DOWNLOAD PDF CAPILLARY FUNCTION AND THE LYMPHATIC SYSTEM

Chapter 1 : Lymphatic system: Definition, anatomy, function, and diseases

Correspondingly, 8 L of interstitial fluid drain into the lymphatic system and eventually return to the circulation by this route. Of the 8 L of fluid entering the lymph capillaries, about half is reabsorbed during passage through the lymph nodes and the other half will re-enter the circulation at the subclavian veins (see p.).

January 17, 3 Comments The lymphatic system returns fluids that have leaked from the blood vascular system back to the blood. Without it, our cardiovascular and immune systems would begin to shut down. The lymphatic system contains three parts, a network of lymphatic vessels, a fluid inside of the vessels called lymph, and lymph nodes that cleanse the lymph while it passes through. Lymphatic System While blood circulates through the body, wastes, gases, and nutrients are exchanged between the blood and interstitial fluid. Different pressures hydrostatic and colloid osmotic pressure operating at capillary beds at the very tip of where arteries and veins meet cause most of the fluid to be reabsorbed at the vein end. The fluid that remains behind in the tissue spaces between the capillary beds as much as 3 liters a day becomes part of the interstitial fluid. This leaked fluid, along with plasma proteins that have escaped from the bloodstream, must be returned, to make sure the cardiovascular system continues to operate properly. The problem of circulatory dynamics is resolved by lymphatic vessels, also known as lymphatics. Lymphatic vessels are drainage vessels that collect the excess interstitial fluid and return it to the bloodstream. Once interstitial fluid enters the lymphatic vessels, it is called lymph. Lymphatic vessels form a one-way system in which lymph only flows toward the heart. Distibution and special features of lymphatic capillaries. Lymphatic Capillaries Lymph transport begins at the very tip of microscopic lymphatic capillaries. These capillaries weave through tissue cells and blood capillaries in loose connective tissues of the body. Lymphatic capillaries are widespread, but they are absent from bones, teeth, bone marrow, and the central nervous system where excess tissue fluid drains into cerebrospinal fluid. Although they are similar to blood capillaries, lymphatic capillaries are so permeable that scientists used to think they were open at one end like a straw. Now, scientists have discovered that they owe their unique permeability to two specific structural modifications. The endothelial cells that form the walls of lymphatic capillaries are not tightly joined. Instead, the cells edges overlap each other loosely, forming easy opening flaplike minivalves. Collagen filaments anchor the endothelial cells to surrounding structures so that any increase in interstitial fluid volume opens the minivalves, rather than causing the lymphatic capillaries to collapse. So, what we have is a system which is very similar to a bunch of one-way swinging doors. When fluid pressure in the interstitial space is greater than the pressure in the lymphatic capillaries, the minivalve flaps open, allowing fluid to enter the lymphatic capillary. However, when the pressure is greater inside the lymphatic capillary, it forces the endothelial minivalve flaps shut, preventing lymph from leaking back out as the pressure moves it through the vessel. In addition, when tissues become inflamed, lymphatic capillaries develop openings that permit the uptake of even larger particles such as cell debris, pathogens, and cancer cells. The pathogens can then use the lymphatics to travel throughout the body. A special set of lymphatic capillaries called lacteals transports absorbed fat from the small intestine to the blood stream. Lacteals are so-called because of the milky white lymph that drains through them. This fatty lymph, called chyle drains from the fingerlike villi of the intestinal mucosa. Larger Lymphatic Vessels From the lymphatic capillaries lymph flows through larger and thicker-walled channels â€” first, collecting vessels, then trunks, and finally the largest vessels, the ducts. The collecting lymphatic vessels have the same three tunics as veins, but the collecting vessels have thinner walls and more internal valves. Generally lymphatic vessels in the skin travel along with superficial veins, while the deep lymphatic vessels travel with deep arteries. The largest collecting vessels unite to form lymphatic trunks, which drain fairly large areas of the body. Lymph is eventually delivered to one of the two large ducts in the thoracic region. The right lymphatic duct drains lymph from the right upper limb and the right side of the head and thorax. The thoracic duct which is much larger receives lymph from the rest of the body. It arises as enlarged sac called the cisterna chyli, that collects lymph from the two large lumbar trunks that drain the lower limbs and from the intestinal trunk that drains the digestive organs. As the thoracic duct runs superiorly, it receives lymphatic drainage from the left side of the thorax, left upper limb, and the left side of the head. Each terminal duct empties its lymph into the venous circulation at the junction of the internal jugular vein and subclavian vein in its own side of the body. Like the larger blood vessels, the larger lymphatics receive their nutrient blood supply from a branching vasa vasorum. When lymphatic vessels are severely inflamed, the related vessels of the vasa vasorum become congested with blood. As a result, the pathway of the associated superficial lymphatics becomes visible through the skin as red lines that are tender to the touch. This unpleasant condition is called lymphangitis. Lymph Transport Major lymphatic ducts and trunks in relation to veins anterior view of the thoracic and abdomnial wall. The lymphatic system lacks a pump. Under normal conditions, lymphatic vessels are low-pressure conduits and the same mechanism that promotes venous return in blood vessels acts here as well the milking action of skeletal muscles, pressure changes in the thorax during breathing, and valves to prevent backflow. Lymphatic vessels are usually bundled together in connective tissue sheaths, along with blood vessels, and pulsations in nearby arteries also promote lymph flow. In addition to these mechanisms, smooth muscles in the walls of lymphatic vessels contract rhythmically, helping to pump the lymph along. Even with aid from the above, lymph transport is still slow and sporadic. Movement of adjacent tissues is very important in propelling lymph through the lymphatic vessels. When physical activity and movement increase, lymph flows more rapidly. Anything that prevents the normal return of lymph to the blood tumors, etc. However, usually the vessels in the area begin to grow and drainage is reestablished. To summarize, lymphatic vessels: Return excess tissue fluid to the bloodstream Return leaked proteins to the blood Carry absorbed fat from the intestine to the blood through lacteals Related Posts.

Chapter 2 : What are the four main functions of the lymphatic system? | Socratic

Like a system of storm drains channeling rainwater from a city's streets, your lymphatic capillaries pick up the fluid that leaks into your tissues and help return it to your circulatory system.

News The lymphatic system is part of the immune system. It also maintains fluid balance and plays a role in absorbing fats and fat-soluble nutrients. The lymphatic or lymph system involves an extensive network of vessels that passes through almost all our tissues to allow for the movement of a fluid called lymph. Lymph circulates through the body in a similar way to blood. There are about lymph nodes in the body. These nodes swell in response to infection, due to a build-up of lymph fluid, bacteria, or other organisms and immune system cells. A person with a throat infection, for example, may feel that their "glands" are swollen. Swollen glands can be felt especially under the jaw, in the armpits, or in the groin area. These are, in fact, not glands but lymph nodes. They should see a doctor if swelling does not go away, if nodes are hard or rubbery and difficult to move, if there is a fever , unexplained weight-loss, or difficulty breathing or swallowing. Fast facts about the lymphatic system The lymphatic system plays a key role in the immune system, fluid balance, and absorption of fats and fat-soluble nutrients. As lymph vessels drain fluid from body tissues, this enables foreign material to be delivered to the lymph nodes for assessment by immune system cells. The lymph nodes swell in response to infection, due to a build-up of lymph fluid, bacteria, or other organisms and immune system cells. Lymph nodes can also become infected, in a condition known as lymphadenitis. If lymph nodes remain swollen, if they are hard and rubbery, and if there are other symptoms, you should see a doctor. Definition Lymph nodes, or "glands" may swell as the body responds to a threat. The lymphatic system has three main functions: It maintains the balance of fluid between the blood and tissues, known as fluid homeostasis. It facilitates absorption of fats and fat-soluble nutrients in the digestive system. The system has special small vessels called lacteals. These enable it to absorb fats and fat-soluble nutrients from the gut. They work with the blood capillaries in the folded surface membrane of the small intestine. The blood capillaries absorb other nutrients directly into the bloodstream. Anatomy The lymphatic system consists of lymph vessels, ducts, nodes, and other tissues. Around 2 liters of fluid leak from the cardiovascular system into body tissues every day. The lymphatic system is a network of vessels that collect these fluids, or lymph. Lymph is a clear fluid that is derived from blood plasma. They work in a similar way to the blood vessels. The lymph vessels work with the veins to return fluid from the tissues. Unlike blood, the lymphatic fluid is not pumped but squeezed through the vessels when we use our muscles. The properties of the lymph vessel walls and the valves help control the movement of lymph. However, like veins, lymphatic vessels have valves inside them to stop fluid from flowing back in the wrong direction. Lymph is drained progressively towards larger vessels until it reaches the two main channels, the lymphatic ducts in our trunk. From there, the filtered lymph fluid returns to the blood in the veins. The vessels branch through junctions called lymph nodes. These are often referred to as glands, but they are not true glands as they do not form part of the endocrine system. In the lymph nodes, immune cells assess for foreign material, such as bacteria, viruses, or fungus. Lymph nodes are not the only lymphatic tissues in the body. The tonsils, spleen, and thymus gland are also lymphatic tissues. What do the tonsils do? In the back of the mouth, there are tonsils. These produce lymphocytes, a type of white blood cell, and antibodies. They have a strategic position, hanging down from a ring forming the junction between the mouth and pharynx. This enables them to protect against inhaled and swallowed foreign bodies. The tonsils are the tissues affected by tonsillitis. What is the spleen? The spleen is not connected to the lymphatic system in the same way as lymph nodes, but it is lymphoid tissue. This means it plays a role in the production of white blood cells that form part of the immune system. Its other major role is to filter the blood to remove microbes and old and damaged red blood cells and platelets. The thymus gland The thymus gland is a lymphatic organ and an endocrine gland that is found just behind the sternum. It secretes hormones and is crucial in the production, maturation, and differentiation of immune T cells. It is active in developing the immune system from before birth and through childhood. The bone marrow Bone marrow is not lymphatic tissue, but it can be considered part of the lymphatic system because it is here that the B cell lymphocytes of the immune system mature. Liver of a fetus During gestation, the liver of a fetus is regarded as part of the lymphatic system as it plays a role in lymphocyte development. Below is a 3-D model of the lymphatic system, which is fully interactive. Explore the model using your mouse pad or touchscreen to understand more about the lymphatic system. Function The lymph system has three main functions. Fluid balance The lymphatic system helps maintain fluid balance. It returns excess fluid and proteins from the tissues that cannot be returned through the blood vessels. The fluid is found in tissue spaces and cavities, in the tiny spaces surrounding cells, known as the interstitial spaces. These are reached by the smallest blood and lymph capillaries. Around 90 percent of the plasma that reaches tissues from the arterial blood capillaries is returned by the venous capillaries and back along veins. The remaining 10 percent is drained back by the lymphatics. Each day, around liters is returned. This fluid includes proteins that are too large to be transported via the blood vessels. Loss of the lymphatic system would be fatal within a day. Without the lymphatic system draining excess fluid, our tissues would swell, blood volume would be lost and pressure would increase. Absorption Most of the fats absorbed from the gastrointestinal tract are taken up in a part of the gut membrane in the small intestine that is specially adapted by the lymphatic system. The lymphatic system has tiny lacteals in this part of the intestine that form part of the villi. These finger-like protruding structures are produced by the tiny folds in the absorptive surface of the gut. Lacteals absorb fats and fat-soluble vitamins to form a milky white fluid called chyle. This fluid contains lymph and emulsified fats, or free fatty acids. It delivers nutrients indirectly when it reaches the venous blood circulation. Blood capillaries take up other nutrients directly. The immune system The lymphatic system produces white blood cells, or lymphocytes that are crucial in fending off infections. The third function is to defend the body against unwanted organisms. Without it, we would die very soon from an infection. Our bodies are constantly exposed to potentially hazardous micro-organisms, such as infections. In this case, the lymphatic system enables our immune system to respond appropriately. If the immune system is not able to fight off these micro-organisms, or pathogens, they can be harmful and even fatal. A number of different immune cells and special molecules work together to fight off the unwanted pathogens. How does the lymphatic system fight infection? The lymphatic system produces white blood cells, known as lymphocytes. There are two types of lymphocyte, T cells and B cells. They both travel through the lymphatic system. As they reach the lymph nodes, they are filtered and become activated by contact with viruses, bacteria, foreign particles, and so on in the lymph fluid. From this stage, the pathogens, or invaders, are known as antigens. As the lymphocytes become activated, they form antibodies and start to defend the body. They can also produce antibodies from memory if they have already encountered the specific pathogen in the past. Collections of lymph nodes are concentrated in the neck, armpits, and groin. We become aware of these on one or both sides of the neck when we develop so-called "swollen glands" in response to an illness. It is in the lymph nodes that the lymphocytes first encounter the pathogens, communicate with each other, and set off their defensive response. Activated lymphocytes then pass further up the lymphatic system so that they can reach the bloodstream. Now, they are equipped to spread the immune response throughout the body, through the blood circulation. The lymphatic system and the action of lymphocytes, of which the body has trillions, form part of what immunologists call the "adaptive immune response. Diseases The lymphatic system can stop working properly if nodes, ducts, vessels, or lymph tissues become blocked, infected, inflamed, or cancerous. Lymphoma Cancer that starts in the lymphatic system is known as lymphoma. It is the most serious lymphatic disease. Hodgkin lymphoma affects a specific type of white blood cell known as Reed-Sternberg cells.

Chapter 3 : CAPILLARY FUNCTION AND THE LYMPHATIC SYSTEM | Clinical Gate

The lymphatic system is a network of tissues and organs that help rid the body of toxins, waste and other unwanted materials. The primary function of the lymphatic system is to transport lymph, a.

The fluid and proteins within the tissues begin their journey back to the bloodstream by passing into tiny lymphatic capillaries that infuse almost every tissue of the body. Only a few regions, including the epidermis of the skin , the mucous membranes , the bone marrow , and the central nervous system , are free of lymphatic capillaries, whereas regions such as the lungs , gut , genitourinary system , and dermis of the skin are densely packed with these vessels. Once within the lymphatic system, the extracellular fluid, which is now called lymph , drains into larger vessels called the lymphatics. These vessels converge to form one of two large vessels called lymphatic trunks, which are connected to veins at the base of the neck. One of these trunks, the right lymphatic duct, drains the upper right portion of the body, returning lymph to the bloodstream via the right subclavian vein. The other trunk, the thoracic duct , drains the rest of the body into the left subclavian vein. Lymph is transported along the system of vessels by muscle contractions, and valves prevent lymph from flowing backward. The lymphatic vessels are punctuated at intervals by small masses of lymph tissue, called lymph nodes , that remove foreign materials such as infectious microorganisms from the lymph filtering through them. Role in immunity In addition to serving as a drainage network, the lymphatic system helps protect the body against infection by producing white blood cells called lymphocytes , which help rid the body of disease-causing microorganisms. The organs and tissues of the lymphatic system are the major sites of production, differentiation, and proliferation of two types of lymphocytesâ€”the T lymphocytes and B lymphocytes, also called T cells and B cells. Although lymphocytes are distributed throughout the body, it is within the lymphatic system that they are most likely to encounter foreign microorganisms. Created and produced by QA International. Primary lymphoid organs include the thymus , bone marrow , fetal liver , and, in birds, a structure called the bursa of Fabricius. In humans the thymus and bone marrow are the key players in immune function. All lymphocytes derive from stem cells in the bone marrow. Stem cells destined to become B lymphocytes remain in the bone marrow as they mature, while prospective T cells migrate to the thymus to undergo further growth. Mature B and T lymphocytes exit the primary lymphoid organs and are transported via the bloodstream to the secondary lymphoid organs, where they become activated by contact with foreign materials, such as particulate matter and infectious agents, called antigens in this context. Thymus The thymus is located just behind the sternum in the upper part of the chest. It is a bilobed organ that consists of an outer, lymphocyte-rich cortex and an inner medulla. The differentiation of T cells occurs in the cortex of the thymus. In humans the thymus appears early in fetal development and continues to grow until puberty , after which it begins to shrink. The decline of the thymus is thought to be the reason T-cell production decreases with age. The thymocytes then move to the medulla of the thymus, where further differentiation occurs. Positive and negative selection destroy a great number of thymocytes; only about 5 to 10 percent survive to exit the thymus. Those that survive leave the thymus through specialized passages called efferent outgoing lymphatics, which drain to the blood and secondary lymphoid organs. The thymus has no afferent incoming lymphatics, which supports the idea that the thymus is a T-cell factory rather than a rest stop for circulating lymphocytes. Bone marrow In birds B cells mature in the bursa of Fabricius. The process of B-cell maturation was elucidated in birdsâ€”hence B for bursa. In mammals the primary organ for B-lymphocyte development is the bone marrow, although the prenatal site of B-cell differentiation is the fetal liver. Unlike the thymus, the bone marrow does not atrophy at puberty, and therefore there is no concomitant decrease in the production of B lymphocytes with age. The secondary lymphoid organs serve two basic functions:

Chapter 4 : lymphatic system | Structure, Function, & Facts | racedaydvl.com

The lymphatic system is a blunt-ended linear flow system, in which tissue fluids, cells, and large extracellular molecules, collectively called lymph, are drained into the initial lymphatic capillary vessels that begin at the interstitial spaces of tissues and organs.

Structure of capillaries Aspects of the structure of capillaries are discussed, along with the other types of blood vessel, in Chapter 1. A diagram of a microcirculatory unit is shown in Figure 1. A capillary is a tube made up of a single layer of endothelial cells surrounded by a basement membrane. During passage along the 0. This flow pattern is known as bolus flow. Between adjacent endothelial cells there are gaps pores or clefts of varying size which contribute substantially to the permeability characteristics of the capillary wall. However, capillary structures are not all identical and three main types have been identified. These are designated continuous, fenestrated and discontinuous capillaries. It must be remembered that there are discrete variations in structure and function even within these three broad types of capillary. With the development of early microscopes in the 17th century, the Italian Malpighi was able to see capillary blood vessels for the first time. They are the most widely distributed type of capillary. Larger molecules are thought to cross endothelial cells via the extensive invaginations caveolae which cover both surfaces of endothelial cells. Caveolae are linked to the formation of vesicles which can cross the cells transporting larger molecules. An intact basement membrane, which consists mainly of collagen, surrounds the endothelial tube. Pericytes partially surround the capillary and provide support. In some circumstances they are contractile and may be relaxed by nitric oxide generated in the endothelial cells Chapter 9. The least leaky capillaries are found in the brain see p. Tight junctions between cells determine capillary permeability. Pericytes surround part of the capillary wall and provide support. These include the glomerulus of the kidney, intestinal villi and the choroid plexus of the brain the site of cerebrospinal fluid formation. The fenestrae are not generally completely open holes but are covered by a very thin diaphragm which is derived from the glycocalyx. Viewed from the blood side of the capillary, these diaphragms are said to resemble a cartwheel-like structure with 14 wedge-shaped gaps. As with continuous capillaries, fenestrated capillaries have an intact basement membrane. A Fenestrated capillary wall. In the fenestrae there is a thin diaphragm configured like a miniature cartwheel. The basement membrane is intact. B Discontinuous capillary wall. These have relatively large gaps in between cells c.

Chapter 5 : The Lymphatic System : Anatomy & Physiology

What is the lymphatic system and its function? consists of vessels that assist in circulatory body fluids closely related to the cardiovascular system, transport excess fluid away from the interstitial spaces in most tissues and return it to the bloodstream, organs oflymphatic system help defend the body against infection and disease causing.

The lymphatic tissue of these organs filters and cleans the lymph of any debris, abnormal cells, or pathogens. The lymphatic system also transports fatty acids from the intestines to the circulatory system. Immune and Lymphatic System Anatomy Red Bone Marrow and Leukocytes Red bone marrow is a highly vascular tissue found in the spaces between trabeculae of spongy bone. It is mostly found in the ends of long bones and in the flat bones of the body. Red bone marrow is a hematopoietic tissue containing many stem cells that produce blood cells. All of the leukocytes, or white blood cells, of the immune system are produced by red bone marrow. Leukocytes can be further broken down into 2 groups based upon the type of stem cells that produces them: Myeloid Stem Cells Myeloid stem cells produce monocytes and the granular leukocytesâ€"eosinophils, basophils, and neutrophils. Monocytes are agranular leukocytes that can form 2 types of cells: Monocytes respond slowly to infection and once present at the site of infection, develop into macrophages. Macrophages are phagocytes able to consume pathogens, destroyed cells, and debris by phagocytosis. As such, they have a role in both preventing infection as well as cleaning up the aftermath of an infection. Monocytes also develop into dendritic cells in healthy tissues of the skin and mucous membranes. Dendritic cells are responsible for the detection of pathogenic antigens which are used to activate T cells and B cells. Granular Leukocytes include the following: Eosinophils are granular leukocytes that reduce allergic inflammation and help the body fight off parasites. Basophils are granular leukocytes that trigger inflammation by releasing the chemicals heparin and histamine. Basophils are active in producing inflammation during allergic reactions and parasitic infections. Neutrophils are granular leukocytes that act as the first responders to the site of an infection. Neutrophils use chemotaxis to detect chemicals produced by infectious agents and quickly move to the site of infection. Once there, neutrophils ingest the pathogens via phagocytosis and release chemicals to trap and kill the pathogens. T lymphocytes, also commonly known as T cells, are cells involved in fighting specific pathogens in the body. T cells may act as helpers of other immune cells or attack pathogens directly. After an infection, memory T cells persist in the body to provide a faster reaction to subsequent infection by pathogens expressing the same antigen. B lymphocytes, also commonly known as B cells, are also cells involved in fighting specific pathogens in the body. Once B cells have been activated by contact with a pathogen, they form plasma cells that produce antibodies. Antibodies then neutralize the pathogens until other immune cells can destroy them. After an infection, memory B cells persist in the body to quickly produce antibodies to subsequent infection by pathogens expressing the same antigen. Natural killer cells, also known as NK cells, are lymphocytes that are able to respond to a wide range of pathogens and cancerous cells. NK cells travel within the blood and are found in the lymph nodes, spleen, and red bone marrow where they fight most types of infection. Lymph Capillaries As blood passes through the tissues of the body, it enters thin-walled capillaries to facilitate diffusion of nutrients, gases, and wastes. Blood plasma also diffuses through the thin capillary walls and penetrates into the spaces between the cells of the tissues. Some of this plasma diffuses back into the blood of the capillaries, but a considerable portion becomes embedded in the tissues as interstitial fluid. To prevent the accumulation of excess fluids, small dead-end vessels called lymphatic capillaries extend into the tissues to absorb fluids and return them to circulation. Lymph The interstitial fluid picked up by lymphatic capillaries is known as lymph. Lymph very closely resembles the plasma found in the veins: Lymph may also contain bacterial cells that are picked up from diseased tissues and the white blood cells that fight these pathogens. In late-stage cancer patients, lymph often contains cancerous cells that have metastasized from tumors and may form new tumors within the lymphatic system. A special type of lymph, known as chyle, is produced in the digestive system as lymph absorbs triglycerides from the intestinal villi. Due to the presence of triglycerides, chyle has a milky white coloration to it. Lymphatic Vessels Lymphatic capillaries merge together into larger lymphatic vessels to carry lymph through the body. The structure of lymphatic vessels closely resembles that of veins: Lymph is transported through lymphatic vessels by the skeletal muscle pumpâ€”contractions of skeletal muscles constrict the vessels to push the fluid forward. Check valves prevent the fluid from flowing back toward the lymphatic capillaries. Lymph Nodes Lymph nodes are small, kidney-shaped organs of the lymphatic system. There are several hundred lymph nodes found mostly throughout the thorax and abdomen of the body with the highest concentrations in the axillary armpit and inguinal groin regions. The outside of each lymph node is made of a dense fibrous connective tissue capsule. Inside the capsule, the lymph node is filled with reticular tissue containing many lymphocytes and macrophages. The lymph nodes function as filters of lymph that enters from several afferent lymph vessels. The reticular fibers of the lymph node act as a net to catch any debris or cells that are present in the lymph. Macrophages and lymphocytes attack and kill any microbes caught in the reticular fibers. Efferent lymph vessels then carry the filtered lymph out of the lymph node and towards the lymphatic ducts. Lymphatic Ducts All of the lymphatic vessels of the body carry lymph toward the 2 lymphatic ducts: These ducts serve to return lymph back to the venous blood supply so that it can be circulated as plasma. The right lymphatic duct connects the lymphatic vessels of the right arm and the right side of the head, neck, and thorax to the right brachiocephalic vein. Lymphatic Nodules Outside of the system of lymphatic vessels and lymph nodes, there are masses of non-encapsulated lymphatic tissue known as lymphatic nodules. The lymphatic nodules are associated with the mucous membranes of the body, where they work to protect the body from pathogens entering the body through open body cavities. There are 5 tonsils in the bodyâ€”2 lingual, 2 palatine, and 1 pharyngeal. The lingual tonsils are located at the posterior root of the tongue near the pharynx. The palatine tonsils are in the posterior region of the mouth near the pharynx. The pharyngeal pharynx, also known as the adenoid , is found in the nasopharynx at the posterior end of the nasal cavity. The tonsils contain many T and B cells to protect the body from inhaled or ingested substances. The tonsils often become inflamed in response to an infection. Once the antigens of a pathogen are detected, the T and B cells spread and prepare the body to fight a possible infection. The spleen is a flattened, oval-shaped organ located in the upper left quadrant of the abdomen lateral to the stomach. The spleen is made up of a dense fibrous connective tissue capsule filled with regions known as red and white pulp. Red pulp contains reticular tissues whose fibers filter worn out or damaged red blood cells from the blood. Macrophages in the red pulp digest and recycle the hemoglobin of the captured red blood cells. The red pulp also stores many platelets to be released in response to blood loss. White pulp is found within the red pulp surrounding the arterioles of the spleen. It is made of lymphatic tissue and contains many T cells, B cells, and macrophages to fight off infections. The thymus is a small, triangular organ found just posterior to the sternum and anterior to the heart. The thymus is mostly made of glandular epithelium and hematopoietic connective tissues. The thymus produces and trains T cells during fetal development and childhood. T cells formed in the thymus and red bone marrow mature, develop, and reproduce in the thymus throughout childhood. The vast majority of T cells do not survive their training in the thymus and are destroyed by macrophages. The surviving T cells spread throughout the body to the other lymphatic tissues to fight infections. By the time a person reaches puberty, the immune system is mature and the role of the thymus is diminished. After puberty, the inactive thymus is slowly replaced by adipose tissue. Immune and Lymphatic System Physiology Lymph Circulation One of the primary functions of the lymphatic system is the movement of interstitial fluid from the tissues to the circulatory system. Like the veins of the circulatory system, lymphatic capillaries and vessels move lymph with very little pressure to help with circulation. To help move lymph towards the lymphatic ducts, there is a series of many one-way check valves found throughout the lymphatic vessels. These check valves allow lymph to move toward the lymphatic ducts and close when lymph attempts to flow away from the ducts. In the limbs, skeletal muscle contraction squeezes the walls of lymphatic vessels to push lymph through the valves and towards the thorax. In the trunk, the diaphragm pushes down into the abdomen during inhalation. This increased abdominal pressure pushes lymph into the less pressurized thorax. The pressure gradient reverses during exhalation, but the check valves prevent lymph from being pushed backwards. Transport of Fatty Acids Another major function of the lymphatic system is the transportation of fatty acids from the digestive system. The digestive system breaks large macromolecules of carbohydrates, proteins, and lipids into smaller nutrients that can be absorbed through the villi of the intestinal wall. Most of these nutrients are absorbed directly into the bloodstream, but most fatty acids, the building blocks of fats, are absorbed through the lymphatic system. In the villi of the small intestine are lymphatic capillaries called lacteals. Lacteals are able to absorb fatty acids from the intestinal epithelium and transport them along with lymph. The fatty acids turn the lymph into a white, milky substance called chyle. Chyle is transported through lymphatic vessels to the thoracic duct where it enters the bloodstream and travels to the liver to be metabolized. Types of Immunity The body employs many different types of immunity to protect itself from infection from a seemingly endless supply of pathogens. These defenses may be external and prevent pathogens from entering the body. Conversely, internal defenses fight pathogens that have already entered the body. Among the internal defenses, some are specific to only one pathogen or may be innate and defend against many pathogens. Some of these specific defenses can be acquired to preemptively prevent an infection before a pathogen enters the body.

Chapter 6 : The Lymphatic System

The lymphatic system contains three parts, a network of lymphatic vessels, a fluid inside of the vessels called lymph, and lymph nodes that cleanse the lymph while it passes through. Lymphatic System While blood circulates through the body, wastes, gases, and nutrients are exchanged between the blood and interstitial fluid.

Chapter 3The Lymphatic Vasculature 3. Anatomy and Nomenclature of the Lymphatic Vasculature While initial study of the blood vascular system dates back to the sixth century BC, the lymphatic vasculature was not discovered until by Asellius. In stark contrast to the blood vasculature, the lymphatic circulatory system has been far less extensively studied. The reason for this is not its late discovery, but rather pertains to the prevailing misperception that the lymphatics represent a largely passive system for return of extravasated fluid and proteins to the systemic circulation and that no specific molecular markers had been identified to distinguish cells comprising this circulatory system from those in the blood vasculature until the last two decades [44]. As such, no common nomenclature for the lymphatic vasculature has developed, so one previously used for rat mesenteric lymphatics will be introduced next [ ]. Interstitial fluid, formed from the extravasation of solute and fluid from the capillaries, enters blind-ended sacs composed only of an endothelial layer that is tethered to the interstitial matrix. Initial lymphatics possess overlapping endothelial cells that behave collectively like a valve, only permitting unidirectional entry of fluid, solute, and cells into the lumen of these vessels Figure 3. The fluid, thereafter referred to as lymph, next moves into lymphatic vessels of a similar diameter, termed microlymphatics or lymphatic capillaries , consisting of an endothelial layer and basement membrane [ ]. Microlymphatic vessels then carry lymph towards the larger collecting lymphatic vessels. Pericytes do not envelope the smaller initial and microlymphatics [ ]. The lymphatic muscle layer is unique in that it possesses both tonic and phasic contractile activity [,]. Phasic contractions of lymphatic muscle, referred to as spontaneous contractions, aid in propelling lymph along the intervalvular segments of the lymphatic vessel, called lymphangions. After passing through lymph nodes and then larger collecting lymphatic ducts, lymph is finally propelled to the thoracic duct, which empties into the left subclavian vein. This creates a small pressure difference that drives interstitial fluid into more The anatomy of collecting lymphatic vessels appears to be similar to that of comparable veins in that they both are low-pressure vessels vested with a muscle layer and intraluminal valves. In support of the theory of lymphatic development originally proposed by Sabin [ ], one group has shown that lymphatic endothelial cells are derived directly from the cardinal vein [ ]. Akin to the venules, numerous cytoplasmic vesicles have been reported in initial lymphatic endothelium [9 , 33 , , , ,], but a role for these vesicles in solute uptake has not been elucidated fully at present. However, whether lymphatic vessels possess other similar features â€" such as a glycocalyx â€" has not been established. Although the preceding description is accurate for the mesenteric lymphatic vasculature, it is important to recognize that lymphatic vessel morphology varies greatly between organs. Since it is beyond the scope of this section to thoroughly summarize these varying anatomical features, the reader is directed to several excellent detailed reviews for this information [14 , ,]. Two of these reviews [14 ,] summarize classical views on several aspects of the lymphatic vasculature, while the present chapter hopes to provide the reader with the most current perspectives, highlighting active areas of research and needed studies. Lymph Formation Lymph formation refers to the entry of fluid and protein into the initial lymphatics. The mechanisms responsible for this process are poorly understood, but two main hypotheses have been proposed. The first suggests that an osmotic gradient becomes established across the initial lymphatic wall through sieving of protein that then generates its own convective flow by pulling in protein-containing interstitial fluid against a concentration gradient [34]. Very little, if any, experimental support exists for this unlikely theory despite its original appearance nearly four decades ago. Therefore, the following discussion will focus on the second hypothesis, which relies upon a hydrostatic pressure gradient to fill the initial lymphatics. As stated before, the initial lymphatics possess overlapping endothelial cells tethered to the tissue Figure 3. Considering their unique structure, one would arrive at the logical conclusion that a pressure gradient across the interstitium may drive fluid and solute accumulation within the initial lymphatics. Few studies on interstitial pressure gradients have been performed, but each proposes a gradient between 0. At first glance this pressure gradient seems small, but others have calculated that a pressure head of only 0. The main problem with this hypothesis is that negative values of interstitial pressure are routinely measured [40 , 91]. Significant overlap of the simultaneously measured interstitial and initial lymphatic pressures was observed [40 ,], depending on the superfusion solution and the time of measurement immediately following exteriorization or 30 minutes later. Therefore, it is possible that a positive pressure gradient can allow fluid to enter the initial lymphatics even with a negative interstitial pressure. More current support for this hypothesis has been reported [ ]. A passive interstitial pressure gradient, while sufficient, is not a complete description of every mechanism contributing to the formation of lymph. Pulsation of arteries was shown to aid in removal of interstitial tracer, which ceased after application of a steady arterial pressure [ ]. Likewise, in the bat wing, cyclical dilation of the venules is a form of extrinsic pumping that also stimulates intrinsic spontaneous contractions of collecting lymphatics [63]. Other factors that increase local tissue pressure facilitate lymph formation such as respiration, muscle contraction e. Opposite to an increase in interstitial pressure, a variant of the hydrostatic pressure hypothesis posits that spontaneously contractile collecting lymphatic lymphangions, during their relaxation phase, are able to generate a suction force that draws interstitial fluid into the initial lymphatics [ ]. Further support for the hydrostatic pressure gradient hypothesis is derived from studies demonstrating a positive correlation between interstitial pressure and lymph flow, which are discussed next. Interstitial Fluid Pressure and its Influence on Lymph Flow A convincing argument for an interstitial pressure gradient to drive lymph formation has been outlined in the previous section. The potential of the initial lymphatic lumen to collapse under a positive pressure difference is minimized by their unique anatomy. Therefore, interstitial fluid is able to access the initial lymphatic lumen especially during edematous states when tissue pressure becomes positive. Possibly as a result of the direct communication of the interstitial fluid and the lumen of the initial lymphatics, interstitial pressure and lymph flow are positively related. Several studies where tissue pressure was measured with the capsule technique provide direct evidence for this relationship [82 ,]. The importance of this curve is that it maintains a constant interstitial volume due to the tight correlation between interstitial volume and interstitial pressure shown in Figure 3. Two mechanisms protecting against edema i. Thus, a small increase in interstitial volume greatly increases its pressure, promoting lymph flow that acts to restore the interstitial volume to normal. Reprinted from reference [], with permission. Lymphatic Solute Permeability As summarized by Drinker [65], the main responsibility of the lymphatic circulaton is to be: Extravascular accumulation of plasma proteins, if unchecked, leads to the osmotic flow of water into the interstitium, producing edema. Instead, after injection of colloid or radiolabeled protein, inferences were made from visualizing tracer uptake, analyzing downstream lymph samples, or viewing histological sections. As previously stated, both interendothelial pores [ ] and transendothelial vesicles [9 ,] have been implicated in solute and fluid removal from the interstitium by initial lymphatics. The physiological role for vesicles in the lymphatic vasculature remains unknown, but their appearance may reflect the anatomic variation in lymphatic morphology [84]. Leak [ ] favored the view that the interendothelial route was the major conduit for solute transport, whereas vesicles facilitated digestion of interstitial protein by the initial lymphatic endothelium. Generally, it is now believed that initial lymphatics are able to passively absorb particles, protein, cells, and fluid from the interstitium through large pores without regard for molecular size. Consequently, the lymph protein concentration of initial lymphatics probably approximates the protein concentration of the interstitium [,]. Much controversy still surrounds whether the protein concentration of lymph from collecting lymphatics is equal to that of interstitial fluid; i. Unlike initial lymphatic solute uptake, flux of solute across the collecting lymphatic walls depends on molecular size [ ]. Studies performed by Mayerson [ ] were initially aimed at answering questions regarding blood capillary permeability, using the lymphatic vaculature as a window into the interstitium, but became focused on how efficiently lymph is transported through the lymphatic circulation. However, these studies were novel for the time and provided a first approximation of the size selectivity of the lymphatic ducts up to and including the thoracic duct. Simply put, large lymphatic ducts seemed to possess a relatively low permeability to large macromolecules and a higher permeability to molecules smaller than insulin. Conversely, a paper reporting rat mesenteric collecting lymphatic permeability to rat serum albumin RSA in vivo concluded that it did not significantly differ from venular RSA permeability 3. Three major implications are immediately apparent: The last point must be emphasized, as lymph protein concentrations have been widely assumed to equal that of interstitial fluid. Indeed, lymph composition is further modified by nodal transit as evidenced by concentration differences in pre- vs postnodal lymph which is the usual site for lymph collection for in vivo studies and often equated to interstitial fluid [2 , 3 , 4 , 5]. Scallan and Huxley [ ] presented evidence supporting the hypothesis that lymph is concentrated by collecting lymphatics via loss of water over solute. When the total protein and albumin concentration of plasma, interstitium, and collecting lymphatic lymph were measured simultaneously, lymph protein concentrations were significantly greater than interstitial protein concentrations. Consequently, these data show that solute flux is directed from the vessel lumen to the interstitium; i. The fact that lymph flow is inversely related to lymph protein concentration lends further support to this hypothesis [29]. Lymphatic permeability may influence the effectiveness of the lymphatic edema safety factor given that vasoactive substances increasing collecting lymphatic permeability to solute or water may facilitate edema formation if most collecting lymphatics possess solute fluxes directed towards the interstitium. The implications of such findings in this newly revived area of research are that we will have to modify the conventional understanding of how lymphatic physiology affects fluid homeostasis. Propulsion of Lymph by the Lymphatic Muscle Pump The field of research examining the functional and molecular control of lymphatic contractility has been productive in the past two decades. One key discovery is that lymphatic muscle may act as a functional hybrid between smooth muscle and cardiac muscle because it contains molecular machinery from both cell types [ ]. This has stimulated new hypotheses about how collecting lymphatics are able to independently regulate both tonic and phasic contractions. Hydrostatic pressure increases progressively as lymph moves downstream into larger vessels of the lymphatic vasculature. On the contrary, peripheral veins experience a greater hydrostatic pressure than the downstream central veins, especially when standing, owing to the effects of gravity. Restated, the pressure gradient produced by the heart, in addition to the extrinsic venous pump, provides the driving force for venous return [14]. The lymphatic vasculature has no such pressure head i. However, under edematous conditions, the interstitial pressure rises so that lymph may flow down a pressure gradient [ ]. Lymph is transported throughout the lymphatic vasculature by intrinsic phasic contractions generated by the lymphatic muscle of collecting lymphatics that, along with valves, are necessary for unidirectional lymph flow. The spontaneous contractions are analogous to the cardiac contraction cycle consisting of a contraction and relaxation phase, stroke volume, and ejection fraction [20]. Since the walls of collecting lymphatics are vested with muscle cells, they are able to regulate their diameter and tone, therefore modulating lymph flow resistance. Several factors, both mechanical and chemical, are able to regulate collecting lymphatic tone [ ]. Mechanical stimuli include lymph flow, shear stress, hydrostatic pressure, and temperature. Hydrostatic pressure has been shown to elicit a myogenic response in collecting lymphatic muscle measured during the relaxation phase analogous to the arteriolar myogenic response [56]. In this study, an elevation in hydrostatic pressure induced constriction, thus reducing the end diastolic diameter of isolated collecting lymphatics, similar to the arteriolar myogenic response to pressure. Interestingly, addition of the neuropeptide substance P to the superfusion bath potentiated this effect of pressure on tone. Chemical factors influencing collecting lymphatic tone include neurotransmitters, neuropeptides, hormones, and metabolites [12 , 58 ,]. For example, substance P increases basal collecting lymphatic tone [12 , 58]. Similar to cardiac myocytes, length-tension curves have been determined for the perivascular muscle of collecting lymphatics, arterioles, and venules [20 , , ,]. Wall tension and stress derived from these curves were found to be lowest in rat mesenteric lymphatics, while mesenteric veins possessed higher tension and stress, and that of mesenteric arteries was the highest. Functionally, this makes sense in that arterioles, the resistance vessels, constrict to regulate pressure and flow; venules and lymphatics possess lower hydrostatic pressures reflecting their roles as capacitance vessels. Other research has focused on the regulation of collecting lymphatic phasic activity. Functional studies demonstrated that lymph flow inhibits spontaneous contraction frequency and amplitude of both collecting lymphatic and thoracic duct isolated vessels [79]. However, the conclusion was that in vivo total lymph flow defined as passive flow plus contraction-generated flow would not be diminished as expected. Instead, lack of pumping activity was suggested as a mechanism to reduce the outflow resistance in the presence of high passive flows [79 ,]. Another vessel possessing spontaneous contractile activity besides the collecting lymphatics is the portal vein. Like the portal vein, collecting lymphatics were more sensitive to the rate of circumferential stretch than to the magnitude [57 ,].

Chapter 7 : Lymphatic system - Wikipedia

The lymphatic system includes a system of lymphatic capillaries, vessels, nodes, and ducts that collects and transports lymph, which is a clear to slightly yellowish fluid, similar to the plasma in blood. The lymphatic system is important for maintaining your body's fluid balance, and it helps.

The Lymphatic System Objective The student should become familiar with the widespread distribution of the lymphatic system throughout the body, recognize and distinguish the different lymphatic organs and tissues and understand the arrangement of cells within them in relation to their functions. The lymphatic system consists of lymphatic vessels and lymphatic tissue. Lymphatic capillaries begin as blind pouches in the connective tissue of nearly all organs. Lymphatic vessels have not been found in brain, spinal cord, bone marrow, cartilage, eyeball, or inner ear, even though lymphocytes may be found in some of these tissues. The walls of lymphatic vessels are composed of endothelial cells and a few collagenous fibers. When dilated, lymphatic capillaries have a greater and more variable diameter than blood capillaries. Lymphatic capillaries drain into larger collecting vessels which contain paired valves. These vessels have thin irregular walls and pursue an erratic course toward the nearest regional lymph nodes, where some pierce the convex surface of a node as afferent lymphatics. Their contents then enter lymphatic sinuses within the node. Efferent vessels emerge at the concave or hilar surface of the lymph nodes. The large vessels eventually drain into the thoracic duct or the right lymphatic duct. Lymphatic tissue is made up of a framework of reticular fibers which are produced by reticular cells and which support lymphocytes, macrophages, and related cells. Lymphoid tissue can be described as: Non-Encapsulated Lymphatic Tissue Examine slide 58, a section of human appendix, by reversed ocular. A central lumen bordered by pale-staining epithelial cells should be visible. Surrounding the lumen is a dense blue mass of lymphocytes. Within this mass lighter regions may seen. These are the germinal centers of lymph nodules. On some slides nodules are hard to identify. On slide 58 even, which is stained with MEA, segments of venules with high endothelium may be seen at the periphery where there are fewer lymphocytes. Note that the endothelium does not have the typical squamous appearance but is closer to cuboidal. Lymphocytes may be seen crossing this endothelium. Examine the diffuse lymphatic tissue and look for eosinophils, plasma cells large cells with eccentric nuclei and blue cytoplasm and lymphocytes. The nodules are usually pear-shaped structures with their apices just below the intestinal epithelium and 9 or more nodules aggregate. They will be seen in a later laboratory G. Tonsils The tonsils are accumulations of diffuse, nodular lymphatic tissue found in the wall of the naso and oropharynx but are partially encapsulated. On their outer surface, the tonsils are covered by epithelium which forms infoldings or crypts. The internal surface is partially covered by a poorly organized capsule which sends connective tissue septa into the parenchyma. The three tonsils may be identified by the nature of their epithelium and the arrangement of the crypts. The pharyngeal tonsil is usually covered by pseudostratified epithelium which is invaginated in a series of folds often associated with mucous or seromucous glands. The palatine tonsils are covered by a stratified squamous epithelium and contain relatively long branched crypts. The lingual tonsil located at the base of the tongue is covered by stratified squamous epithelium and usually has a long unbranched crypt. Skeletal muscle and mucous glands of the tongue may be found closely apposed to this tonsil. Examine the palatine tonsil slide Locate the epithelium Stratified squamous and identify crypts. A primary nodule is a uniform mass of small and medium size lymphocytes in a delicate framework of reticular fibers. They are characteristically found in lymph nodes of fetuses and neonates. In adults, most nodules are secondary nodules and contain a pale staining central portion called a germinal center composed of large differentiating lymphocytes transitional cells, plasmablasts and plasma cells, reticular cells and macrophages. Some macrophages may be recognized by the presence of ingested cellular debris e. Students need not distinguish the various cell types present. A corona of small lymphocytes mainly B-cells makes up the outer portion of each nodule. Macrophages may be recognized as large cells containing fragments of dead lymphocytes. Lymph Nodes These are encapsulated bean-shaped structures of lymphatic tissue located in many regions of the body. They lie along the course of lymphatic vessels and vary in size from a few millimeters to more than a centimeter in length. Important nodes are present in the axillae, groin, and neck which are frequently swollen in patients with ongoing infections. The lymph node is embedded in fatty connective tissue and is covered by a fibrous capsule. Examine slide 33 lymph node from both odd and even boxes. Although they are unlikely to be seen on your slides, afferent lymphatics perforate the capsule and deposit lymph and cells into the subcapsular sinus, a clear space visible just beneath the capsule and separating it from the densely basophilic cortical region. Branching inward from the subcapsular sinus are the cortical sinuses which lead the lymph through the cortex to the medulla, an irregular and more eosinophilic region. Identify cortical sinuses e. Try to identify endothelial cells and reticular fibers spanning the lumen. Beneath the subcapsular sinus are lymph nodules located in the outer part of the cortex. Their structure and composition is the same as that described above for the tonsils. Somewhat deeper to the area containing nodules and not physically demarcated from them is the paracortical area which is composed primarily of sheets of lymphocytes. Most small lymphocytes found in the paracortical areas are thymus-dependent T-cells. These cells arrive either via afferent lymphatic vessels or high endothelial venules which can be seen in this region. B-lymphocytes B-cells predominate in the outer cortex especially in the corona of nodules. Lymphocytes may leave the lymph node by passing into the sinuses subcapsular, cortical and medullary and then into efferent lymphatic vessels in the hilus. Lymphocytes pass through several nodes before entering the thoracic duct and eventually the large veins subclavian of the neck. Locate the medullary region of the lymph node consisting of irregular anastomosing cords of cells medullary cords consisting of reticular cells, macrophages, plasma cells, and lymphocytes. Between cords are the medullary sinuses. Due to the shape of the lymph nodes, some sections contain the central region and may lack the hilar region, and have varying amounts of medullary tissue. Examine the reticular fiber framework of a lymph node on slide 34 to understand the supporting architecture. Note sinuses and their structure. Spleen The spleen is the largest mass of lymphatic tissue in the body. It consists of cells and vessels contained within a capsule lined by mesothelium, from which trabecula enter the splenic parenchyma. The parenchyma is supported by a framework of reticular fibers. The spleen consists of two types of parenchymal tissue, the white and red pulp. The white pulp is composed of elongated cords of compact lymphatic tissue containing nodules. The red pulp is composed of pulp cords and splenic sinusoids sinusoid is another term for blood sinus. Examine the spleen slide 35, odd and even and locate the capsule covered by a mesothelium may have been damaged. Collagen, elastic and a few reticular fibers as well as some smooth muscle cells make up the capsule and the trabeculae projections from the capsule into the organ. The arrangement of the fibers permits the spleen to expand passively and to serve as a small temporary reservoir for blood. Note that the trabeculae which originate at the hilus contain and support trabecular arteries and veins which enter and leave the organ at the hilus. Trabeculae from other areas of the capsule do not contain vessels. Arteries branching out of the trabeculae are immediately surrounded by lymphocytes forming the white pulp. Examine the white pulp blue stained regions and note that the lymphocytes make up the majority of the cells. A dense lymphatic collar of mainly T-cells surrounds the central or follicular arteriole. This collar is called the periarterial lymphatic sheath PALS. Despite its name the central arteriole is usually on one side of the white pulp. Although not often visible, nodules are scattered along the length of the PALS. At 10x, the dense blue collar is seen to have a diffuse edge, the marginal zone, which is highly vascular best seen on the injected specimen and is a zone of B and T cell interaction containing many antigen presenting cells. Many branches of the central arteriole ramify and are believed to end blindly at the marginal zone. Branches of the central arteriole pass from the white pulp into the red pulp and branch to form penicillar arteries or penicilli. A penicillus has three sections; the first is a straight vessel called the artery of the pulp or pulp arteriole. The pulp arteriole branches to form many smaller arterioles some of which are sheathed arterioles. These have a slit-like lumen surrounded by macrophages which make up the peri-arteriolar macrophage sheath PAMS. The sheathed arteriole branches to form the terminal arterial capillary, which empties into either a pulp cord open circulation or a sinusoid closed circulation. The smaller branches of the penicillus are difficult to identify, but students should be able to identify pulp arterioles. Blood vessels may be easier to find on slide 35, even. Most of the terminal vessels end openly open circulation delivering blood into the pulp cords which consist of reticular c. Some terminal arterioles may connect directly with venous sinusoids closed circulation as shown in the diagram. Blood delivered to the pulp cords eventually enters venous sinusoids which are lined by elongated endothelial cells separated by slits. Their basement membrane is discontinuous and they are lined on their outer surface by reticular cells and supported by elongated reticular fibers. Distinguish between sinusoids and pulp cords. The sinuses may be easier to distinguish on slide 35, odd, spleen. The venous sinusoids empty into pulp veins which then form trabecular veins and exit from the spleen at the hilus. Thymus The thymus is bilobed and each lobe is segmented into lobules. The parenchyma is arranged in cortical and medullary components.

Chapter 8 : Immune and Lymphatic Systems â€“ Anatomy Pictures and Information

The lymphatic system is a circulatory system for lymphatic fluid, comprising a network of conduits called lymphatic vessels that carry the fluid in one direction toward the heart. Its functions include providing sites for certain immune system functions and facilitating plasma circulation in the cardiovascular system.

A lymph node showing afferent and efferent lymphatic vessels A lymph node is an organized collection of lymphoid tissue, through which the lymph passes on its way back to the blood. Lymph nodes are located at intervals along the lymphatic system. Several afferent lymph vessels bring in lymph, which percolates through the substance of the lymph node, and is then drained out by an efferent lymph vessel. There are between five and six hundred lymph nodes in the human body, many of which are grouped in clusters in different regions as in the underarm and abdominal areas. Lymph node clusters are commonly found at the base of limbs groin, armpits and in the neck, where lymph is collected from regions of the body likely to sustain pathogen contamination from injuries. The substance of a lymph node consists of lymphoid follicles in an outer portion called the cortex. The inner portion of the node is called the medulla , which is surrounded by the cortex on all sides except for a portion known as the hilum. The hilum presents as a depression on the surface of the lymph node, causing the otherwise spherical lymph node to be bean-shaped or ovoid. The efferent lymph vessel directly emerges from the lymph node at the hilum. The arteries and veins supplying the lymph node with blood enter and exit through the hilum. The region of the lymph node called the paracortex immediately surrounds the medulla. Unlike the cortex, which has mostly immature T cells, or thymocytes , the paracortex has a mixture of immature and mature T cells. Lymphocytes enter the lymph nodes through specialised high endothelial venules found in the paracortex. A lymph follicle is a dense collection of lymphocytes, the number, size and configuration of which change in accordance with the functional state of the lymph node. For example, the follicles expand significantly when encountering a foreign antigen. The selection of B cells , or B lymphocytes, occurs in the germinal centre of the lymph nodes. Lymph nodes are particularly numerous in the mediastinum in the chest, neck, pelvis, axilla , inguinal region , and in association with the blood vessels of the intestines. It consists of connective tissue formed of reticular fibers , with various types of leukocytes , white blood cells , mostly lymphocytes enmeshed in it, through which the lymph passes. Lymphoid tissue can either be structurally well organized as lymph nodes or may consist of loosely organized lymphoid follicles known as the mucosa-associated lymphoid tissue. The central nervous system also has lymphatic vessels, as discovered by the University of Virginia Researchers. The search for T-cell gateways into and out of the meninges uncovered functional meningeal lymphatic vessels lining the dural sinuses , anatomically integrated into the membrane surrounding the brain. Lymphatic vessel Lymph capillaries in the tissue spaces The lymphatic vessels , also called lymph vessels, conduct lymph between different parts of the body. They include the tubular vessels of the lymph capillaries , and the larger collecting vesselsâ€"the right lymphatic duct and the thoracic duct the left lymphatic duct. The lymph capillaries are mainly responsible for the absorption of interstitial fluid from the tissues, while lymph vessels propel the absorbed fluid forward into the larger collecting ducts, where it ultimately returns to the bloodstream via one of the subclavian veins. These vessels are also called the lymphatic channels or simply lymphatics. Its network of capillaries and collecting lymphatic vessels work to efficiently drain and transport extravasated fluid, along with proteins and antigens, back to the circulatory system. Numerous intraluminal valves in the vessels ensure a unidirectional flow of lymph without reflux. The collecting lymphatics, however, act to propel the lymph by the combined actions of the intraluminal valves and lymphatic muscle cells. The first lymph sacs to appear are the paired jugular lymph sacs at the junction of the internal jugular and subclavian veins. Each jugular lymph sac retains at least one connection with its jugular vein, the left one developing into the superior portion of the thoracic duct. The next lymph sac to appear is the unpaired retroperitoneal lymph sac at the root of the mesentery of the intestine. It develops from the primitive vena cava and mesonephric veins. Capillary plexuses and lymphatic vessels spread from the retroperitoneal lymph sac to the abdominal viscera and diaphragm. The sac establishes connections with the cisterna chyli but loses its connections with neighbouring veins. The last of the lymph sacs, the paired posterior lymph sacs, develop from the iliac veins. The posterior lymph sacs produce capillary plexuses and lymphatic vessels of the abdominal wall, pelvic region, and lower limbs. The posterior lymph sacs join the cisterna chyli and lose their connections with adjacent veins. With the exception of the anterior part of the sac from which the cisterna chyli develops, all lymph sacs become invaded by mesenchymal cells and are converted into groups of lymph nodes. The spleen develops from mesenchymal cells between layers of the dorsal mesentery of the stomach. The lymphatic system has multiple interrelated functions: Fat absorption[edit] Nutrients in food are absorbed via intestinal vili greatly enlargened in the picture to blood and lymph. Long-chain fatty acids and other lipids with similar fat solubility like some medicines are absorbed to the lymph and move in it enveloped inside chylomicrons. Lymph vessels called lacteals are at the beginning of the gastrointestinal tract , predominantly in the small intestine. While most other nutrients absorbed by the small intestine are passed on to the portal venous system to drain via the portal vein into the liver for processing, fats lipids are passed on to the lymphatic system to be transported to the blood circulation via the thoracic duct. There are exceptions, for example medium-chain triglycerides are fatty acid esters of glycerol that passively diffuse from the GI tract to the portal system. The enriched lymph originating in the lymphatics of the small intestine is called chyle. The nutrients that are released into the circulatory system are processed by the liver , having passed through the systemic circulation. Cells in the lymphatic system react to antigens presented or found by the cells directly or by other dendritic cells. When an antigen is recognized, an immunological cascade begins involving the activation and recruitment of more and more cells, the production of antibodies and cytokines and the recruitment of other immunological cells such as macrophages. Lymphatic disease The study of lymphatic drainage of various organs is important in the diagnosis, prognosis, and treatment of cancer. The lymphatic system, because of its closeness to many tissues of the body, is responsible for carrying cancerous cells between the various parts of the body in a process called metastasis. The intervening lymph nodes can trap the cancer cells. If they are not successful in destroying the cancer cells the nodes may become sites of secondary tumours. Enlarged lymph nodes[edit] Main article: Lymphadenopathy Lymphadenopathy refers to one or more enlarged lymph nodes. Small groups or individually enlarged lymph nodes are generally reactive in response to infection or inflammation. This is called local lymphadenopathy. When many lymph nodes in different areas of the body are involved, this is called generalised lymphadenopathy. Generalised lymphadenopathy may be caused by infections such as infectious mononucleosis , tuberculosis and HIV , connective tissue diseases such as SLE and rheumatoid arthritis , and cancers , including both cancers of tissue within lymph nodes, discussed below, and metastasis of cancerous cells from other parts of the body, that have arrived via the lymphatic system. Lymphedema Lymphedema is the swelling caused by the accumulation of lymph, which may occur if the lymphatic system is damaged or has malformations. It usually affects limbs, though the face, neck and abdomen may also be affected. In an extreme state, called elephantiasis , the edema progresses to the extent that the skin becomes thick with an appearance similar to the skin on elephant limbs. Lymphangiomatosis is a disease involving multiple cysts or lesions formed from lymphatic vessels. Treatment is by manual lymphatic drainage. There is no evidence to suggest that the effects of manual lymphatic drainage are permanent.

Chapter 9 : Structure and function of the lymphatic system

Functions of the Lymphatic system. Returns interstitial fluid and leaked plasma proteins back to the blood. Together with lymphoid organs and tissues, provide the structural basis of the ______ _______.

The lymphatic system also removes excess fluid, and waste products from the interstitial spaces between the cells. This fluid is now known as interstitial fluid and it delivers its nourshing products to the cells. Then it leaves the cell and removes waste products. Unlike blood, which flows throughout the body in a continue loop, lymph flows in only one direction within its own system. After plasma has delivered its nutrients and removed debris, it leaves the cells. The cleansed lymph continues to travel in only one direction, which is upward toward the neck. At the base of the neck, the cleansed lymph flows into the subclavian veins on either side of the neck. Lymph returning to the subclavian veins. This fluid delivers nutrients, oxygen, and hormones to the cells. As this fluid leaves the cells, it takes with it cellular waste products and protein cells. Here it enters the venous circulation as plasma and continues in the circulatory system. Lymphatic capillaries begin as blind-ended tubes that are only a single cell in thickness. These cells are arranged in a slightly overlapping pattern, much like the shingles on a roof. Each of these individual cells is fastened to nearby tissues by an anchoring filament. Deeper within the body the lymphatic vessels become progressively larger and are located near major blood veins. Smooth muscles in the walls of the lymphatic vessels cause the angions to contract sequentially to aid the flow of lymph upward toward the thoracic region. Because of their shape, these vessels are previously referred to as a string of pearls. They also remove debris and excess fluids. It is the role of these nodes to filter the lymph before it can be returned to the circulatory system. Although these nodes can increase or decrease in size throughout life, any nodes that has been damaged or destroyed, does not regenerate. Afferent lymphatic vessels carry unfiltered lymph into the node. Here waste products, and some of the fluid, are filtered out. In another section of the node, lymphocytes, which are specialized white blood cells, kill any pathogens that may be present. The right drainage area clears the right arm and chest. When lymphatic tissues or lymph nodes have been damaged, destroyed or removed, lymph cannot drain normally from the affected area. When this happens excess lymph accumulates and results in the swelling that is characteristic of lymphedema. The treatment of lymphedema is based on the natural structures and the flow of lymph. The affected drainage area determines the pattern of the manual lymph drainage MLD and for self-massage. Although lymph does not normally cross from one area to another, MLD stimulates the flow from one area to another. It also encourages the formation of new lymph drainage pathways. MLD treatment and self-massage begin by stimulating the area near the terminus and the larger lymphatic vessels. This stimulates the flow of lymph that is already in the system and frees space for the flow of the lymph that is going to enter the capillaries during the treatment. MLD treatment continues as a gentle massage technique to stimulate the movement of the excess lymph in affected tissues. The rhythmic, light strokes of MLD provide just the right pressure to encourage this excess lymph to flow into the lymph capillaries. Exercise is important in the treatment of lymphedema because the movements of the muscles stimulate the flow of the lymph into the capillaries. Wearing a compression garment during exercise also provides resistance to further stimulate this flow. Self-massage or simplified lympatic drainage, as prescribed by your therapist, is another way in which lymph is encouraged to flow into the capillaries. This information does not replace the advice of a qualified health care professional. Got a question or comment?