

Chapter 14 - Lymphatic System and Immunity

14.1 Introduction (Fig. 14.1)

- A. The lymphatic system is comprised of a network of vessels that transport body fluids, the cells and chemicals in those vessels and the organs and glands that produce them.
- B. Lymphatic vessels collect and carry away excess fluid from interstitial spaces and special vessels called lacteals transport fats to the circulatory system.
- C. The organs of the lymphatic system help defend against disease.

14.2 Lymphatic Pathways

- A. Lymphatic pathways start as lymphatic capillaries that merge to form larger vessels that empty into the circulatory system.
- B. Lymphatic Capillaries (Fig. 14.2)
 - 1. Lymphatic capillaries are tiny, closed-ended tubes that extend into interstitial spaces.
 - 2. They receive tissue fluid through their thin walls; once inside, tissue fluid is called lymph.
- C. Lymphatic Vessels (Fig. 14.3)
 - 1. The walls of lymphatic vessels are thinner than those of veins but are constructed with the same three layers with semilunar valves on the inside.
 - 2. Larger lymphatic vessels pass through lymph nodes and merge to form lymphatic trunks.
- D. Lymphatic Trunks and Collecting Ducts (Figs. 14.4-14.5)
 - 1. The lymphatic trunks drain lymph from the body and are named for the regions they drain.
 - 2. These trunks join one of two collecting ducts — either the thoracic duct or right lymphatic duct.
 - 3. The thoracic duct drains into the left subclavian vein, while the right lymphatic duct drains into the right subclavian vein.

14.3 Tissue Fluid and Lymph

- A. Tissue fluid becomes lymph once it has entered a lymphatic capillary; lymph formation depends on tissue fluid formation.
- B. Tissue Fluid Formation
 - 1. Tissue fluid is made up of water and dissolved substances that leave blood capillaries by filtration and diffusion.
 - 2. During filtration, some smaller proteins leak from capillaries into the tissues and are not returned to the bloodstream, thus increasing osmotic pressure within the tissues.
- C. Lymph Formation and Function
 - 1. Rising osmotic pressure in tissues interferes with the return of fluids to the bloodstream.
 - 2. Increasing interstitial pressure forces some of the fluid into lymphatic capillaries.

14.4 Lymph Movement

- A. The hydrostatic pressure of tissue fluid drives the entry of lymph into lymphatic capillaries.
- B. Forces that move blood in veins (skeletal muscle contraction, breathing movements, and contraction of smooth muscle in the walls of lymphatic trunks) are the forces that propel lymph through lymphatic vessels.
- C. A condition that interferes with the flow in lymph will result in edema.
- D. During surgery, lymphatic vessels or tissues may be removed or disturbed, resulting in edema.

14.5 Lymph Nodes

- A. Lymph nodes, which contain lymphocytes and macrophages, are located along lymphatic pathways.

- B. Structure of a Lymph Node (Figs. 14.6-14.7)
 1. Lymph nodes are bean-shaped, with blood vessels, nerves, and efferent lymphatic vessels attached to the indented hilum, and with afferent lymphatic vessels entering on the convex surface.
 2. Lymph nodes are covered with connective tissue that extends inside the node and divides it into nodules and spaces called sinuses.
 3. These contain both lymphocytes and macrophages, which clean the lymph as it flows through the node.
- C. Locations of Lymph Nodes (Fig. 14.8)
 1. The lymph nodes generally occur in chains along the parts of the larger lymphatic vessels.
- D. Functions of Lymph Nodes
 1. The macrophages and lymphocytes within lymph nodes filter lymph and remove bacteria and cellular debris before lymph is returned to the blood.
 2. Lymph nodes are also centers of lymphocyte production; these cells function in immune surveillance.

14.6 Thymus and Spleen

- A. The functions of the thymus and spleen are similar to those of lymph nodes.
- B. Thymus (Fig. 14.9)
 1. The thymus is a soft, bi-lobed organ located behind the sternum; it shrinks in size during the lifetime (large in children, microscopic in the elderly).
 2. The thymus is surrounded by a connective tissue capsule which extends inside it and divides it into lobules.
 3. Lobules contain lymphocytes, some of which mature into T lymphocytes (T cells) that leave the thymus to provide immunity.
 4. The thymus secretes the hormone thymosin, which influences the maturation of T lymphocytes once they leave the thymus.
- C. Spleen (Figs. 14.9-14.10)
 1. The spleen lies in the upper left abdominal cavity and is the body's largest lymphatic organ.
 2. The spleen resembles a large lymph node except that it contains blood instead of lymph.
 3. Inside the spleen lies white pulp (containing many lymphocytes) and red pulp (containing red blood cells, macrophages, and lymphocytes).
 4. The spleen filters the blood and removes damaged blood cells and bacteria.

14.7 Body Defenses Against Infection

- A. Diseases-causing agents, also called pathogens, can produce infections within the body.
- B. The body has two lines of defense against pathogens: nonspecific defenses that guard against any pathogen, and specific defenses (immunity) that mount a response against a very specific target.
 1. Specific defenses are carried out by lymphocytes that recognize a specific invader.
 2. Nonspecific and specific defenses work together to protect the body against infection.

14.8 Innate (Nonspecific) Defenses

- A. Species Resistance
 1. A species is resistant to diseases that affect other species because it has a unique chemical environment or temperature that fails to provide the conditions required by the pathogens of another species.
- B. Mechanical Barriers
 1. The unbroken skin and mucous membranes of the body create mechanical barriers that prevent the entry of certain pathogens.

2. Mechanical barriers represent the body's first line of defense.
- C. Chemical Barriers
 1. Chemical barriers, such as the highly acidic and caustic environment provided by gastric juice, or lysozyme in tears, kill many pathogens.
 2. Interferons, hormone-like peptides that serve as antiviral substances, are produced by cells when they are infected with viruses and induce nearby cells to produce antiviral enzymes that protect them from infection.
- D. Natural Killer (NK cells)
 1. Defend the body against various viruses and cancer cells by secreting cytolytic substances called perforins.
 2. NK cells also secrete chemicals that enhance inflammation.
- E. Inflammation
 1. Inflammation, a tissue response to a pathogen, is characterized by redness, swelling, heat, and pain.
 2. Major actions that occur during an inflammatory response include: dilation of blood vessels; increase of blood volume in affected areas; invasion of white blood cells into the affected area; and appearance of fibroblasts and their production of a sac around the area.
- F. Phagocytosis
 1. The most active phagocytes are neutrophils and monocytes; these leave the bloodstream at areas of injury by diapedesis.
 - a. Neutrophils engulf smaller particles; monocytes attack larger ones.
 2. Monocytes give rise to macrophages, which become fixed in various tissues.
 3. Monocytes, macrophages, and neutrophils constitute the mononuclear phagocytic system.
 4. Phagocytosis also removes foreign particles from the lymph.
- D. Fever
 1. Fever offers powerful protection against infection by interfering with the proper conditions that promote bacterial growth.
 - a. During fever, the amount of iron in the blood is reduced, and thus fewer nutrients are available to support the growth of pathogens.
 - b. Phagocytic cells attack with greater vigor when the temperature rises.

14.9 Adaptive (Specific) Defenses, or Immunity (Table 14.1)

- A. The body's third line of defense, immunity refers to the response mounted by the body against specific, recognized foreign molecules.
- B. Antigens
 1. Before birth, the body makes an inventory of "self" proteins and other large molecules.
 2. Antigens are generally larger molecules that elicit an immune response.
 - a. Sometimes small molecules called haptens combine with larger molecules and become antigenic.
- C. Lymphocyte Origins (Figs. 14.11-14.12)
 1. During fetal development, red bone marrow releases lymphocytes into circulation, 70-80% of which become T lymphocytes (T cells) and the remainder of which become B lymphocytes (B cells).
 2. Undifferentiated lymphocytes that reach the thymus become T cells; B cells are thought to mature in the bone marrow.
 3. Both B and T cells reside in lymphatic organs.
- D. T Cells and the Cellular Immune Response (Fig. 14.13; Table 14.2)
 1. T cell activation requires the presence of an antigen-presenting cell, such as a B cell

- or macrophage, that has already encountered the antigen.
 - 2. In order for a helper T cell to become activated, it must first encounter a macrophage displaying the antigen on its major histocompatibility complex (MHC) proteins; if the antigen fits the helper T cell's antigen receptor, it becomes activated and stimulates B cells to produce antibodies.
 - 3. Cytotoxic T cells continually monitor the body's cells, recognizing and eliminating tumor cells and virus-infected cells by release of proteins, cutting holes and by other means.
 - a. Cytotoxic T cells become activated when an antigen binds to its receptors.
 - 3. Memory T cells provide a no-delay response to any future exposure to the same antigen.
- F. B Cells and the Humoral Immune Response (Fig. 14.14; Table 14.2)
 - 1. A B cell may become activated and produce a clone of cells when its antigen receptor encounters its matching antigen, but most B cells need helper T cells for activation.
 - 2. When a helper T cell encounters a B cell that has itself encountered an antigen, the helper T cell releases cytokines that activate the B cell so that it can divide and form a clone.
 - 3. Some of the B cells become plasma cells, producing and secreting antibodies.
 - 4. Like T cells, some of the B cells become memory cells to respond to future encounters with the antigen.
- G. Types of Antibodies
 - 1. There are five major types of antibodies (immunoglobulins) that constitute the gamma globulin fraction of the plasma.
 - a. IgG is in tissue fluid and plasma and defends against bacterial cells, viruses, and toxins and activates complement.
 - b. IgA is in exocrine gland secretions (breast milk, saliva, tears) and defends against bacteria and viruses.
 - c. IgM is found in plasma and activates complement and reacts with blood cells during transfusions.
 - d. IgD is found on the surface of most B lymphocytes and functions in B cell activation.
 - e. IgE is found in exocrine gland secretions and promotes allergic reactions.
- H. Antibody Actions (Fig. 14.15)
 - 1. Antibodies can react to antigens in three ways: direct attack, activation of complement, or stimulation of changes in areas that help prevent the spread of the pathogens.
 - 2. Direct attack methods include agglutination, precipitation, and neutralization of antigens.
 - 3. The activation of complement can produce opsonization, chemotaxis, inflammation, or lysis in target cells or antigens.
- I. Immune Responses (Figs. 14.14, 14.16)
 - 1. When B or T cells become activated the first time, their actions constitute a primary immune response, after which some cells remain as memory cells.
 - 2. If the same antigen is encountered again, more numerous memory cells can mount a more rapid response, known as the secondary immune response.
 - a. The ability to produce a secondary immune response may be long-lasting.
- J. Practical Classification of Immunity (Table 14.3)
 - 1. Naturally acquired active immunity occurs after exposure to the antigen itself.
 - 2. Artificially acquired active immunity occurs through the use of vaccines, without the person becoming ill from the disease.

3. Artificially acquired passive immunity involves the injection of gamma globulin containing antibodies and is short-lived.
 4. Naturally acquired passive immunity occurs as antibodies are passed from mother to fetus and is short-lived.
- K. Allergic Reactions
1. Allergic reactions to allergens are excessive immune responses that may lead to tissue damage.
 2. Delayed-reaction allergy results from repeated exposure to substances that cause inflammatory reactions in the skin.
 3. Immediate-reaction allergy is an inherited ability to overproduce IgE.
 4. During allergic reactions, mast cells release histamine and leukotrienes, producing a variety of effects.
 5. Allergy mediators sometimes flood the body, resulting in anaphylactic shock, a severe form of immediate-reaction allergy.
- L. Transplantation and Tissue Rejection
1. A transplant recipient's immune system may react with foreign antigens on the surface of the transplanted tissue, causing a tissue rejection reaction.
 2. Close matching of donor and recipient tissues can reduce the chances of tissue rejection, and use of immunosuppressive drugs may reduce rejection, although the individual may be more susceptible to infection.
- M. Autoimmunity
1. In autoimmune disorders, the immune system manufactures antibodies against some of its own antigens.
 2. Autoimmune disorders may result from viral infection, faulty T cell development, or reaction to a nonself antigen that bears close resemblance to a self antigen.