

Human Physiology
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Week - 03
Lecture - 01

Thank you, everyone. Welcome to another new class of human physiology. In the last few classes, we have discussed blood, blood composition, coagulation pathways or the hemostasis pathway, different types of anticoagulants and their mechanisms, and finally, we have also discussed different types of blood-related diseases, blood prototyping, and blood transfusion. Starting this week, this class will begin discussing the lymph and its functions. So, what different content will be covered in this class? We will cover what the lymphatic system is, what the function of the lymphatic system is, lymphatic circulation, lymphoid cells, lymph nodes, and their structure and function. All of these would be covered in this class.

So, what is the lymphatic system? The lymphatic system is a closed system of lymph channels or lymph vessels through which lymph flows. So, lymph is basically a kind of fluid like blood. So, let us consider that lymph is like a fluid, similar to blood, but for this circulation of lymph, there is a lymphatic circulatory system. For example, in our body, blood circulates in a capillary circulation similar to the arteries and veins, and who controls the blood circulation? Our heart.

In the same way as the circulation of lymph, we have another network called the lymphatic circulation. And it is mostly a one-way system that allows lymph to flow from the tissue spaces to the blood. This is mostly like a one-way exchange system where the lymph can flow from the interstitial tissues to the blood. So, what is the organization of the lymphatic system? The lymphatic system arises from the tissue space as a meshwork of delicate vessels, and these vessels are called lymph capillaries. What is this vessel called? These are called lymph capillaries, and they start from the tissue space or the interstitial spaces of the tissue, enlarged like blind-ended terminals called capillary balls.

Okay, lymph capillaries are lined by regular-like endothelial cell lines. The structure of lymph capillaries is slightly different from that of blood capillaries. Even though there are endothelial cell lines, the structure is a little bit different for those capillaries. Lymph capillaries are more porous in nature, and the cells lie overlapping on each other. So, in cases of blood capillaries, the endothelial cells are tighter.

So, if you consider this a blood capillary, the endothelial cells are tighter, but in cases of lymph, these are more porous, okay. Because the lymphatic cells, like immune cells, WBCs, and all the other components, are much bigger in size. So, for the right exchange between the interstitial tissues and the blood, the capillaries need to be more porous in nature compared to blood capillaries, okay. Functions of the lymphatic system. So, what it does is basically drain excess lymphatic fluid.

So, it drains excess interstitial fluid that is present in our tissue. So, lymphatic vessels drain excess interstitial fluids, which return to the blood. This is very important because, as a whole, we have to kind of maintain the water balance in our body. So, if the excess water is removed from the body, we can experience a dehydration-like situation. So, it is important that all the tissue fluids after the function of cellular respiration should be returned to the blood.

So, that overall our blood and body maintain a good water balance. Okay, it transports dietary lipids, which is also a very important application; lymphatic vessels transport lipids and lipid-soluble vitamins like A, D, E, K, etc. Which is generally absorbed by our gastrointestinal tract. And the most important function of the third one is that lymphatic circulation carries immune responses or immune functions of our body. This lymph can carry, like WBCs, other cells like T cells, and they generate highly specific responses related to any microbe or abnormal cells like tumor cells.

So, the immune cell function of the lymph is very important and is crucial for our body. So you can see that this lymphatic circulation overall is drawn here. It is connected to the pulmonary network and the blood circulation. So this part is the artery, and the blood and arteries and veins are connected with each other, creating a blood capillary network through which blood circulation occurs. And you can see side by side to this blood circulation, we have these lymphatic capillaries with the lymph nodes present, which are creating the lymphatic circulation system, and using these lymphatic capillaries and the blood capillaries, there is a continuous exchange of fluid from interstitial fluid to the blood.

So, basically, the fluid that will go from the interstitial space to the lymphatic capillary will eventually exchange from this interstitial capillary to the blood capillary, and any excess fluid will basically drain out into the blood. So, what is lymph? Lymph is formed from the interstitial fluid due to the permeability of the lymphatic capillaries. So, when blood passes by the blood capillaries in the tissue, nine-tenths of almost like eight or ninth part of the whole fluid passes into the venous end of the capillary from the arterial end, but the remaining one-tenth of that fluid gets retained in the lymph capillary. So, mostly nine-tenths of the fluid passes from the arterial to the venous end, but one-tenth of that fluid gets retained and passes through the lymph capillary, which has more permeability than the blood capillary. And when lymph passes through the lymph capillaries, its composition is more or less similar to that of interstitial fluid, including the protein content.

Proteins present in the interstitial fluid eventually cannot enter the blood capillary because of their larger size. So, any protein that is carried by the lymphatic fluids or lymph will not be able to enter the blood; only the water content or the electrolytes will be able to go into the blood; the rest of the protein will be retained. So, these proteins eventually enter the lymphatic vessels. If you go to the last slide again, you will remember that there are lymph nodes or lymph vessels present. So, any excess protein that is unable to return to the blood circulation will enter the lymphatic vessels, which are permeable to larger particles.

So, basically, these lymphatic vessels will capture those proteins, and sometimes they may degrade those proteins back, or they can retain them for other functions. So, what is the composition of lymph? You can say lymph is basically a clear and colorless type of fluid that is formed with almost 96 percent water and only about 4 percent solids, and sometimes blood cells, including immune cells, are also present in the lymph. The rate of lymph flow is about 120 ml of lymph that flows per hour in our body. Through this, about 120 ml of lymph flows within an hour, out of which 100 ml per hour flows through the thoracic duct and 20 ml per hour flows from our right lymphatic duct. So, there are two different lymphatic ducts out of the 120 ml; 100 ml mostly goes to the thoracic duct, and only 20 ml per hour flows through the right lymphatic duct.

And then what are the different factors that can release or increase the lymphatic flow or the flow of lymph? Interstitial fluid pressure, blood capillary pressure, surface area of the lymph capillary in cases of dilation, permeability, high permeability of the lymph capillary, or functional activities of the tissues can increase the flow of lymph in our body. What are the different functions of lymph? The important functions of lymph are to return protein from the tissue space into the blood and also to return or redistribute water. So, it is very important that there is return and redistribution of water. Back to the blood; it is so important, right? Bacterial toxins, if anything is present, are met by immune cells in the lymph that will destroy them. So, any type of bacterial toxin, foreign bodies, or abnormal cells can be removed from the tissues via the lymph.

Lymph flow is also responsible for maintaining the structural and functional integrity of the tissue. Obstruction of lymph flow affects various tissues, and lymphedema or enlargement of the organ can occur. Lymph flow also serves as an important route for intestinal fat absorption. So, intestinal fat absorption can occur through the lymph flow. This is why lymph appears a little bit milky in nature after a fatty meal.

It also has a very important role in terms of serving immunity by transporting lymphocytes. So, a lymphocyte is an immune cell in our body. It also has a lot of macrophage cells that will basically phagocytize different types of abnormal microbes. By engulfing those microbes or abnormal cells like tumor cells, macrophage cells and lymphocyte cells can destroy any type of foreign particles that are harmful to our body. So the most important role of the lymph is maintaining our immunity.

Okay, so what are the different types of lymphoid cells as you can see, like mostly lymphoid cells have what lymphocytes, right? This is a part of like WBC cells in lymphocytes. You can see there are two types of cells, mostly T cells and B cells, right? So lymphocytes have two different categories. What are the functions of T cells and B cells? T cells manage immune responses; they destroy foreign cells. For B cells, it produces antibodies in cases where a foreign particle is presented as an antigen. In detail, we will discuss in our next or the following class the immune function of the blood and lymph.

There we will thoroughly discuss how lymphatic cells, lymphocytes, T cells, and B cells actually perform. But try to remember that these are different lymphoid cells, mostly the T lymphocyte, B cell, and then we have macrophages, dendritic cells, and natural killer cells. Macrophages directly engulf all these bacteria and viruses, and they can phagocytize. By having this destruction through the engulfing process and enzymatic degradation, macrophages can kill all those foreign particles. Dendritic cells act like antigen-presenting cells.

So, dendritic cells act as antigen-presenting cells. So, whenever there is an antigen that comes into contact with our body, this dendritic cell, or the APC, which is the antigen-presenting cell, presents the antigen to our immune cells, mostly the B cells, and what happens is that B cells start producing or secreting the antibody, which eventually destroys those antigens. And finally, the natural killer cells, or NK cells, are also responsible for destroying various types of foreign particles and toxins. Then what are the different lymphoid organs present in our body? So, lymph nodes, tonsils, thymus gland, spleen, and bone marrow. These are all the important lymphoid organs that are present in the body.

Lymph nodes have a smaller, granular, glandular structure that is located in the lymph vessels. Lymph nodes are also called lymph glands or lymphatic nodes. Then cervical lymph nodes

drain and cleanse lymph from the head and neck areas. So, mostly like three different lymph nodes you can see. One is a cervical lymph node, one is an axillary lymph node, and then there is an inguinal lymph node.

Cervical lymph nodes mostly come from the head and neck area; they clear out the lymph, then from the upper extremities of the body, like the shoulder and breast area, the axillary lymph nodes cleanse all the fluid, and from the lower extremities or the external genital area, the inguinal lymph nodes mostly participate. Then this is the structure of a lymph node. As you can see, this is also like a P-shaped structure, right? It almost looks like this kidney type; kidneys also have this type of P-shaped structure. The size of it is around 2.

5 centimeters in length. This gets divided into several compartments, right? So you can see different compartments are present. B lymphocytes can develop from the overall lymph node, and they can release antibodies, while T lymphocytes are generated, which generally circulate. T lymphocytes perform a surveillance type of activity. If there is formation of any abnormal cells, like cancer cells, T cells participate in the immune activity of our body, destroying those abnormal cells. So, this is mostly the structure of a lymph node.

You can see we are not going into too much detail, but mostly the cortex and medulla parts are present, which are connected directly with the blood capillaries, as well as the arteries and vessels. So, from the efferent part of these lymphatic vessels, the efferent part of the lymphatic vessels. So, lymph will go from one side, and eventually, the interstitial fluid will be exchanged and will pass into the blood. The functions of lymph nodes include filtering lymph as it passes through; water and electrolytes are removed, while proteins and lipids are retained in the lymph. If the lymph carries any type of bacteria, toxic substances, or abnormal cells, they are destroyed by macrophages or other immune cells, mostly macrophages.

So, they can phagocytize the abnormal cells or bacteria and immediately destroy them. So, this is basically a kind of defense barrier for our body. So, you can kind of consider that these are the posts right outside a castle where, if our enemies are attempting to cross, we are putting surveillance activities in place to attack them and destroy our enemies. So, next is the tonsil. Right, the tonsil is present in the palatine tonsils, which are located near our oral cavities; the pharyngeal tonsils are at the opening of the nasal cavity in the upper pharynx, and then the lingual tonsils are present at the back of the tongue.

So, as we see our tonsils in the back of the tongue, those are lingual tonsils, and tonsils are very important because if we have any food that comes into contact with the first line of defense, which is the tonsil. What are the functions of the tonsils? Tonsils are the lymphoid organs that act as a first line of defense. So, as I said, through our breathing or eating, if we are consuming any food that is carrying any toxic substances or bacteria, it is immediately in contact with the first line of defense, which is the tonsils and macrophage cells, and our immune cells present in the tonsils will eventually try to eliminate those infections, bacteria, or any other foreign bodies. So, tonsils are connected to the lymphatic network, allowing the immune cells and filtered debris to travel to nearby lymph nodes for further immune processing. They also help in draining excess fluid and all the other applications that we have already discussed, such as retaining water, retaining proteins, and immune reactions.

So, everything same way tonsils also perform. The thymus gland is another very important lymphoid organ; it is a primary lymphoid organ and is responsible for the development and maturation, mainly the maturation, of T lymphocytes or T cells, which are essential for our

adaptive immune system. It plays a crucial role in maintaining our immune functions, especially in early life. So, the maturation of T cells is a very important function of the thymus, which is located near our upper chest, just behind the sternum, in front of our heart, and is largest and most active during childhood; it gradually shrinks or decreases in size after puberty. Mostly before adulthood, thymus activity is highly potent.

Functions of the thymus gland include its essential role in T cell maturation and immune tolerance. It does not filter the lymph, but it produces and trains T lymphocytes. It is highly active during childhood, as we mentioned, right? So, unlike the lymph nodes, the thymus does not filter the lymph; okay, but it produces the lymphocytes. So, this is very important to note that unlike other lymph nodes, the thymus does not filter the lymph. And then T cells, the mature T cells from the thymus, enter the bloodstream and migrate to any other secondary lymphoid organ.

The spleen is the largest lymphoid organ in our body. It has a very important role, such as filtering the blood, recycling the RBCs, and supporting our immune system. Okay, so we have, like, uh, this is actually the largest lymphoid organ, and it is located in the upper left abdomen, just behind the stomach. It is composed of two different main tissues; one is white pulp, or lymphoid tissue. It is involved in the immune response, and then there is another type of tissue, which is the red pulp.

What does it do? It basically filters the blood, removes or destroys the old RBCs, and restores the platelets. So, mostly the lymphoid function is performed by the white pulp. Because the white pulp is mostly involved in the immune response, the red pulp has the function of filtering the blood and removing the old, turned-out RBCs. So what are the different functions of the spleen? As we discussed, the spleen filters blood and removes old RBCs. It supports immune function by activating B and T lymphocytes; the white pulp participates in immune function.

It restores or stores the platelets and immune cells for rapid response. It is not directly, of course, connected to the lymphatic vessels, but it works with lymphoid cells. So, it performs blood filtration along with immune surveillance in our body, and it also has a role in lymphocyte production and activation. So, these are the different functions of the spleen. Then finally, one of the very important and common limb-related diseases is lymphoma, or cancer of the limb.

Cancer of the lymphatic system involves immune cells, which cause the swelling of the lymph organs or lymph nodes in various areas, mostly in the neck, armpit, or groin. This can cause symptoms such as fever and weight loss, and if the tumor cells metastasize, you may experience the tumor spreading to other organs, which is a very aggressive form of cancer that can lead to rapid death. The survival rate is also very poor unless it is detected very early. And there are two types of lymphoma mostly. One is Hodgkin lymphoma, and another is non-Hodgkin lymphoma.

So, you can see that in addition to the presence or lack of Reed-Sternberg cells, other differentiations between non-Hodgkin lymphomas are included. So, what happens is that Reed-Sternberg cells are distinctive giant cells that are found after the biopsy. So, in cases of this lymphoma, if the doctor collects some tissue during the biopsy and if they analyze the cells using histology or any other molecular technique, they can observe a certain large size of cells that are distinctive, called Reed-Sternberg cells, which are only present in cases of Hodgkin lymphoma. These are derived from B lymphocyte cells, so if the Reed-Sternberg stained cells,

which you can see here, are present, then this particular form of lymphoma is called Hodgkin lymphoma. And if these Reed-Sternberg big cells are not present, then they are termed non-Hodgkin lymphoma.

Non-Hodgkin lymphoma is incidentally the more common form of lymphoma than Hodgkin lymphoma. Both types of cancers are rare, but with growing factors such as environmental pollution, other lifestyle-related complications, and a lot of adulteration in food and genetic mutations, we are experiencing a high rate of lymphoma conditions. And it is also very important to know that non-Hodgkin lymphoma may arise in lymph nodes anywhere in the body, so it can occur in any part of your body, while Hodgkin lymphoma mostly develops in the upper part of the body. Hodgkin lymphoma also tends to progress in a more predictable way, making it a little bit less risky. Okay, so apart from lymphoma, another type of disease that can occur due to the blockage of lymphatic flow is swelling.

If lymph flow is obstructed due to various issues, swelling of the glands can happen in the legs and hands, leading to conditions like elephantiasis and lymphedema. This type of enlarged lymph organ can cause this type of abnormality; these are rare, but this can happen. Okay, so hopefully you enjoyed the class about the lymphatic system. Now let's think about it: how does the lymph circulate in the body, and what role do lymph nodes play in the lymphatic system? What is edema? And what are lymphocytes, and what is their role? So, you can work on these few questions. I hope you came to know a lot about lymph and the lymphatic system.

And you can refer to different types of class notebooks like these textbooks. And thank you again for attending another one of these classes in human physiology. Let's meet with all of you in the next class. If you have any questions, we will do a live session.

You can also send the questions to the email. Thank you again for attending today's class. Thank you.