

Lymphatic System Anatomy and Function

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The lymphatic system performs three important tasks in the mammalian body.

1. It is closely tied to the cardiovascular system and helps maintain the fluid balance between the blood vessels and the tissues.
2. The lymphatic system plays a large role in immunity.
3. This important system also absorbs digested fats from the small intestine.

The components of the lymphatic system are divided into two groups – the primary organs and the secondary organs.

1. Primary Organs: The thymus gland and the bone marrow are primary organs. They regulate the production and differentiation of lymphocytes – the cells that make up the immune system.
2. Secondary Organs: The secondary organs include the lymphatic vessels, lymph nodes, aggregated lymphoid tissue, and spleen. These secondary organs are involved, to some extent, in all three lymphatic functions.

Primary organs

Thymus

The mammalian thymus has two lobes and is situated slightly above the heart and ventral to (below) the trachea. It is relatively large at birth, but after sexual maturity, it begins to degenerate and is quite small in older animals.

The main function of the thymus is to "educate" certain white blood cells of the immune system called 'T-lymphocytes,' or 'T-cells.' T-cells identify foreign cells in the body, such as invading bacteria, and mark them for destruction by other immune cells. The T-cells mature in the thymus gland and are "taught" to distinguish between self and non-self cells. If they develop correctly, they are able to recognize the difference between those cells that are supposed to be in the body and those that are foreign. Those T-cells that fail to recognize this difference are destroyed by the thymus so they cannot harm the body. After maturing in the thymus, the T-cells move to the secondary organs, where most of them will remain.

Bone marrow

Bone marrow is the soft material in the cavities of bones. It is a network of connective tissue fibers, fat cells, blood vessels, and blood-producing cells. Bone marrow produces both red and white blood cells, including the lymphocytes. Both T-lymphocytes and B-lymphocytes are produced in the bone marrow. The young T-cells move to the thymus for final development, but the B-cells remain in the bone marrow during maturation. Once the B-cells are fully developed in the bone marrow, they are also released into circulation and most of them take up residence in the secondary lymphatic organs.

The B-cells are white blood cells that are sensitive to antigens and produce antibodies against them. Antigens are any chemicals that produce an immune response in the body, such as toxins, foreign proteins, particulate matter, or bacterial cells. When an antigen is present, the B-cell becomes active and begins to produce antibodies against that antigen. Antibodies are special proteins that bind (attach) to antigens and mark them for destruction. Antibodies are antigen specific, and the immune system is able to remember each antigen it fights. Once a B-cell makes antibodies against a certain antigen, e.g., a bacteria, it keeps a memory of that antigen. If the antigen appears again, the B-cell can produce a large number of antibodies very rapidly. In this way, a second infection with that bacteria is often prevented.

Secondary organs

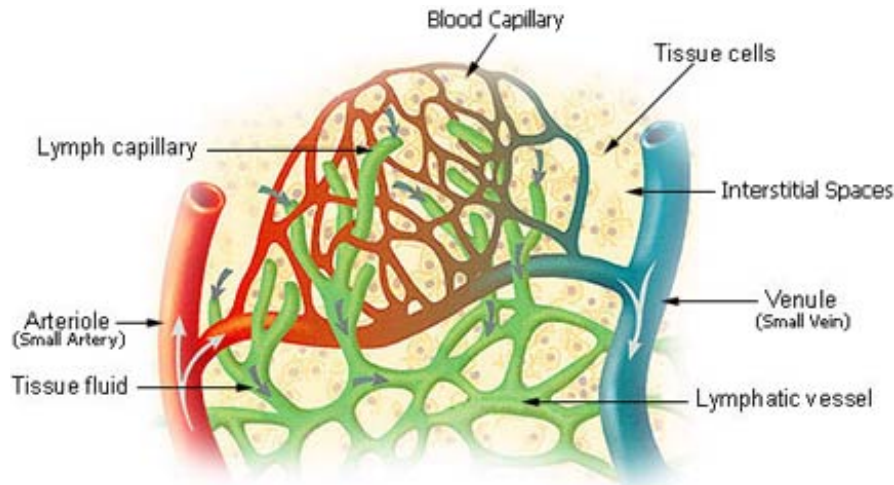
As mentioned, the secondary organs include the lymphatic vessels, lymph nodes, aggregated lymphoid tissue, and spleen. While the primary organs are only involved in the immune function of the lymphatic system, the secondary organs are collectively involved in all three functions:

1. Immunity
2. Fat absorption
3. Fluid regulation

Lymphatic vessels

The lymphatic vessels link together all of the secondary organs and also connect to the cardiovascular system. They provide a route for the one-way flow of lymph from the tissues of the body to the heart. Lymph is the clear, yellowish fluid that is collected from the interstitial spaces (the spaces between the cells of a tissue) into lymphatic capillaries.

Lymphatic capillaries are interwoven with the blood capillaries. Fluid and proteins are forced out of the arterial end of the blood capillary and into the interstitial space. About 90% of the fluid is reabsorbed in the venous end of the blood capillary, but none of the proteins are able to reenter the blood vessels because they cannot fit through the tight junctions of the cells. The lymph capillaries have extremely loose cell junctions, however, and they are able to absorb the remaining 10% of the fluid along with the plasma proteins. Once inside of the lymph vessels, the fluid is then termed "lymph."

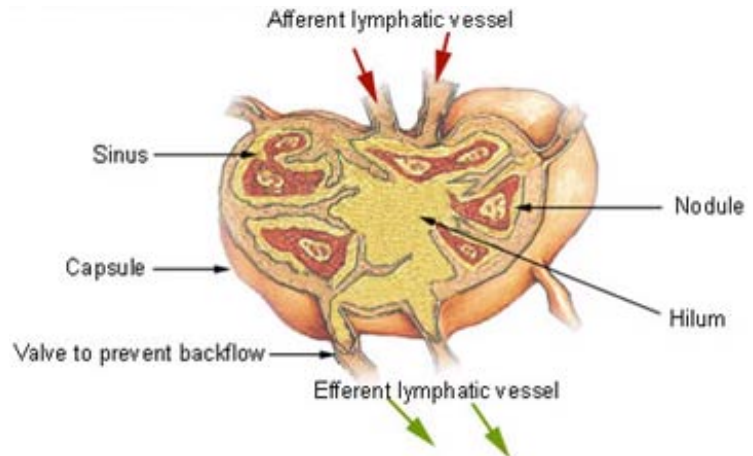


The lymphatic vessels are structured similar to veins, with thin walls and valves to prevent backflow. They are not muscular vessels, and external forces such as limb movement regulate the flow of lymph. Once in the capillaries, the lymph moves into progressively larger vessels, passes through the lymph nodes and/or spleen, reaches the large ducts, and enters the blood circulation near the junctions of the jugular and subclavian veins in the upper chest. Thus, the fluid and proteins are eventually returned to the blood, which helps maintain the proper balance of fluid between the blood vessels and the tissues. All of the lymph from the lower body, left arm, and left thorax are drained through the thoracic duct into the junction of the left jugular and subclavian veins. The fluids from the neck, right arm, and right thorax empty into the right lymphatic duct which joins the venous system at the junction of the right jugular and subclavian veins.

Near the small intestine, where fats are digested and absorbed, the lymphatic vessels have a special function and, therefore, a special name. They are involved in the absorption of digested fat from the small intestine, and are called "lacteals." After a meal the fluid within the lacteals generally has a fat content of 1-2%, and it appears cloudy. This cloudy lymph in the lacteals is called "chyle."

Lymph nodes

Lymph nodes are round or bean-shaped structures that are widely distributed throughout the body. Imbedded in connective tissue or fat, they are concentrated in the cervical, axillary, and inguinal regions – the neck, armpits, and groin, respectively. They are typically less than ½ inch in length, depending on the size of the animal. The lymph nodes filter the lymph before returning it to the veins. They are arranged so that all lymph has to pass through at least one node before returning to the veins.



Lymph nodes are enclosed by a capsule of connective tissue and comprised of several compartments called "lymph nodules." The nodules are masses of T-cells, B-cells, and macrophages. Macrophages are specialized cells that ingest and destroy foreign material. The nodules are separated by spaces called "lymph sinuses." The vessels that deliver unfiltered lymph are called "afferent vessels," and there are several per node. The lymph is then filtered for antigens and particulate matter, and an immune response is generated, if necessary. The filtered lymph leaves the node through one or two efferent vessels near an indentation called the "hilum." Blood vessels also enter and exit the node at the hilum.

Aggregated lymphoid tissue

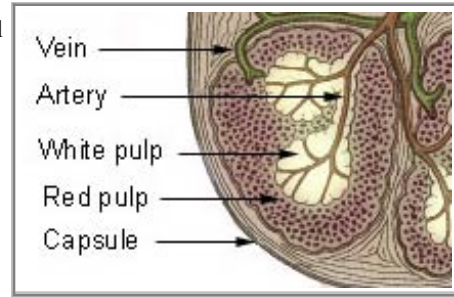
Aggregated (clumped) lymphoid tissues are collections of lymphoid tissue that are not encapsulated (in a capsule). They have varying degrees of size and organization. The most highly organized and widely known examples are tonsils and Peyer's patches. The tonsils are found at the back of the oral cavity. Peyer's patches are found in the lining of the small intestine. Tonsils and Peyer's patches have specialized epithelial cells that are capable of transporting antigens, and though they do not filter lymph, they are generally surrounded by capillaries. The main purpose of the aggregated lymphoid tissue is defense from invasion at the mucosal surfaces. These are sites where large numbers of bacteria and other microorganisms are present and can easily enter the body. These specialized lymphatic cells help to prevent infections from developing at these sites.

Spleen

The spleen is a spongy organ located in the upper left portion of the abdominal cavity along the outside curve of the stomach. It is composed of two types of tissue - the red pulp and the white pulp.

1. The red pulp is mostly used to store blood and break down old red blood cells.
2. The white pulp has the lymphatic function of filtering the blood for antigens.

The spleen traps antigens and is another site for initiation of the immune response. In a sense, it is like a large lymph node. A swollen spleen can be a sign of serious infection and is easily palpated.



Conclusion

Though the lymphatic system is often overlooked, it is an important part of the mammalian body. By absorbing fats and trapping antigens, it helps to keep the animal healthy and disease-free. Also, the role of maintaining proper fluid balances is essential. Truly, a healthy lymphatic system is necessary to the survival of the animal.

Interesting Facts

- Domestic birds do not have lymph nodes. Instead, there are nodules of lymphoid tissue in the bone marrow.
- If an infection is present in the body, the lymph nodes nearest the site of infection may become swollen or painful. This is caused by an accumulation of cells and fluids involved in the immune response.
- In 24 hours, approximately 50% of the lymphocytes in the blood pass through the spleen.
- In a human, the lymphatic system returns 2.83 liters (3 quarts) of lymph to the heart every 24 hours. That is about a ½ a cup per hour!