Human Physiology
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Lecture – 23
Lymphatic system

So, we are talking of the lymphatic system and we know that there are capillaries and capillaries and under the fluid, under pressure it oozes out and it contains no RBCs, no large proteins, but the fluid part of the plasma flows out along with that goes the glucose, the amino acids and all the small molecules and they continuously come out in a huge amount. It is almost calculated that as much as 20 liters of fluid may flow out via all the capillaries, over a period of 24 hours, that is a lot, ok. But thanks to the that hypothesis what was that hypothesis very good what was that hypothesis? Say that again please. Starling. Say that again please. Starling. Say that again please.

Starling. Say that again please. Starling. Loudly I everybody shut up again please.

Starling. No, he has to say other side. Starling. Starling. Starling ok, because of Starling hypothesis that fluid comes out and it again goes back, ok. And there it goes back, but not all and about 2 or 3 liters of fluid, it stays there. It stays there ok. But it keeps on it comes on moving and it is very important because there may be some large protein molecules there. We see no system is perfect ok.

So, there are some large protein molecules which have leaked out or oozed out and then you need to return them back to the blood. You have borrowed from the blood you need to return to the blood and therefore, we have what you call as the lymphatic system. So, actually what comes out of the capillaries, it is interstitial fluid what is it? It is interstitial fluid it is extra cellular fluid, fluid ok. It is it is very poor in protein molecules as compared to blood. No RBCs, but short of that it is watery, ok and it has all the small molecules and all the ions there as much in the blood - they are there in the same in the same concentration. They are also in the extra-cellular fluid. Now, this extra-cellular fluid is going to enter into a system of tubes which I will call as lymphatics ok and it is a very tiny tube, it is again made up of endothelial cells and it is the system of tubes that is going to return the interstitial fluid back to the back to the blood or back to the heart. It is the interstitial fluid as long as it has not entered into the tubes, once it has entered into the tubes, I will not call it a interstitial fluid anymore I will call it as a lymph, but it is essentially, it is essentially the same thing, ok.

So, we have seen this we have seen. So, we have the lymphatic system and we have the terminal branches and the terminal branches get together get together, get together and en route they encounter several nodes about which you will focus on the in the immune system and then finally, the it will get to blood. So, what is the most important question that you ask yourself is this is a system that is not driven by heart - there is no heart ok. And there is every

day over a period of 24 hours about 2 to 3 liters of fluid is coming out and then it has to flow it has to go back how who drives the fluid getting the question where there is no heart, who drives the fluid. The answer to that question is very interesting number 1 - the fluid that is continuously coming out where from the capillaries ok which means it is it is gently generating a pressure ok which is the fluid is coming ok the fluid has to go somewhere ok.

As the fluid goes it generally enters into what you call - this picture very clear. You can see the red vessel that is an artery - then it branches and then the capillaries and the capillaries run and then the and the blue ones which will carry the deoxygenated blood and here we have a system of blind terminals and we will call this. This is made up of - this is the beginning of the lymphatic system which is made up of extremely flat extremely flat and curve like capillaries they are capillaries we will call them as lymphatic capillaries and they of course flat and they make a certain tube and is blind at the other end and in between the 2 cells ok there is lot of gap ok. And one interesting point that you have here is there is no basement membrane normally, all blood vessels everywhere you have in the capillaries, you may or may not have depending on what kind of capillary you are ok. That we have done. So, so essentially on the terminals there is no basement membrane. So, just a single layer of cells and there is a space between the 2 cells and as a result of that the fluid which is being pushed out of the capillaries can gently flow into this system of tubes.

Now, here the interesting point is it is something. Just imagine there is one cell here hello one endothelial cell here another endothelial cell here there is a slight overlap can you see that and there is a slight space in that and through that space the fluid trickles in gently as it trickles in as it trickles in the volume in this space the volume in this lumen what is the lumen of the terminal tube of the lumen here in that lumen the fluid is the fluid is arriving are you ok so far. As a result of that these 3 cells - they slightly stretch and the beauty of the cells is that they contain actin mycin filaments as a result of that if you stretch them they will contract and the moment they contract you know this this space between the 2 acts as a wall. Just see and it closes, are you with me? So, whereas the fluid which is coming under gentle pressure from the capillaries can get into that terminal lymphatic vessel it cannot go back, ok. And then the fluid flows, fluid flows and then as if we were to design, put valves there ok. just to make sure that the fluid does not go back. So, we have a system of valves ok. I just put this histological picture to give a real perspective of the lymphatic vessels. What we have a muscle tissue in the muscle tissue. Can you appreciate the muscle there, are all muscle bundles there ok.

And then can you see that big artery there, branch of arterial there, but I want to draw your attention to this - the author has labeled as L what does L stand for? Lymphatic vessel. Lymphatic vessel is extremely thin extremely thin cells are there, which are lining and they do not have basement membrane. They do not essentially form a particular a specific circular shape, no there they can take any shape depending on the tissue around them. So, here we have a terminal lymphatic there is a cell here there is a cell here there is a gap here the fluid will flow this way this way it will go here and once as the fluid accumulates, this is going to swell once it swell it is going to contract this flap of the endothelial cells going to serve as a

valve and close and will not allow the fluid to go back by the same route by which it came are you with me? And then it will start flowing and then beyond a particular limit then you see, this actually histological section of a of a lymphatic can you actually see the valve. So, the fluid can go here, but the fluid cannot go back ok. Eventually what happens is, so, there is a lymphatic terminal there the fluids can enter and the fluids can go there is a valve here eventually as more and more lymphatic vessels coalesce which means come together ok and they become more in diameter eventually the larger or the collecting lymphatic vessels - we find that they are equipped with smooth muscles what are what are they equipped with smooth muscles. Have we done smooth muscles in this class, no, we will talk about it when we do the digestive system, but they are the smooth muscles, but we talked about them hundred times smooth muscle they are they are the smooth muscles and these smooth muscles they show peristalsis.

Hello you get the meaning of the word. We have done it, peristalsis. What is peristalsis? we have done it with reference to the transport of food along our alimentary canal, ok. This peristalsis, peristaltic movement ok. A wave of contraction that is goes along and there is a peristaltic movement drives the fluid towards the towards the heart. The lymphatic, it goes towards the heart as the fluid cannot go back as a result of the peristaltic movement it actually creates a negative pressure here are you with me. So as you go means, as you go ahead and ahead and as the tubes become larger and larger and as they get thicker and thicker covering of the smooth muscles and as those smooth muscles show peristaltic movement and as the fluid is being driven in a particular direction on the other direction there is negative pressure. So the fluid is being drawn which is the fluid that is coming out the capillaries get into the interstitial fluid get into those terminals we will call it as a lymphatic and then it will flow it will flow along and it will flow along along it will go towards it will go towards here. So that negative pressure is very very important that negative pressure is important because you know some people some book actually compare it to the terminal serves as a bit of vacuum cleaner are you with me. It sucks lymph what does it suck it is a lymph, ok. It is continuously lymphatic fluid it is it is sucking interstitial fluid and calling it as lymphatic and that is very important I talk about it again when I come back to respiratory system that is very important with reference to our lungs ok. We have already seen that there are capillaries and the capillaries in our lungs are under what kind of pressure please hello, pressure the blood vessel ok the blood vessel that is going to the lungs is under what systolic pressure what systolic pressure why ok ok. You can keep on guessing ok ok 15 mm Hg is the average one so ok ok 25, 8. I am talking about what - the pulmonary systolic ok I will go back I will go back to system make how much 120 80, am I right there? Hello everybody hello how much is it systemic how much it is 120 80, now I will take my pressure sensor and put it on the pulmonary artery and then pulmonary artery which is taking deoxygenated blood to the lungs is showing you what variation 25 8 you should never make a mistake 25 8 average is about 15 or 16 whatever, ok.

Now even under that pressure, if the capillaries start leaking the same fluid does leak or they do because the capillaries are in the lungs. Do they leak now if that fluid leaks out in the lungs and if that fluid forms a tiny layer in the alveoli what are you doing you are drowning

ok. You are creating a barrier between air on one side and alveolar epithelium on the other and that going to impede with your gaseous exchange. Therefore we have a lymphatic system that effectively keeps on serving like a vacuum pump and keep on sucking out that liquid ok. And making, I will use the word keep making sure that the inner surface of the alveolus, is relatively dry, it is not dry in strict sense, but - there is a thin layer of liquid has always got to be there. But make sure that the thin layer of liquid actually remains thin and it does not become it does not it does not become the thick is the point. The second point is you see why nature is amazing is because every time you remember when we talked about your calf muscles two calf muscles ok and they play a role in driving the venous blood towards the heart against the gravity. You know what are we doing. We are you are using your skeletal muscle to serve a particular purpose your entire skeletal system ok. So whenever you are doing any particular activity the whole the whole engineering design of your lymphatic system is such that it is keeps on it keeps on pressing it keeps on pressing these tubes so that they will keep on the driving the fluid in the direction. It is so genius there is nothing else. Every time you breathe in and every time you breathe out ok there is a mechanical movement of your thoracic cavity. Am I right yes or no. Even with that the lymphatics are being pressed and released pressed and released pressed and released the moment you press them the lymph will go towards the heart are you are you with me. So it is our biology has linked the movement of the lymph in the large lymphatic vessels with our respiratory movement. Next point, we continuously have pulse so there are blood vessels which are depending on systole and diastole and they are moving they are generally designed in such a way that they are close to the lymphatic and even under that pulse pressure the lymphatic vessel and it keeps on pushing. So in the nature - whatever is possible in that scenario, the nature has used it to drive the lymph. This is because, there is no designated heart for that purpose ok. Look at this. This is the interstitial fluid pressure and interstitial fluid pressure means pressure of the fluid has come out of the capillary. It has not entered into the lymphatics and we are monitoring the pressure so the pressure may be minus 2 mmHg. You see this fluid has come out of capillaries, we already know that by the time the blood is in the capillary it may be about how much 30 mmHg very good. May be about 8 or 10 when it comes out. As the pressure goes on increasing the lymph flow goes on increasing means what the lymph is coming is the interstitial fluid is coming out from the capillary. If you increase the pressure, the lymph flow goes up means what the lymph flow depends on that ok. And there is a direct correlation, within a certain limit, who can tell me what is the meaning why the author wants to give us in this slide. Can you make a sense? There is edema, there is edema means the lymph has to flow and for some reason if the lymph does not flow, ok. Then this may give rise to what stagnation of a lymph in a particular area of the body and then it might give rise to what you call as the edema is of I mean even for ratio with little more edema is generally considered into 2 types one is called as a pitting type and non-pitting type what did I say pitting type and non-pitting in the pitting type of in the pitting type of edema. If there is a if there is a if your foot is swollen you press there press there and remove your finger the pit is still there ok what do we call it as pitting type there is other type in which you press there you remove your the pit is no more there the tissue comes back ok.

So, the pitting, and not this, is generally the pitting type of edema that you can you can have

in front of you and then you can have and then finally, you have the it pours into what you call as the thoracic duct. And the thoracic duct goes into the vena cava and then it is finally, returned to the heart. I think I will complete this in another 5 minutes. We will complete this interesting topic on lymph. Well, I think you can guess what is the image on the left. There we are talking about histological picture through the intestine. Hello, intestine - the moment I talk of intestine you know that I am talking absorption of food. You know that it is thrown into villi ok. And villi, the purpose of the villi, is to increase the surface area. We have done it very good. So, we look at the histological picture and you can see those villi and, let us take it one villus, one villus singular villus, and we are trying to diagrammatically show what in a single villus, I am sure you can find out there are those red vessels which are carrying oxygenated blood and then it is giving oxygen and the venous ends of the blood the blue ones are taking the de-oxygenated blood away from the villus. But inside that can you see a little creamish tube there. That is the terminal lacteal or terminal lymphatic vessel. It is called a central lacteal. What do you call it as central lacteal and if I were to take a transverse section of a villus it looks something like this. There is a single layer of cells which is epithelial cells which is the inner lining of a villi or inner lining of the intestine you can call and the red and the blue ones are of course the capillaries which are bringing the oxygenated blood, giving away oxygen becoming de-oxygenated and going to the venous etc. and at the center I am drawing your attention to this pinky circle which author is labeling is what central lacteal. What do you call it central lacteal or lacteal or whatever. Now this central lacteal is interesting because, we are talking about the intestine and it is a digested food and the digested food again I will draw I will divide into three categories I will say that there are small molecules like amino acids, small carbohydrates like glucose and other they are all small molecules.

Now listen to this whether it is amino acids or amino acids or glucose or carbohydrate digested carbohydrate molecules I will put all of them together are you okay so far. Whereas these molecules will be taken up by the blood vascular system blood vascular system and they will be carried to the blood. So the molecule of the food that you have absorbed not all not all, but the amino acids and the carbohydrate glucose etc. they will be taken to the liver by what - you call as hepatic portal system. Now what is hepatic portal system - hang on I will talk about it when we talk about the digestive system but the only point that I want to make is that the blood is being taken the all the nutritious material not all not all amino acids and carbohydrates are being taken from the intestine taken where taken here how just remember the name what blood vessel hepatic portal system okay. But the digested fats, listen to this, the digested fats are poured into the lacteals and the digested fats are absorbed and taken okay along with the lymphatic system to the vena cava and then to the heart and then to the general circulation. So whereas the carbohydrates digested carbohydrates and digested proteins in the amino acids are essentially taken from the digestion first to the liver for further processing, the lipids shunted okay they do not go to the liver they go to the general circulation elsewhere also.

So please appreciate this very interesting role of the lacteals with reference to the absorption of fats. okay I am sure this is a node I just put the slide here wherein the lacteals are flowing

from all over and here the of course you know the T cells and the B cells and the immune function will take yeah please. Sir could you go to so that will I will ask sir how is the distinction made? How are the glucose and amino acids segregated from fats and then. Okay I did not want to talk about it but okay the it is all dependent on the size the fat molecules are organized into larger particles which are called as chylomicrons okay. And they are very large ones relative to the size of amino acids are so whereas the smaller ones can enter into the capillary the larger ones like chylomicrons, which are containing different fatty acids and all the digested part of the fats okay. They are organized okay they are not travelling as a single independent fat molecule no they are organized in certain very large globules and those ones which we call as chylomicron. They cannot enter into the capillaries they are big enough so they have no that they enter into the they enter into the lacteals central lacteals and then they are carried it is they differentiated they are differentiated on the basis of the size. Oh the lacteals the endothelial cells of the lactials of far far larger space far larger space - fat molecules so wrong word - I am using the chylomicron okay. They can enter but not the but you got the answer right got this sense okay. And this is the last slide what can what does this slide tells you, are talking of a disease what is that we are talking about why is the disease what is the what is the root cause etiology of the disease there is a there is a nematode okay there is a nematode *Wuchereria bancrofti* type okay. That is the name of the worm okay and that worm, worm tiny there can you see that it is a nematode. It is a nematode. It is the vector for that is a mosquito again so mosquito does - 10 things 10 bad things among one among them is one among these is those worms okay filaria worms okay. And those filaria worms if they get into your body they specifically sit into the lymphatic network okay and then they over a period nothing happens right away but over a period of time as the flow of the lymphatic or lymphatic fluid is obstructed then the tissue responds, by generating what you call as there is a formation of fibrous tissue and as a result of formation of fibrous you have this elephantiasis or of this rather ugly looking disease.