal pattern of these P, Q, R, S, and T waves, and by measuring those wave patterns, a doctor can determine if there is any serious issue related to our heart. Okay, hopefully, it is clear. Of course, there is a lot more we can read about the ECG and a lot more detail we can discuss about the electrical activities of our heart.

If you have any questions, please read the books and the web content as well. If you have, especially like a guidance book, any further questions, please discuss them with us during the live session and also drop us the questions in the email. Finally, the peripheral circulation will try to quickly wrap this up so that once the heart receives the oxygenated blood from the lungs, it pumps out all the oxygenated blood to the upper and lower extremities of our body. So, basically, the peripheral circulation is part of the upper and lower extremities of the body. So, you can see that both the upper part and the lower part of all the extremities are part of the peripheral.

So, basically, it is the peripheral area. And like various arteries and veins, in the same way as the coronary circulation, they are dependent and they basically perform proper functions to carry the oxygenated blood to all the cells and tissues of different parts of the body, and eventually, after cellular respiration and cellular function, they carry the deoxygenated blood back to the heart. This is not difficult; there is not too much to know, and different types of peripheral circulation can occur. For example, there is skin circulation, then cerebral circulation, then renal circulation where the kidneys are involved, and hepatic circulation where the liver is involved. So, these are various areas or organs where different types of peripheral circulation are reported, and there might be various regulations that can control peripheral circulation. For example, the sympathetic nervous system can constrict the blood vessels, or vasoconstriction can occur, causing a lower amount of blood flow.

Alternatively, the parasympathetic nervous system, or the PNS, can relax the blood vessels or cause vasodilation, which will result in higher blood flow. So, higher blood flow, and in cases of vasoconstriction, the blood flow can be lower. Then hormones can also play an important part. For example, epinephrine and norepinephrine can increase blood pressure by vasoconstriction. They will certainly slow down the blood flow because vasoconstriction will occur, right? And then angiotensin 2 can also cause vasoconstriction, which will also result in lower blood flow.

Then the AMP peptide, or the atrial natriuretic peptide, will promote vasodilation, and blood flow may increase. And then there can be local or metabolic factors. For example, during exercise, lactic acid gets generated by cellular metabolic activity, and this lactic acid will cause vasodilation, which will promote increased blood flow because, during exercise, our body and cells require a lot of oxygen. So, this lactic acid, by promoting vasodilation, will ensure that blood flow increases and that it can carry more oxygen and nutrients to various parts of our body, especially the muscles. Finally, the splenic circulation is involved through the connection to the liver.

So, you can see the splenic circulation, which happens mostly in our intraperitoneal area, or the IP cavity area where our liver is located. So, from the aorta, the blood either goes directly to the liver or gets connected to the stomach, spleen, pancreas, or even colon, and from there, it eventually connects to the liver via the portal vein. Right, and the liver basically acts as a

detoxifier. So, all the metabolic activity happens in the liver; it destroys all the toxins, and eventually the blood comes out of the liver and goes to the heart via the inferior carotid vein. So, if the liver is basically one connective unit of the whole circulation that happens in the IP cavity of our body, this part of circulation is also called splenic circulation.

So, we discussed coronary circulation, where mostly the heart and lungs have an important role to play. Then we also discussed peripheral circulation, where the oxygenated blood from the heart actually distributes to all the peripheral upper and lower parts of our body, and finally the splenic circulation, where the intraperitoneal organs like the stomach, spleen, and pancreas eventually connect to the liver, where detoxification occurs. So, I hope you liked all this, like the circulation part and different types of issues, for example, hypertension, hypotension, peripheral artery disease, or deep vein thrombosis. So, all these diseases can happen, especially since deep vein thrombosis is a serious issue where thrombus formation can eventually part of or slow down the blood flow. Apart from cholesterol deposition, lipid deposition can also cause narrowing of the artery.

So, these are some significant issues that can slow down the blood flow and also increase blood pressure. So, basically, blood pressure may increase and blood flow can decrease. So, if you enjoyed the class, let us think about what the normal range of blood pressure is, what some common types of heart failure are, if you can also tell what the difference is between the arteries and veins, and also if you can explain what a stroke is and how it is related to circulation. So let us think about this question. If you have any questions, you can also refer to various books like Guyton's book or Tarota's book, and you can also check different web content.

Further, if you have any questions, please drop us your question in an email, and we can also discuss it further during the live session. Thank you for attending today's class. We will soon meet with another class of human physiology. Thank you.