UNIT 8 - BLOOD / LYMPHATIC / CARDIOVASCULAR SYSTEMS
LECTURE NOTES

8.01 COMPONENTS OF THE BLOOD AND THEIR FUNCTIONS

Blood is the complex transport medium that performs vital transportation services for the body. It picks up food and oxygen from the digestive and respiratory systems and delivers them to the body cells while picking up their waste products. Blood also transports hormones, enzymes, antibodies, buffers, and other critical biochemical substances. Blood also helps regulate heat in the body. There are four components of the blood: erythrocytes, leukocytes, thrombocytes, and plasma.

A. Erythrocytes
   Erythrocytes are the red blood cells or RBCs. They are responsible for transporting both oxygen and carbon dioxide.

B. Leukocytes
   Leukocytes are the white blood cells or WBCs. They are responsible for protecting the body against infection.

C. Thrombocytes
   Thrombocytes are the platelets or plts. They assist in hemostasis and blood clotting.

D. Plasma
   Plasma is the fluid portion of blood. It consists mostly of water and also carries dissolved substances such as electrolytes, hormones, gases, and organic compounds.

8.02 DESCRIBE ERYTHROCYTES AND THE STRUCTURE OF HEMOGLOBIN

A. Erythrocytes
   1. Erythrocytes are the most numerous of all formed elements. Men average approximately 5.5 million per cubic millimeter of blood while women average 4.8 million per cubic millimeter of blood.
   2. The mature erythrocyte is an anucleated biconcave disc approximately 7 mm in diameter.
   3. Are produced from the bones in the red bone marrow.
   4. At maturity, the erythrocyte does not contain ribosomes, mitochondria, or other organelles found in most body cells to make room for the principle pigment, hemoglobin.
   5. The advantage of the biconcave disk shape is the cell can move without injury through the narrow blood capillaries.
B. Hemoglobin
   1. The principle pigment of the erythrocyte.
   2. Hemoglobin is composed of four protein chains called the globin each
      containing a red pigment called heme. The heme is composed of an iron
      atom.
   3. The heme transports oxygen while the globin transports carbon dioxide.
   4. It is estimated each erythrocyte contains 200 to 300 million molecules of
      hemoglobin.

8.03 LEUKOCYTES

A. Description
   The leukocytes are nucleated cells capable of dividing and living for years. They
   are larger than erythrocytes. They help protect the body from infection and provide
   immunity. There are 5,000 - 10,000 leukocytes per cubic millimeter. They are
   produced in the red bone marrow of bones. There are five types of leukocytes.

B. Types of Leukocytes
   1. Granulocytes
      These leukocytes have protein granules in their cytoplasm. There are three
      specific types.
      a. Neutrophils
         Neutrophils have cytoplasmic granules which stain pink or light purple.
         They are the most numerous of all leukocytes, about 60% of the total
         count. The nuclei are divided into two, three, or four lobes. The
         neutrophils help to protect the body by performing phagocytosis.
      b. Basophils
         Basophils have large cytoplasmic granules which stain dark blue or
         purple. These cells are very mobile and travel easily throughout the body.
         Their nuclei resemble an S-shape. These cells produce histamine (used
         in the inflammation response) and heparin (an anticoagulant used to
         prevent blood clotting).
      c. Eosinophils
         Eosinophils contain large cytoplasmic granules which stain reddish-
         orange. Their nuclei contain two lobes and resemble head phones.
         Eosinophils ingest inflammatory chemicals and proteins and help to
         protect against allergens.
   2. Agranulocytes
      These leukocytes do not have large granules in the cytoplasm. There are two
      specific types.
a. Monocytes
Monocytes are the largest of all leukocytes. They have dark kidney bean-shaped nuclei surrounded by large amounts of a distinctive light bluish-gray cytoplasm. These cells are very mobile and protect the body by performing phagocytosis.

b. Lymphocytes
Lymphocytes are the smallest of all leukocytes. They have large spherical nuclei surrounded by a limited amount of pale blue stained cytoplasm. The lymphocytes will specialize into the T-lymphocytes (T-cells) and the B-lymphocytes (B-cells). The T-cells are responsible for directly attacking antigens or infected cells while the B-cells produce antibodies.

8.04 HEMOSTASIS AND COAGULATION

A. Description
Hemostasis refers to stopping bleeding which is extremely important when the blood vessels are damaged to prevent excessive blood loss. These mechanisms are most effective in slowing down blood losses from smaller blood vessels. Damage to larger vessels will require additional interventions to slow down and stop the bleeding. There are three stages including vascular spasm, platelet plug formation, and coagulation.

B. Three Stages

1. Vascular Spasm
Vascular Spasm occurs when an arteriole or venule is broken or has been cut. The smooth muscles in the blood vessel wall are stimulated to contract and the blood loss is decreased almost immediately. The reflex response may last only a few minutes, but the effect will last for around 30 minutes. Serotonin, a chemical released by the platelets, also stimulates the blood vessel walls to contract.

2. Platelet Plug Formation
Platelets tend to stick to the exposed ends (collagen) of injured blood vessels. Actually, platelets stick to any rough surface which makes internal blood clotting possible. When the platelets come into contact with the collagen, their shapes actually change and many spiny processes begin to extend from their membranes. At the same time, the platelets stick to each other to form a platelet plug in the blood vessel break.

3. Coagulation
   a. Coagulation is the actual formation of a blood clot. It is the most effective of all of the hemostatic mechanisms.
   b. There are two mechanisms associated with blood clotting -- the intrinsic mechanism and the extrinsic mechanism. The intrinsic mechanism is triggered by the release of chemical substances from the platelets while the extrinsic mechanism is triggered by the release of chemical substances released from the damaged blood vessels and tissues.
c. The process of coagulation depends on the presence of clotting factors (blood proteins produced by the liver) as well as calcium ions in the blood.
d. The basic event in blood coagulation is the conversion of the soluble plasma protein fibrinogen to relatively insoluble threads of protein fibers. These form a strong netting over the blood vessel to hold the ends together while healing occurs.

8.05 THROMBUS AND EMBOLUS

A. Thrombus (plural - thrombi)
   1. A thrombus is a blood clot that has formed abnormally in a blood vessel.
   2. May be life-threatening because the clot may occlude a blood vessel and stop the blood supply to an organ or body part.
   3. Predisposing factors for thrombi include heart and blood vessel disorders, atherosclerosis, obesity, heredity, age, immobility, smoking, and the use of oral contraceptives.
   4. Treatment includes the use of anticoagulants.

B. Embolus (plural - emboli)
   1. An embolus occurs when a thrombus has become dislodged or fragmented and is carried away from the original site by the flow of the blood.
   2. The embolus will travel until they reach a narrow place in vessels where they become lodged and will obstruct blood flow distal to where it is stuck.
   3. Emboli may be solid, liquid, or gas. They may consist of tissue, tumor cells, globules of fat, air bubbles, clumps or bacteria, and foreign bodies.
   4. Emboli typically affect four organs -- the heart, lungs, brains, and the kidneys.
   5. Treatment includes the use of anticoagulants and basket filters to try to trap the emboli.
8.06 BLOOD TYPES

There are four blood types -- A, B, AB, and O. Blood types are based on the type of antigen or protein located on the surface of the erythrocyte membranes. Each blood type also has an antibody found in the blood plasma which attaches to a specific antigen and destroys them.

<table>
<thead>
<tr>
<th>Type</th>
<th>Antigen</th>
<th>Antibody</th>
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<tbody>
<tr>
<td>A</td>
<td>Antigen A</td>
<td>Antibody B</td>
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<tr>
<td>B</td>
<td>Antigen B</td>
<td>Antibody A</td>
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<tr>
<td>AB</td>
<td>Antigens A and B</td>
<td>Neither antibody A or antibody B</td>
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<tr>
<td>O</td>
<td>Neither antigen A or antigen B</td>
<td>Both antibodies A and B</td>
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The Rh Factor

The Rh factor refers to the presence or absence protein D on the surface of the erythrocyte membranes. Rh + refers to the presence of protein D on the surface of the erythrocyte membrane. Rh- refers to the absence of protein D on the surface of the erythrocyte membrane.

8.07 DISEASES AND DISORDERS OF THE BLOOD

A. Anemia
B. Hemolytic Disease of the Newborn
C. Hemophilia
D. Leukemia
E. Mononucleosis
F. Polycythemia
8.08 THE COMPONENTS OF THE LYMPHATIC SYSTEM

A. Tonsils
   1. Description and Location
      The tonsils are large lymphoid nodules located in the wall of the pharynx, including the adenoids and palatine tonsils.
   2. Function
      The mouth is a port of entry into the body for harmful organisms we breathe, as well as those found in the food we eat, the tonsils help to destroy them.

B. Spleen
   1. Description and Location
      The spleen is the largest collection of lymphatic tissue in the body. It is located in the LUQ, lateral to the stomach. It has a deep red color because of all the blood it contains. It contains areas of white pulp which resemble lymphoid nodules and red pulp which contains large quantities of blood.
   2. Functions
      The spleen is able to filter the blood and remove damaged or infected cells. It also helps to initiate the immune response when antigens are detected in the blood. In addition, the spleen functions as a large blood reservoir.

C. Thymus
   1. Description and Location
      The thymus is posterior to the sternum and superior to the heart. It is a two lobed structure consisting of two layers -- a cortex and a medulla. It reaches its greatest size the first two years after birth and gradually shrinks with age.
   2. Function
      The thymus gland produces a hormone called thymosin which helps to mature lymphocytes into T lymphocytes (T cells).

D. Lymph Nodes
   1. Description and Location
      The lymph nodes are small, oval, lymphatic organs which are surrounded by a fibrous capsule and located in clusters along the lymphatic vessels. They contain large numbers of lymphocytes. They are clustered in the cervical, axillary, inguinal regions and in the abdominal cavity.
   2. Function
      The lymph nodes filter and purifies the lymph before it is returned to the blood.

E. Bone Marrow
   1. Description and Function
   2. Lymph Vessels
8.09 MOVEMENT OF LYMPH THROUGH THE BODY

A. Movement of Lymph Through Lymphatic Vessels
Lymph is transported along a network of vessels beginning with the lymphatic capillaries. From there, lymph is transported into lymphatic vessels which empty into the thoracic duct and the right lymphatic duct. Eventually, these lymphatic ducts drain lymph into the subclavian veins and back into the blood.

B. Mechanisms Moving Lymph
The movement of lymph through the lymphatic vessels is similar to the processes which control the movement of blood through the veins.
   1. Pressure gradients caused by the physical movement of breathing.
   2. Skeletal muscle contractions which help to move lymph along the lymphatic vessels.
   3. Valves in the lymphatic vessels which help to assist the one-way movement of lymph.

8.10 CONTRAST ANTIGENS AND ANTIBODIES

A. Antigens
   A foreign protein capable of initiating the immune response and the production of antibodies.

B. Antibodies
   A globular protein produced by the B-plasma cells which will bind to specific antigens and promote their destruction or removal from the body.

8.11 ROLES OF T CELLS AND B CELLS IN THE IMMUNE RESPONSE

A. T-CELLS
   T cells are white blood cells which have matured in the thymus gland under the influence of the hormone thymosin. They function in CMI or cell-mediated immunity. The T cells are responsible for directly attacking antigens and antigen-infected cells.
   1. Cytotoxic T Cells
      These cells are known as the killer T cells which help to track down bacteria, fungi, protozoa, or foreign tissues that contain antigens.
   2. Helper T Cells
      Helper T cells release a variety of chemicals which helps to coordinate specific and nonspecific defenses, help to stimulate cell-mediated immunity and antibody-mediated immunity by helping stimulate the production of T cells and B cells.
   3. Memory T Cells
      Memory T cells store a code of the antigen which may be used if the antigen appears a second time. These cells will immediately differentiate into the cytotoxic T cells producing a more rapid and effective cellular response.
4. Suppressor T Cells
Suppressor T cells stop the responses of the T cells and the B cells when the level of the antigen has decreased.

B. B Cells
B cells are white blood cells which have been produced in the bone marrow and matured in an unknown location -- probably the bone marrow. They are responsible for AMI or antibody mediated immunity which launches a chemical attack on the antigens.

1. Plasma Cells
Plasma cells, sometimes referred to as B plasma cells, make and secrete large numbers of antibodies that will fight against antigens. Antibodies function by the following ways:
   a. neutralization preventing the antigen from attaching to a cell
   b. agglutination the process of clumping antigens together
   c. activation of the complement which helps to destroy the antigen
   d. antigens covered with antibodies attract the phagocytic white blood cells including the neutrophils, macrophages, and eosinophils.
   e. enhancement of phagocytosis
   f. the inflammation response to localize an infection by releasing histamine causing redness, swelling, heat, and pain.

2. Memory B Cells
Memory B cells help to deal with a second exposure to the same antigens. At that time, they respond and differentiate into antibody-secreting plasma cells providing a rapid response to the antigen.

8.12 ACTIVE AND PASSIVE IMMUNITY AND NATURAL VERSUS ARTIFICIAL ACQUISITION OF IMMUNITY

A. Active Immunity
Active immunity occurs when the person has been exposed to an antigen and the body produces antibodies in the immune response.

B. Passive Immunity
Passive Immunity occurs when the person has been given the antibodies to fight a specific antigen.

C. Natural Immunity
Natural immunity begins at birth and is enhanced as the individual is exposed to new antigens which the person makes antibodies to fight against them. Natural may also refer to the passing of antibodies from the mother to the fetus and the mother to baby as she breastfeeds the infant.
D. Artificial Immunity

Artificial immunity stimulates the production of antibodies under controlled conditions so the individual will be able to overcome any natural exposure to the same type of antigen in the future. This includes the use of vaccinations to help the body stimulate the immune response. It may also refer to the injection of ready-made antibodies such as gamma globulins to help fight infections.

8.13 DISEASES AND DISORDERS ASSOCIATED WITH THE LYMPHATIC SYSTEM

A. AIDS
B. Measles
C. Mumps
D. Rubella
E. Tetanus

8.14 GENERAL FUNCTIONS OF THE CARDIOVASCULAR SYSTEM

A. The cardiovascular system, sometimes known as a part of the circulatory system, is composed of the heart and a closed system of blood vessels through which blood is circulated.
B. The primary function is circulation. Critical transportation needs include movement of oxygen and carbon dioxide, heat, nutrients, hormones, waste products, enzymes, electrolytes, and other substances on a continuing basis.

8.15 LAYERS OF THE HEART

There are three distinct layers that compose the heart wall. They include the epicardium, the myocardium, and the endocardium.

A. Epicardium

The epicardium is the outermost layer. It is a serous membrane which is composed of epithelial tissue and some connective tissue. It provides a small amount of protection to the heart.

B. Myocardium

The myocardium is the middle, muscular wall of the heart. It is composed of cardiac muscle, blood vessels, and nerves. The muscular layer is responsible for pumping the blood through the heart and into the great vessels.

C. Endocardium

The endocardium is the most inner layer. It is composed of epithelial tissue and is a very smooth lining. The blood passing through the heart is in contact with this layer.
8.16 CHAMBERS OF THE HEART

A. General Description
   1. The human heart is a four-chambered muscular organ, the size and shaped roughly of a person’s closed fist.
   2. It lies in the mediastinum or the middle region of the thorax.
   3. There are two upper chambers of the heart known as atria (singular, atrium) and two lower chambers called ventricles.
   4. The left chambers are separated from the right chambers by an extension of the heart wall called the septum.

B. The Atria (singular: Atrium)
   1. The atria are the two superior chambers and are called the “receiving chambers” because they receive blood from vessels called veins. The right atrium receives deoxygenated blood from the superior vena cava, the inferior vena cava, and the coronary sinus. The left atrium receives oxygenated blood from the pulmonary veins and the lungs.
   2. The atria are thin-muscular walled chambers which allow blood flow into the ventricles.

C. The Ventricles
   1. The ventricles are the two inferior chambers. They are often called the “pumping chambers” because they pump blood out of the heart and into blood vessels known as arteries. The right ventricle pumps deoxygenated blood into pulmonary arteries which take blood to the lungs. The left ventricle pumps oxygenated blood into the aorta.
   2. More force is needed to pump blood through the body, the myocardium of each ventricle is thicker than the myocardium of the atria.
   3. The myocardium of the left ventricle is the thickest layer because the left ventricle pumps blood into the whole body while the right ventricle pumps blood into the lungs.

8.17 THE GREAT BLOOD VESSELS OF THE HEART

A. The Superior Vena Cava
   The superior vena cava drains deoxygenated blood from veins in the head, neck, and arm regions into the right atrium.

B. The Inferior Vena Cava
   The inferior vena cava drains deoxygenated blood from veins in the abdomen and legs into the right atrium.
C. Pulmonary Trunk
The pulmonary trunk is the first portion of the pulmonary artery. It arises directly from the right ventricle after the pulmonary semilunar valve. The pulmonary trunk branches to form the left and right pulmonary arteries.

D. Pulmonary Arteries
The pulmonary arteries branch from the pulmonary trunk to take deoxygenated blood to the lungs where carbon dioxide - oxygen gas exchange occurs.

E. Pulmonary Veins
The pulmonary veins take the oxygenated blood from the lungs into the left atrium of the heart.

F. The Aorta
1. The aorta is the largest artery in the body extending from the left ventricle after the aortic semilunar valve. It arches and descends into the lower abdomen.
2. There are many arteries which branch from the aorta to deliver oxygen-rich blood to the body tissues. The major branches of the aorta include the coronary arteries, and from the aortic arch, the brachiocephalic artery, left common carotid artery, and the left subclavian artery.
   a. As the aorta leaves the left ventricle, the first branches of the aorta include the coronary arteries, which supply the myocardium with oxygen-rich blood.
   b. The brachiocephalic artery will transport blood into arteries supplying the right arm and the right side of the head.
   c. The left common carotid artery transport blood into arteries which will supply the left side of the head.
   d. The left subclavian artery transports blood into arteries of the left arm.

8.18 HEART VALVES

A. Description of Heart Valves
1. The heart valves are flap-like structures permitting the flow of blood in one direction only.
2. Four valves are of importance to the normal functioning of the heart.
3. The valves are formed from the endocardium.
4. There are four valves: tricuspid valve, pulmonary semilunar valve, bicuspid (mitral) valve, and the aortic semilunar valve.

B. The Four Specific Heart Valves
1. Tricuspid Valve
   The tricuspid valve is located between the right atrium and the right ventricle. It is composed of three flaps (cusps).
2. Pulmonary Semilunar Valve
   The pulmonary semilunar valve is located between the right ventricle and the pulmonary trunk. It is composed of three half-moon shaped flaps.

3. Bicuspid (Mitral Valve)
   The bicuspid valve is located between the left atrium and the left ventricle. It is composed of two flaps (cusps).

4. Aortic Semilunar Valve
   The aortic semilunar valve is located between the left ventricle and the aorta. It is composed of three half-moon shaped flaps.

8.19 THE FLOW OF BLOOD THROUGH THE HEART

A. The superior vena cava drains deoxygenated blood from the head, neck, and arms while the inferior vena cava drains deoxygenated blood from the abdomen and the legs into the right atrium. The coronary sinus drains deoxygenated blood from the myocardium into the right atrium.
B. From the right atrium, deoxygenated blood flows through the tricuspid valve into the right ventricle.
C. From the right ventricle, deoxygenated blood flows through the pulmonary semilunar valve into the pulmonary trunk.
D. The pulmonary trunk branches to form the right and left pulmonary arteries, which take deoxygenated blood to the lungs for gas exchange. Carbon dioxide is released from the blood while oxygen is picked up by the blood.
E. Oxygenated blood returns through the right and left pulmonary veins into the left atrium.
F. From the left atrium, oxygenated blood flows through the bicuspid (mitral) valve into the left ventricle.
G. From the left ventricle, oxygenated blood flows through the aortic semilunar valve into the aorta.
H. From the aorta, oxygenated blood flows into arteries, arterioles, capillaries, venules, and veins, eventually reaching the superior and inferior vena cava once again.
I. The body’s entire blood supply is circulated every minute.

8.20 THE CARDIAC CONDUCTION SYSTEM

A. Description
   The cardiac conduction system, sometimes called the intrinsic conduction system is the heart’s own internal conducting system which allows it to control its own beat exhibiting the property of autorhythmicity.

B. The heart beat may be modified by nerve impulses sent from the brain.

C. There are five parts to the cardiac conduction system: SA Node, AV Node, AV Bundle, Bundle Branches, and Conduction (Purkinje) Fibers.
1. The normal cardiac impulse that initiates myocardial contraction begins in the SA (sinoatrial) node located in the upper right atrium. The SA node is known as the pacemaker. This means even without any stimulation by nerve impulses from the brain and the spinal cord, the SA node initiates impulses at regular intervals. (Even if the heart is removed from the body, it will continue to beat on its own for a period of time.). Each impulse generated at the SA node travels swiftly through the myocardium of both atria causing atrial contraction.

2. The nerve impulse will enter the AV (atrioventricular) node located at the inferior part of the right atrium which will slow down the nerve impulse allowing for the complete contraction of both atrial chambers.

3. The impulse is relayed through the AV bundle (Bundle of His) into the right and left bundle branches. These bundle branches will take impulses to the right and left ventricles.

4. The impulse will continue into the conduction (Purkinje) fibers which stimulates the myocardium of both ventricles to contract simultaneously.

8.21 THE CARDIAC CYCLE

A. Description of the Cardiac Cycle
   1. The term cardiac cycle refers to one complete heartbeat consisting of both contraction (systole) and relaxation (diastole) of both the atria and the ventricles.
   2. The atria will contract simultaneously and then, as the atria relax, the two ventricles contract and relax.

B. Steps of the Cardiac Cycle
   1. When the atria are relaxed, the blood flows into them from the superior and inferior vena cavae as well as the coronary sinus.
   2. As these chambers fill, the pressure within the atria gradually increases.
   3. About 70% of the blood within the atria flows directly into the ventricles (which are in ventricular diastole) through the AV orifices before the atrial walls contract.
   4. During atrial systole, the atrial pressure rises greatly which forces the remaining 30% of the atrial blood into the ventricles.
   5. This is followed by atrial diastole.
   6. Blood will fill the ventricles which increases the pressure within them.
   7. Eventually, ventricular systole occurs and blood is forced into the pulmonary trunk and the aorta.
   8. As ventricular systole occurs, the AV valves, (tricuspid and bicuspid valves) guarding the atrioventricular orifices close passively and begin to bulge back into the atria which increases atrial pressure.
   9. At the same time, the papillary muscles contract and by pulling on the chordae tendineae, they prevent the cusps of the AV valves from bulging too far into the atria.
10. During ventricular systole, the AV valves remain closed and the atrial pressure gradually increases as the atria fill with the blood.
11. At the same time, the pulmonary semilunar valve and the aortic semilunar valve open allowing the blood to flow into the pulmonary trunk and the aorta.
12. When the ventricles are nearly empty and the pressure begins to drop, the pulmonary semilunar valve and the aortic semilunar valve are closed by arterial blood flowing back toward the ventricles.
13. During ventricular diastole the AV valves open passively and the blood flows through them from the atria into the ventricles.

8.22 STROKE VOLUME AND HEART RATE

A. Stroke Volume
Stroke volume (SV) is the volume of blood pumped with each heartbeat. For the purpose of making calculations, one can assume a normal stroke volume of 70 ml (milliliters).

B. Heart Rate
Heart rate (HR) is the number of heart beats in one minute. Generally, normal heart beats per minute range from 60 to 100.

C. Cardiac Output
Cardiac Output (CO) is determined by the volume of blood pumped out of the ventricles by each beat (stroke volume or SV) and by heart rate (HR).

\[ SV \times HR = CO \]

D. Factors Affecting Cardiac Output
1. Anything that makes the heart beat faster or anything that makes it stronger (which will increase the stroke volume) will increase cardiac output. This can include exercise, stress, medications, the effects of nicotine, etc.
2. Anything that tends to cause the heart to beat more slowly. This can include a well-conditioned heart which would be slow and strong, medication, sleep, and genetics.

8.23 ARTERIES, VEINS, AND CAPILLARIES

A. Arteries
1. An artery is a blood vessel which transports blood away from the heart.
2. After birth, all arteries except the pulmonary artery and its branches transport oxygenated blood.
3. Small arteries are called arterioles.
4. The arteries are composed of three layers:
   a. Tunica externa (adventitia). The tunica externa (the outer layer) is composed of fibrous connective tissue and provides flexible support that resists collapse or injury.
b. Tunica media. The tunica media (the middle layer) is composed of smooth muscle and elastic connective tissue. It allows for constriction and dilation of the blood vessels. It is innervated by the autonomic nervous system (the sympathetic and parasympathetic divisions).

c. Tunica intima (endothelium). The tunica intima (the inner layer) is composed of epithelial tissue and provides a smooth inner lining.

B. Veins
1. A vein is a blood vessel which transport blood toward the heart.
2. All of the veins except the pulmonary veins transport deoxygenated blood.
3. Small veins are called venules.
4. The veins are composed of same three layers found in arteries.
5. The veins are composed of three layers
   a. Tunica externa (adventitia). The tunica externa (the outer layer) is composed of fibrous connective tissue and provides flexible support that resists collapse or injury.
   b. Tunica media. The tunica media (the middle layer) is composed of smooth muscle and elastic connective tissue. It allows for constriction and dilation of the blood vessels. It is innervated by the autonomic nervous system (the sympathetic and parasympathetic divisions).
   c. Tunica intima (endothelium). The tunica intima (inner layer) is composed of epithelial tissue and provides a smooth inner lining. It is also modified with valves to ensure the flow of blood in one direction.
6. The major difference between veins and arteries is that the layers of the veins are thinner and the tunica intima forms valves

C. Capillaries
1. A capillary is a small vessel which carries blood from the arterioles to the venules.
2. It is the site nutrients and wastes exchange between the blood and the body cells.
3. The capillary is composed only of a single layer of endothelium (tunica intima). The thinness permits ease of nutrient and waste transport across the blood vessel wall with the body cells.

8.24 PULSE AND PULSE POINTS

A. Definition
1. A pulse is defined as the alternate expansion and recoil of an artery.
2. It is caused when the blood from the heart is pumped into the aorta intermittently resulting in an alternating increase and decrease in the pressure of the aorta and then the arteries.
3. It is also the result of the elasticity of the artery allows which allows them to expand and recoil with the changing pressures.
B. Pulse Points
   1. Definition
      The pulse can be felt wherever an artery lies near the surface and over a
      bone or other firm background.
   2. Locations of Pulse Points
      a. Radial artery is felt at the wrist on the thumb side. May be used to take a
         patient's pulse when taking the vital signs.
      b. Temporal artery is felt in front of the ear or above and to the outer side of
         the eye.
      c. Common carotid artery is felt along the sides of the trachea.
      d. Facial artery is felt at the lower margin of the lower jawbone.
      e. Brachial artery is felt at the inner bend of the elbow in the antecubital
         space. This artery is commonly used to measure the blood pressure.
      f. Femoral artery is located in the groin.
      g. Popliteal artery is felt in the area behind the knee.
      h. Dorsalis pedis artery is felt on the upper surface of the foot.

8.25 BLOOD PRESSURE

A. Measurement of Blood Pressure
   1. Blood pressure is measured with the aid of an apparatus known as a
      sphygmomanometer, which makes it possible to measure the amount of air
      pressure equal to the blood pressure in an artery.
   2. The measurement is made in terms of how many millimeters high the air
      pressure raises a column of mercury in a glass tube, although we do not use
      mercury blood pressure cuffs.
   3. The sphygmomanometer usually consists of a cuff which is wrapped around
      the arm over the brachial artery.
   4. Air is pumped into the cuff by means of the bulb. In this way, air pressure is
      exerted against the outside of the artery. Air is added until the air pressure
      exceeds the pressure within the artery which means the artery is
      compressed.
   5. At this time, no pulse can be heard through a stethoscope placed over the
      brachial artery at the antecubital space.
   6. By slowly releasing the air in the cuff, the air pressure is decreased until it
      approximately equals the blood pressure within the artery.
   7. At this point, the vessel opens slightly and a small spurt of blood comes
      through producing sounds with a rather sharp, tap like quality.
   8. This is followed by increasingly louder sounds that suddenly change
      becoming more muffled and disappearing altogether. These sounds are
      called Korotkoff sounds.
   9. The first sound is read which indicates the systolic blood pressure. Systolic
      blood pressure is the force with which the blood is pushing against the artery
      walls when the ventricles are contracting.
10. The lowest point at which the sounds can be heard, just before they disappear, is approximately equal to the diastolic blood pressure or the force of the blood when the ventricles are relaxed.

B. Blood pressure is used to measure the health of the heart and blood vessels. Normal blood pressure is between 100/60 and 120/80. A new, prehypertensive category has been created for blood pressures between 120/80 and 139/89. These people should have their blood pressure evaluated more frequently by their health care professional. Hypertension or high blood pressure includes any reading about 140/90.

8.26 PULMONARY AND SYSTEMIC CIRCULATION ROUTES

A. Pulmonary Circulation
   1. Description
      Pulmonary Circulation involves the structures of the heart associated with transporting deoxygenated blood from the body tissues to the lungs where gas exchange occurs.
   2. The Pulmonary Pathway
      Deoxygenated blood enters the right atrium of the heart from the inferior vena cava, the superior vena cava, and the coronary sinus. Deoxygenated blood moves through the tricuspid valve and into the right ventricle. From there, deoxygenated blood is pumped past the pulmonary semilunar valve, into the pulmonary trunk, the pulmonary arteries and into the lungs where gas exchange occurs.

B. Systemic Circulation
   1. Description
      Systemic Circulation involves the structures of the heart associated with transporting oxygenated blood from the lungs to the body tissues.
   2. The Systemic Pathway
      Oxygenated blood is transported through the pulmonary veins into the left atrium of the heart. Oxygenated blood moves through the bicuspid valve and into the left ventricle. From there, oxygenated blood is pumped past the aortic semilunar valve, the aorta, and into one of its many branches eventually reaching the body tissues by means of arteries, arterioles, and capillaries.