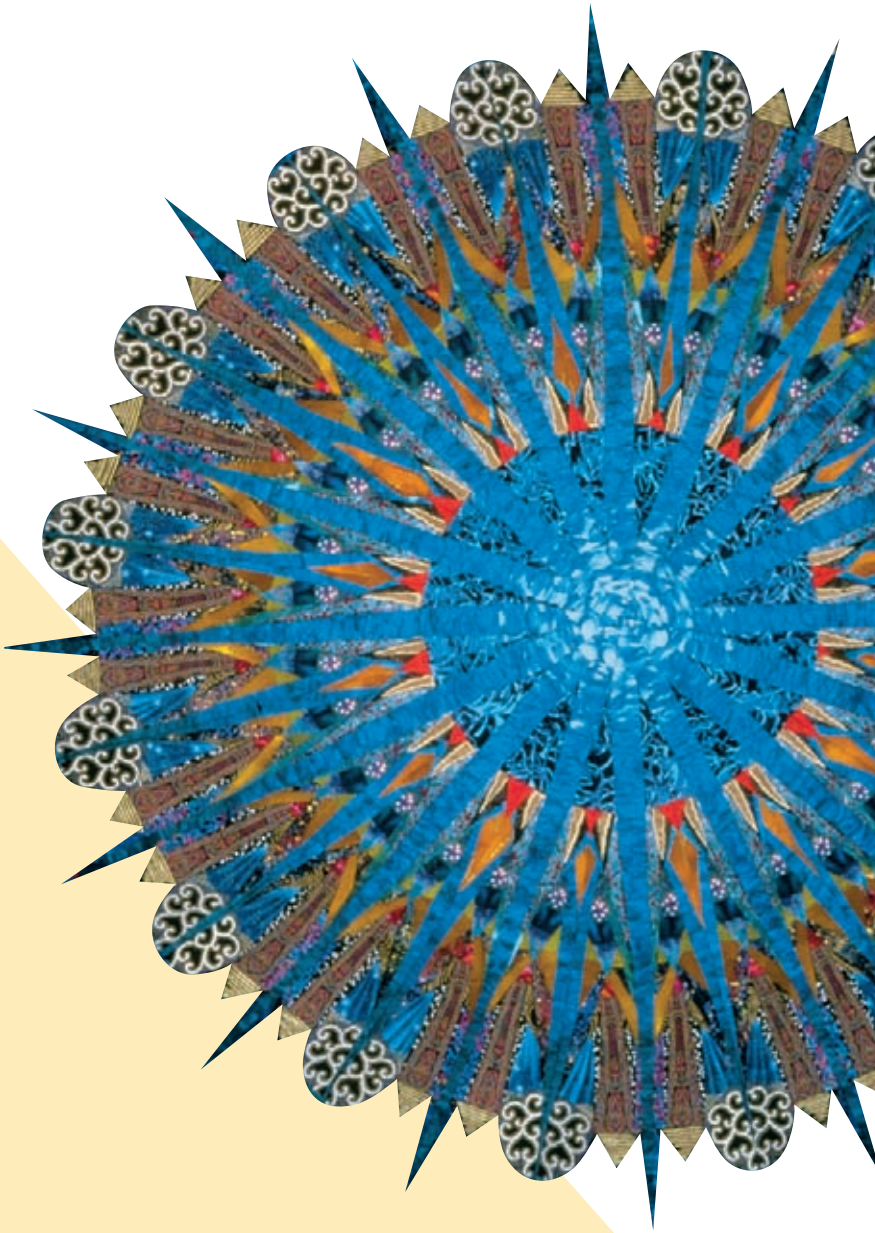
UNIT 10 Responses to Altered Peripheral Tissue Perfusion



CHAPTER 33
Assessing Clients with Hematologic, Peripheral Vascular, and Lymphatic Disorders

CHAPTER 34
Nursing Care of Clients with Hematologic Disorders

CHAPTER 35
Nursing Care of Clients with Peripheral Vascular Disorders

CHAPTER 33 Assessing Clients with Hematologic, Peripheral Vascular, and Lymphatic Disorders

LEARNING OUTCOMES

- Describe the anatomy, physiology, and functions of the hematologic, peripheral vascular, and lymphatic systems.
- Explain the physiologic dynamics of blood flow, peripheral resistance, and blood pressure.
- Compare and contrast the major factors influencing arterial blood pressure.
- Describe normal variations in assessment findings for the older adult.
- Identify manifestations of impairment in the function of the hematologic, peripheral vascular, and lymphatic systems.

CLINICAL COMPETENCIES

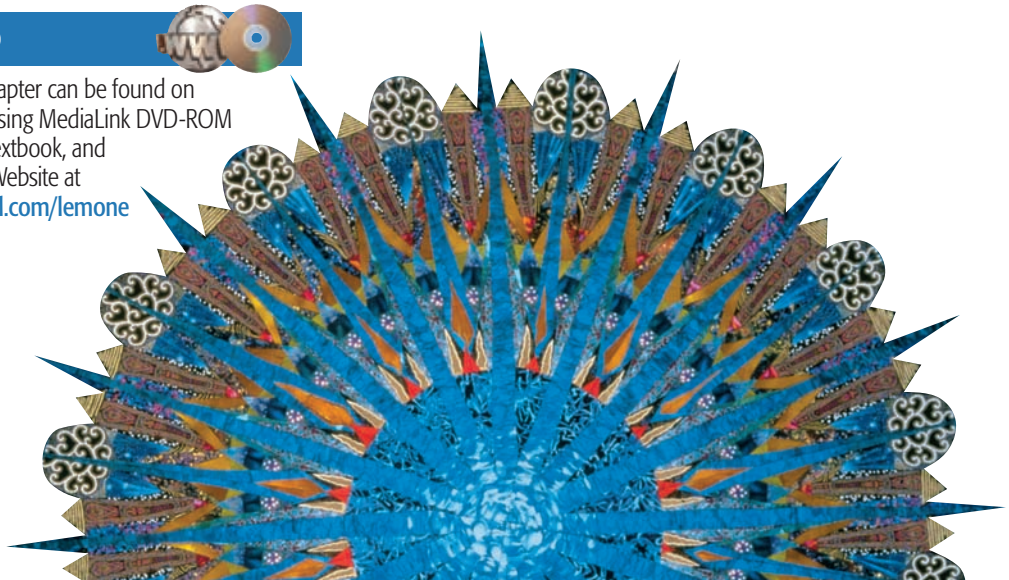
- Conduct and document a health history for clients having or at risk for alterations in the hematologic, peripheral vascular, and lymphatic systems.
- Conduct and document a physical assessment of hematologic, peripheral vascular, and lymphatic status.
- Monitor the results of diagnostic tests and report abnormal findings.

EQUIPMENT NEEDED

- Stethoscope
- Blood pressure cuff
- Tape measure
- Metric ruler
- Doppler ultrasound device (if unable to auscultate blood pressure or palpate pulse)
- Transducer gel for Doppler device

MEDIALINK

Resources for this chapter can be found on the Prentice Hall Nursing MediaLink DVD-ROM accompanying this textbook, and on the Companion Website at http://www.prenhall.com/lemone



KEY TERMS

anemia, *1076*
auscultatory gap, *1092*
blood flow, *1082*
blood pressure, *1085*
erythropoiesis, *1076*
hemolysis, *1078*
hemostasis, *1079*
Korotkoff's sounds, *1092*
leukocytosis, *1079*
leukopenia, *1079*
lymphadenopathy, *1098*
lymphedema, *1093*
mean arterial pressure (MAP), *1085*
orthostatic hypotension, *1093*
peripheral vascular resistance (PVR), *1082*
polycythemia, *1076*
pulse, *1082*
pulse pressure, *1093*

As the heart ejects blood with each beat, a closed system of blood vessels transports oxygenated blood to all body organs and tissues and then returns deoxygenated blood to the heart for reoxygenation in the lungs. The blood components are the hematologic system, and the branching network of vessels is the peripheral vascular system: the arteries, veins, and capillaries. The lymphatic system is a special vascular system that helps maintain sufficient blood volume in the cardiovascular system by picking up excess tissue fluid and returning it to the bloodstream.

ANATOMY, PHYSIOLOGY, AND FUNCTIONS OF THE HEMATOLOGIC SYSTEM

Blood is an exchange medium between the external environment and the body's cells. Blood consists of plasma, solutes (e.g., proteins, electrolytes, and organic constituents), red blood cells, white blood cells, and platelets (which are fragments of cells). The hematopoietic (blood-forming) system includes the bone marrow (myeloid) tissues, where blood cells form, and the lymphoid tissues of the lymph nodes, where white blood cells mature and circulate. All blood cells originate from cells in the bone marrow called stem cells**,** or hemocytoblasts. The origin of the cellular components of blood is illustrated in Figure 33–1 ■.

Regulatory mechanisms cause stem cells to differentiate into families of parent cells, each of which gives rise to one of the formed elements of the blood (red blood cells, platelets, and white blood cells). The functions of blood include transporting oxygen, nutrients, hormones, and metabolic wastes; protecting against invasion of pathogens; maintaining blood coagulation; and regulating fluids, electrolytes, acids, bases, and body temperature.

Red Blood Cells

Red blood cells (RBCs, erythrocytes) and the hemoglobin molecules they contain are required to transport oxygen to body tissues. Hemoglobin also binds with some carbon dioxide, carrying it to the lungs for excretion. Abnormal numbers of RBCs, changes in their size and shape, or altered hemoglobin content or structure can adversely affect health. **Anemia**, the most common RBC disorder, is an abnormally low RBC count or reduced hemoglobin content. **Polycythemia** is an abnormally high RBC count.

The red blood cell is shaped like a biconcave disk (Figure 33–2 ■). This unique shape increases the surface area of the cell and allows the cell to pass through very small capillaries without disrupting the cell membrane. RBCs are the most common type of blood cell.

Hemoglobin is the oxygen-carrying protein within RBCs. It consists of the heme molecule and globin, a protein molecule. Globin is made of four polypeptide chains—two alpha chains and two beta chains (Figure 33–3 ■). Each of the four polypeptide chains contains a heme unit containing an iron atom. The iron atom binds reversibly with oxygen, allowing it to transport oxygen as *oxyhemoglobin* to the cells. Hemoglobin is synthesized within the RBC. The rate of synthesis depends on the availability of iron (Porth, 2005).

Normal adult laboratory values for red blood cells are defined and identified in Table 33–1. The size, color, and shape of stained RBCs also may be analyzed. RBCs may be normocytic (normal size), smaller than normal (microcytic), or larger than normal (macrocytic). Their color may be normal (normochromic) or diminished (hypochromic).

Red Blood Cell Production and Regulation

In adults, RBC production (**erythropoiesis**) (Figure 33–4 ■) begins in red bone marrow of the vertebrae, sternum, ribs, and pelvis, and is completed in the blood or spleen. Erythroblasts begin forming hemoglobin while they are in the bone marrow, a process that continues throughout the RBC life span. Erythroblasts differentiate into normoblasts. As these slightly smaller cells mature, their nucleus and most organelles are ejected, eventually causing normoblasts to collapse inward and assume the characteristic biconcave shape of RBCs. The cells enter the circulation as reticulocytes, which fully mature in about 48 hours. The complete sequence from stem cell to RBC takes 3 to 5 days.

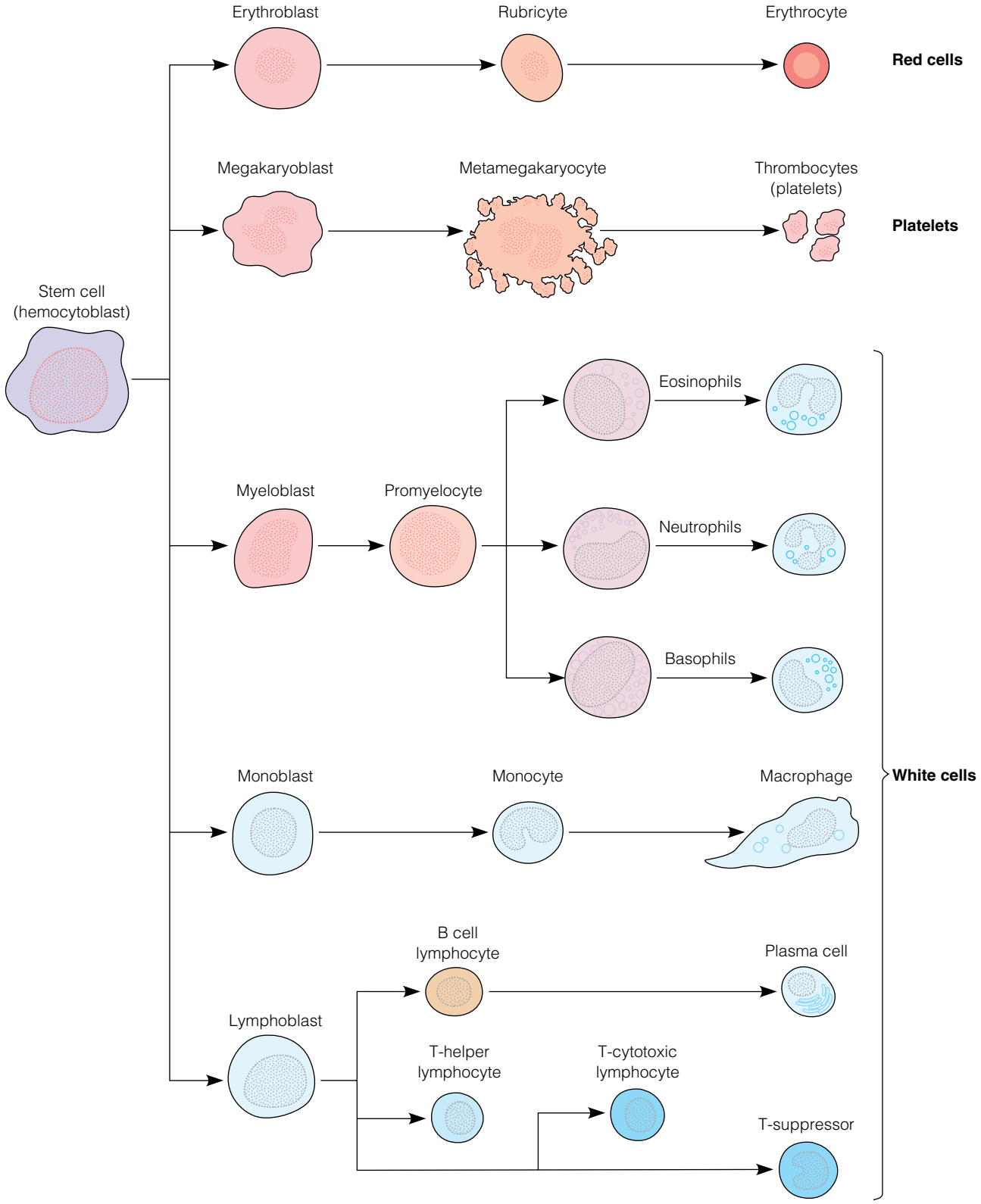


Figure 33–1 ■ Blood cell formation from stem cells. Regulatory factors control the differentiation of stem cells into blasts. Each of the five kinds of blasts is committed to producing one type of mature blood cell. Erythroblasts, for example, can differentiate only into RBCs; megakaryoblasts can differentiate only into platelets.

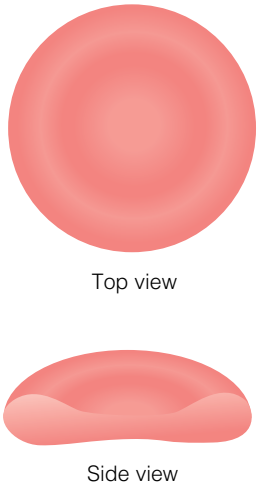


Figure 33–2 ■ Top and side view of a red blood cell (erythrocyte). Note the distinctive biconcave shape.

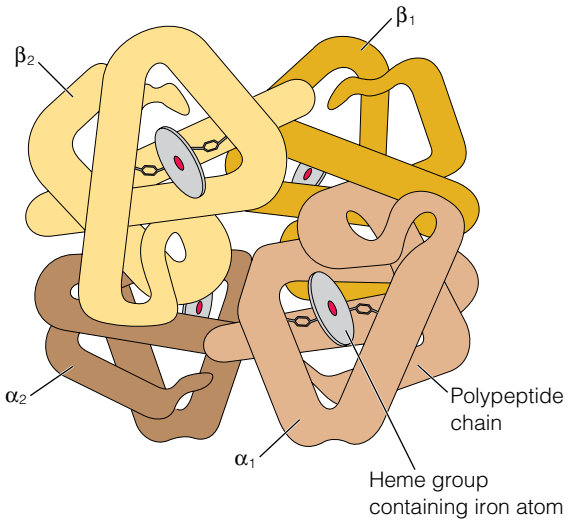


Figure 33–3 ■ The hemoglobin molecule includes globin (a protein) and heme, which contains iron. Globin is made of four subunits, two alpha and two beta polypeptide chains. A heme disk containing an iron atom (red dot) nests within the folds of each protein subunit. The iron atoms combine reversibly with oxygen, transporting it to the cells.

The stimulus for RBC production is tissue hypoxia. The hormone erythropoietin is released by the kidneys in response to hypoxia. It stimulates the bone marrow to produce RBCs. However, the process of RBC production takes about 5 days to maximize. During periods of increased RBC production, the percentage of reticulocytes (immature RBCs) in the blood exceeds that of mature cells.

Red Blood Cell Destruction

RBCs have a life span of about 120 days. Old or damaged RBCs are lysed (destroyed) by phagocytes in the spleen, liver, bone marrow, and lymph nodes. The process of RBC destruction is called **hemolysis**. Phagocytes save and reuse amino acids and iron from heme units in the lysed RBCs. Most of the heme unit is converted to bilirubin, an orange-yellow pigment that is removed from the blood by the liver and excreted in the bile. During disease processes causing increased hemolysis or impaired

TABLE 33–1 **Complete Blood Count (CBC)**

COMPONENT	PURPOSE	NORMAL VALUES
Hemoglobin (Hb)	Measures the capacity of the hemoglobin to carry gases	Women: 12–16 g/dL Men: 13.5–18 g/dL
Hematocrit (Hct)	Measures packed cell volume of RBCs, expressed as a % of the total blood volume	Women: 38%–47% Men: 40%–54%
Total RBC count	Counts number of circulating RBCs	Women: 4–5 × 10^6/μL Men: 4.5–6 × 10^6/μL
Red cell indices:		
MCV	Determines relative size of MCV (mean corpuscular volume)	82–98 fl
10^6MCH	Measures average weight of Hb/RBC (MCH = mean corpuscular hemoglobin)	27–33 pg
MCHC	Evaluates RBC saturation with Hb (MCHC = mean corpuscular hemoglobin concentration)	32%–36%
WBC count	Measures total number of leukocytes (total count) and whether each kind of WBC is present in proper proportion (differential)	Total WBC count: 4000–11,000/ μL (4–11 × 10^9/L) WBC differential: Neutrophils: 50%–70% Eosinophils: 2%–4% Basophils: 0%–2% Lymphocytes: 20%–40% Monocytes: 4%–8%
Platelets	Measures number of platelets available to maintain clotting functions	150,000–400,000/μL (15–400 × 10^9/L)

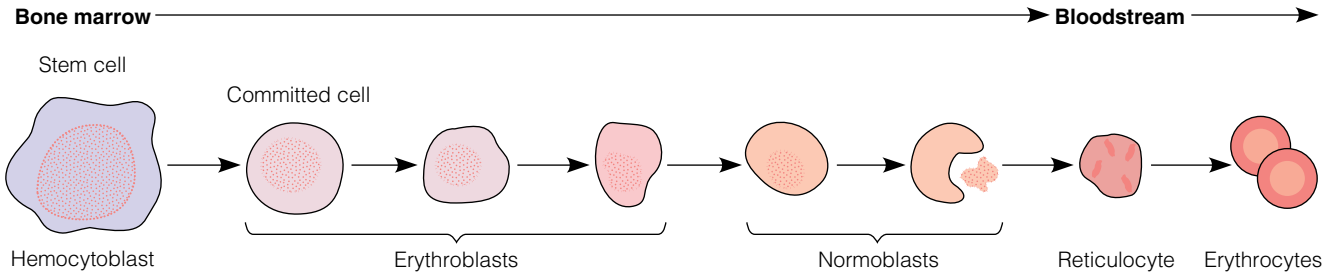


Figure 33–4 ■ Erythropoiesis. RBCs begin as erythroblasts within the bone marrow, maturing into normoblasts, which eventually eject their nucleus and organellas to become reticulocytes. Reticulocytes mature within the blood or spleen to become erythrocytes.

liver function, bilirubin accumulates in the serum, causing a yellowish appearance of the skin and sclera (jaundice).

White Blood Cells

White blood cells (WBCs, leukocytes) are a part of the body's defense against microorganisms. On average, there are 5000 to 10,000 WBCs per microliter of blood, accounting for about 1% of total blood volume. **Leukocytosis** is a higher than normal WBC count; **leukopenia** is a WBC count that is lower than normal.

WBCs originate from hemopoietic stem cells in the bone marrow. These stem cells differentiate into the various types of white blood cells (see Figure 33–1).

The two basic types of WBCs are granular leukocytes (or granulocytes) and nongranular leukocytes. Granulocytes have horseshoe-shaped nuclei and contain large granules in the cytoplasm. Stimulated by granulocyte-macrophage colony-stimulating factor (GM-CSF) and granulocyte colony-stimulating factor (G-CSF), granulocytes mature fully in the bone marrow before being released into the bloodstream. The three types of granulocytes are as follows:

- Neutrophils (also called polymorphonuclear [*PMN*] or segmented [*segs*] leukocytes) comprise 60% to 70% of the total circulating WBCs. Their nuclei are divided into three to five lobes. Neutrophils are active phagocytes, the first cells to arrive at a site of injury. Their numbers increase during inflammation. Immature forms of neutrophils (bands) are released during inflammation or infections, and are referred to as having a shift to the left (so named because immature cell frequencies appear on the left side of the graph) on a differential blood count. Neutrophils have a life span of only about 10 hours and are constantly being replaced.
- Eosinophils comprise 1% to 3% of circulating WBCs, but are found in large numbers in the mucosa of the intestines and lungs. Their numbers increase during allergic reactions and parasitic infestations.
- Basophils, which comprise less than 1% of the WBC count, contain histamine, heparin, and other inflammatory mediators. Basophils increase in numbers during allergic and inflammatory reactions.

Nongranular WBCs (agranulocytes) include the monocytes and lymphocytes. They enter the bloodstream before final maturation.

- Monocytes are the largest of the WBCs. They comprise approximately 3% to 8% of the total WBC count. Monocytes contain powerful bactericidal substances and proteolytic enzymes. They are phagocytic cells that mature into macrophages. Macrophages dispose of foreign and waste material, especially in inflammation. They are an active part of the immune response.
- Lymphocytes comprise 20% to 30% of the WBC count. Lymphocytes mature in lymphoid tissue into B cells and T cells. B cells are involved in the humoral immune response and antibody formation, whereas T cells take part in the cell-mediated immunity process (see Chapter 13 ∞). Plasma cells (which arise from B cells) are lymphoid cells found in bone marrow and connective tissue; they also are involved in immune reactions.

Platelets

Platelets (thrombocytes) are cell fragments that have no nucleus and cannot replicate. They are metabolically active, however, producing ATP and releasing mediators required for clotting. Platelets are formed in the bone marrow as pinched-off portions of large megakaryocytes (see Figure 33–1). Platelet production is controlled by thrombopoietin, a protein produced by the liver, kidney, smooth muscle, and bone marrow. The number of circulating platelets controls thrombopoietin release. Once released from the bone marrow, platelets remain in the spleen for about 8 hours before entering the circulation. Platelets live up to 10 days in circulation. There are about 250,000 to 400,000 platelets in each microliter of blood. An excess of platelets is *thrombocytosis.* A deficit of platelets is *thrombocytopenia.*

Hemostasis

Platelet and coagulation disorders affect **hemostasis**, control of bleeding. Hemostasis is a series of complex interactions between platelets and clotting mechanisms that maintains a relatively steady state of blood volume, blood pressure, and blood flow through injured vessels. The five stages of hemostasis are (1) vessel spasm, (2) formation of the platelet plug, (3) development of an insoluble fibrin clot, (4) clot retraction, and (5) clot dissolution.

Vessel Spasm

When a blood vessel is damaged, thromboxane A_2 (TXA_2) is released from platelets and cells, causing vessel spasm. This spasm constricts the damaged vessel for about 1 minute, reducing blood flow.

Formation of the Platelet Plug

Platelets attracted to the damaged vessel wall change from smooth disks to spiny spheres. Receptors on the activated platelets bind with von Willebrand's factor, a protein molecule, and exposed collagen fibers at the site of injury to form the platelet plug (Figure 33–5 ■). The platelets release adenosine diphosphate (ADP) and TXA_2 to activate nearby platelets, adhering them to the developing plug. Activation of the clotting pathway on the platelet surface converts fibrinogen to fibrin.

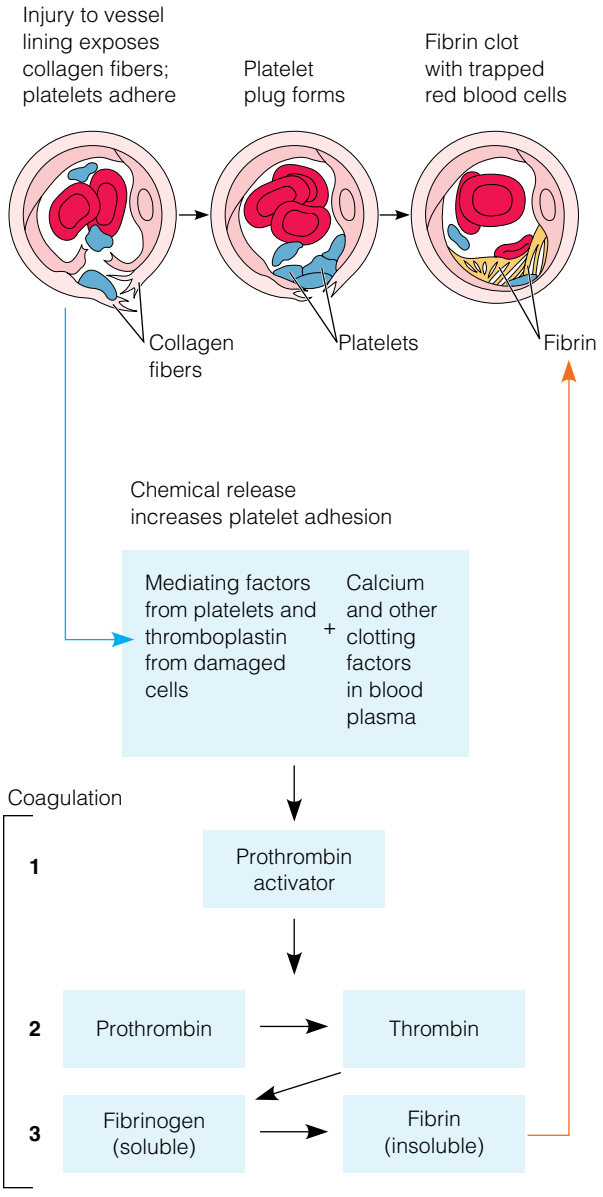


Figure 33–5 ■ Platelet plug formation and blood clotting. The flow diagram summarizes the events leading to fibrin clot formation.

Fibrin, in turn, forms a meshwork that binds the platelets and other blood cells to form a stable plug (Figure 33–6 ■).

Development of the Fibrin Clot

The process of coagulation creates a meshwork of fibrin strands that cements the blood components to form an insoluble clot. Coagulation requires many interactive reactions and two clotting pathways (Figure 33–7 ■). The slower intrinsic pathway is activated when blood contacts collagen in the injured vessel wall; the faster extrinsic pathway is activated when blood is exposed to tissues. The final outcome of both pathways is fibrin clot formation. Each procoagulation substance is activated in sequence; the activation of one coagulation factor activates another in turn. Table 33–2 lists known factors, their origin, and their function or pathway. A deficiency of one or more factors or inappropriate inactivation of any factor alters normal coagulation.

Clot Retraction

After the clot is stabilized (within about 30 minutes), trapped platelets contract, much like muscle cells. Platelet contraction squeezes the fibrin strands, pulling the broken portions of the ruptured blood vessel closer together. Growth factors released by the platelets stimulate cell division and tissue repair of the damaged vessel.

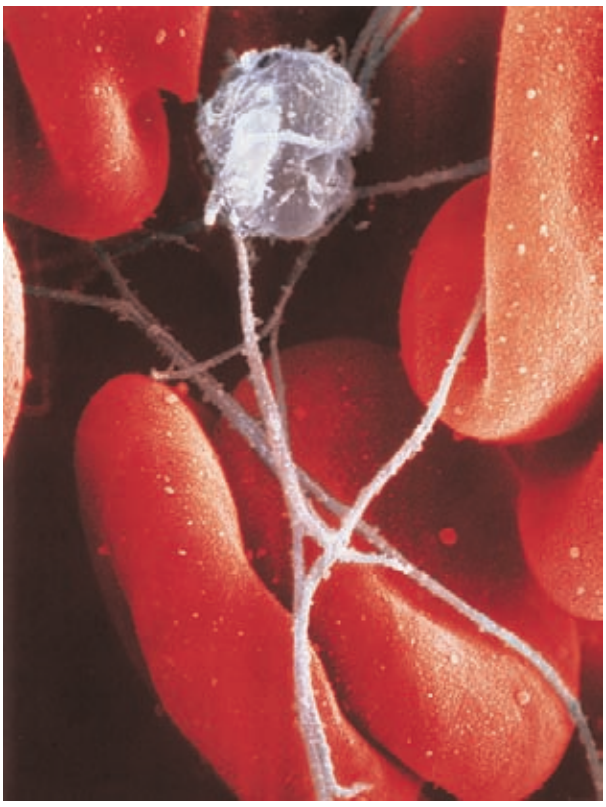


Figure 33–6 ■ Scanning electron micrograph of a RBC trapped in a fibrin mesh. The spherical gray object at top is a platelet.

Source: Copyright © Boehniger Ingelheim; photo Lennart Nilsson, Albert Bonniers Förlog AB.

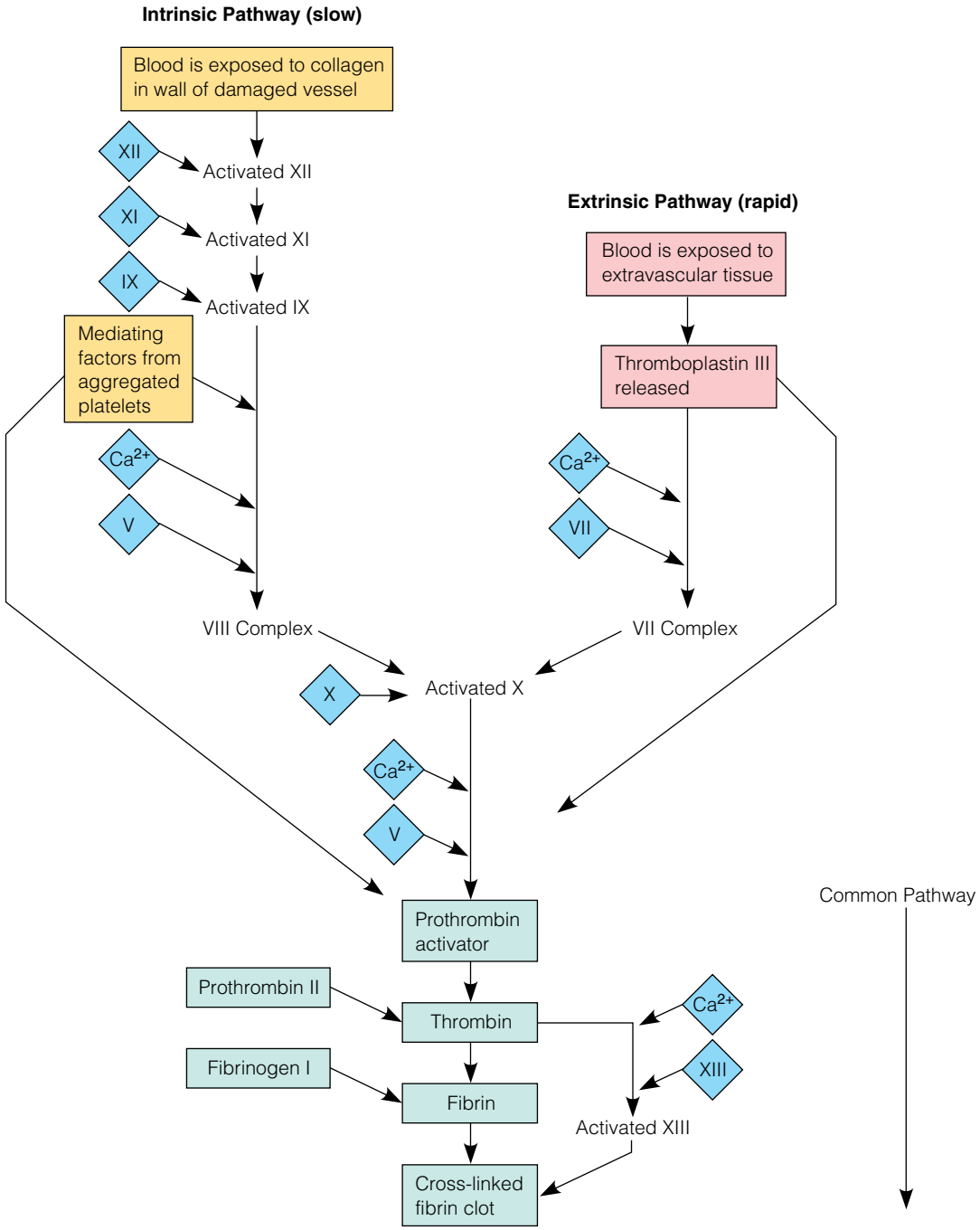


Figure 33–7 ■ Clot formation. Both the slower intrinsic pathway and the more rapid extrinsic pathway activate factor X. Factor X then combines with other factors to form prothrombin activator. Prothrombin activator transforms prothrombin into thrombin, which then transforms fibrinogen into long fibrin strands. Thrombin also activates Factor XIII, which draws the fibrin strands together into a dense meshwork. The complete process of clot formation occurs within 3 to 6 minutes after blood vessel damage.

Clot Dissolution

Fibrinolysis, the process of clot dissolution, begins shortly after the clot has formed, restoring blood flow and promoting tissue repair. Like coagulation, fibrinolysis requires a sequence of interactions between activator and inhibitor substances. Plasminogen, an enzyme that promotes fibrinolysis, is converted into plasmin, its active form, by chemical mediators released from vessel walls and the liver. Plasmin dissolves the clot's fibrin strands and certain coagulation factors. Stimuli such as exercise, fever, and vasoactive drugs promote plasminogen activator release. The liver and endothelium also produce fibrinolytic inhibitors.

TABLE 33–2 **Blood Coagulation Factors**

FACTOR	NAME	FUNCTION OR PATHWAY
I	Fibrinogen	Converted to fibrin strands
II	Prothrombin	Converted to thrombin
III	Thromboplastin	Catalyzes conversion of thrombin
IV	Calcium ions	Needed for all steps of coagulation
V	Proaccelerin	Extrinsic/intrinsic pathways
VII	Serum prothrombin conversion accelerator	Extrinsic pathway
VIII	Antihemophilic factor	Intrinsic pathway
IX	Plasma prothrombin component	Intrinsic pathway
X	Stuart factor	Extrinsic/intrinsic pathways
XI	Plasma prothrombin antecedent	Intrinsic pathway
XII	Hageman factor	Intrinsic pathway
XIII	Fibrin stabilizing factor	Cross-links fibrin strands to form insoluble clot

ANATOMY, PHYSIOLOGY, AND FUNCTIONS OF THE PERIPHERAL VASCULAR SYSTEM

The two main components of the peripheral vascular system are the arterial network and the venous network. The arterial network begins with the major arteries that branch from the aorta. The major arteries of the systemic circulation are illustrated in Figure 33–8 ■. These major arteries branch into successively smaller arteries, which in turn subdivide into the smallest of the arterial vessels, called *arterioles*. The smallest arterioles feed into beds of hairlike capillaries in the body's organs and tissues.

In the capillary beds, oxygen and nutrients are exchanged for metabolic wastes, and deoxygenated blood begins its journey back to the heart through venules, the smallest vessels of the venous network. Venules join the smallest of veins, which in turn join larger and larger veins. The blood transported by the veins empties into the superior and inferior venae cavae entering the right side of the heart. The major veins of the systemic circulation are shown in Figure 33–9 ■.

Structure of Blood Vessels

The structure of blood vessels reflects their different functions within the circulatory system (Figure 33–10 ■). Except for the tiniest vessels, blood vessel walls have three layers: the tunica intima, the tunica media, and the tunica adventitia. The tunica intima, the innermost layer, is made of simple squamous epithelium (the endothelium); this provides a slick surface to facilitate the flow of blood. In arteries, the middle layer, or tunica media, is made of smooth muscle and is thicker than the tunica media of veins. This makes arteries more elastic than veins and allows the arteries to alternately expand and recoil as the heart contracts and relaxes with each beat, producing a pressure wave, which can be felt as a **pulse** over an artery. The smaller arterioles are less elastic than arteries but contain more smooth muscle, which promotes their constriction (narrowing) and dilation (widening). In fact, arterioles exert the major control over arterial blood pressure. The tunica adventitia, or outermost layer, is made of connective tissue and serves to protect and anchor the vessel. Veins have a thicker tunica adventitia than do arteries.

Blood in the veins travels at a much lower pressure than blood in the arteries. Veins have thinner walls, a larger lumen, and greater capacity, and many are supplied with valves that help blood flow against gravity back to the heart (see Figure 33–10). The "milking" action of skeletal muscle contraction (called the muscular pump) also supports venous return. When skeletal muscles contract against veins, the valves proximal to the contraction open, and blood is propelled toward the heart. The abdominal and thoracic pressure changes that occur with breathing (called the respiratory pump) also propel blood toward the heart.

The tiny capillaries, which connect the arterioles and venules, contain only one thin layer of tunica intima that is permeable to the gases and molecules exchanged between blood and tissue cells. Capillaries typically are found in interwoven networks. They filter and shunt blood from precapillary arterioles to postcapillary venules.

Physiology of Arterial Circulation

The factors that affect arterial circulation are blood flow, peripheral vascular resistance, and blood pressure. **Blood flow** refers to the volume of blood transported in a vessel, in an organ, or throughout the entire circulation over a given period of time. It is commonly expressed as liters or milliliters per minute or cubic centimeters per second.

Peripheral vascular resistance (PVR) refers to the opposing forces or impedance to blood flow as the arterial channels become more and more distant from the heart. Peripheral vascular resistance is determined by three factors:

- *Blood viscosity:* The greater the viscosity, or thickness, of the blood, the greater its resistance to moving and flowing.
- *Length of the vessel:* The longer the vessel, the greater the resistance to blood flow.

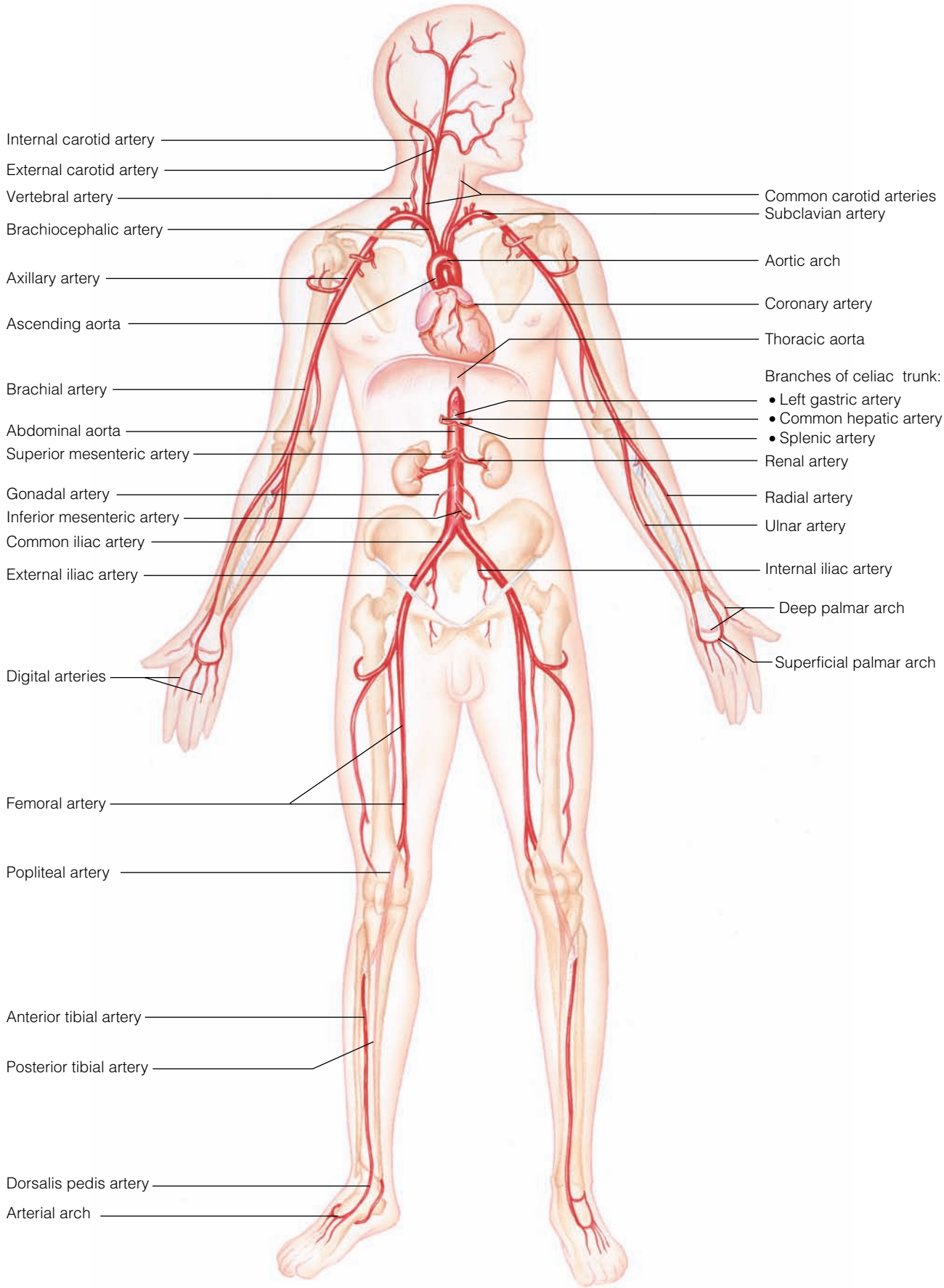


Figure 33–8 ■ Major arteries of the systemic circulation.

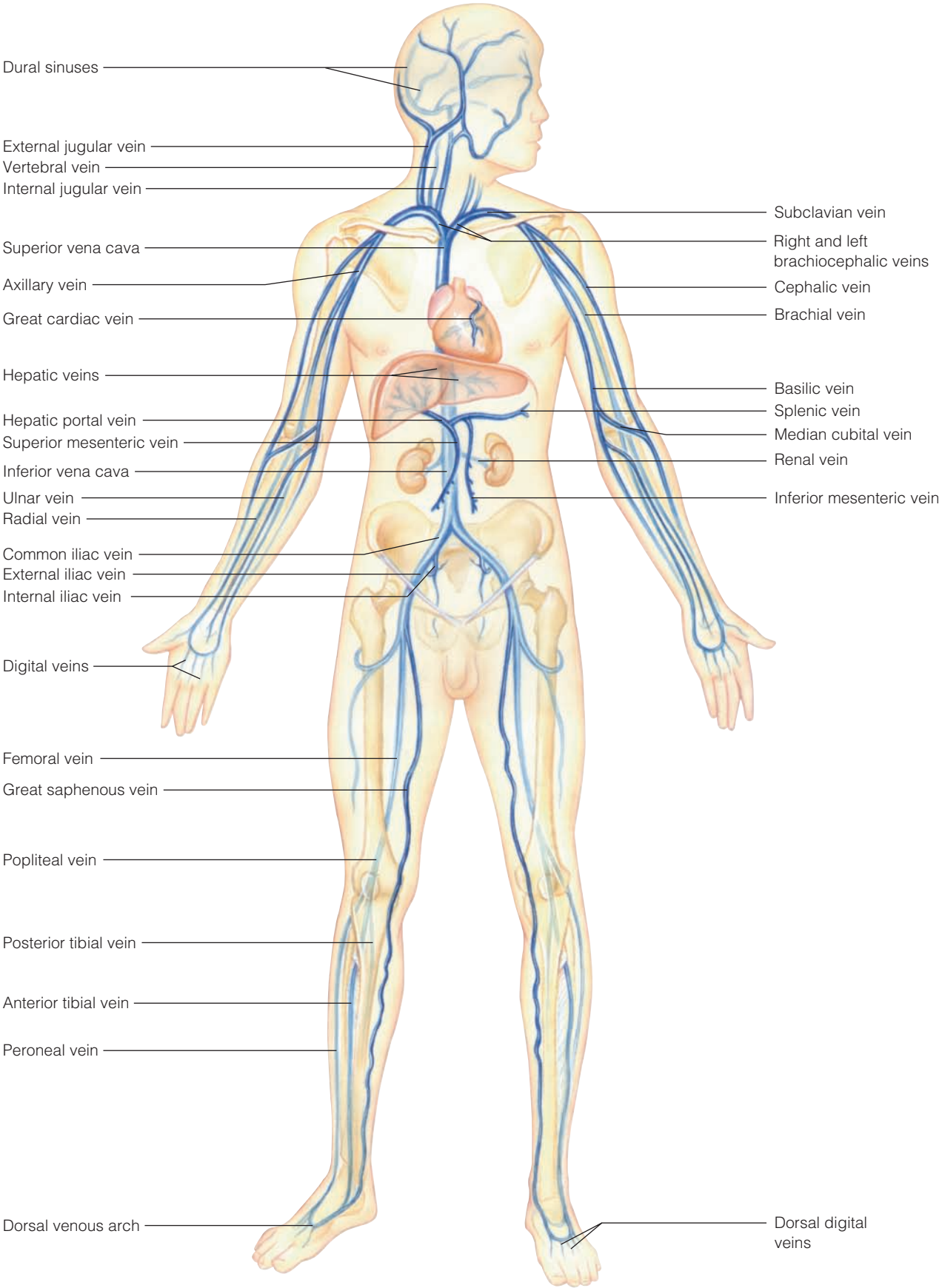


Figure 33–9 ■ Major veins of the systemic circulation.

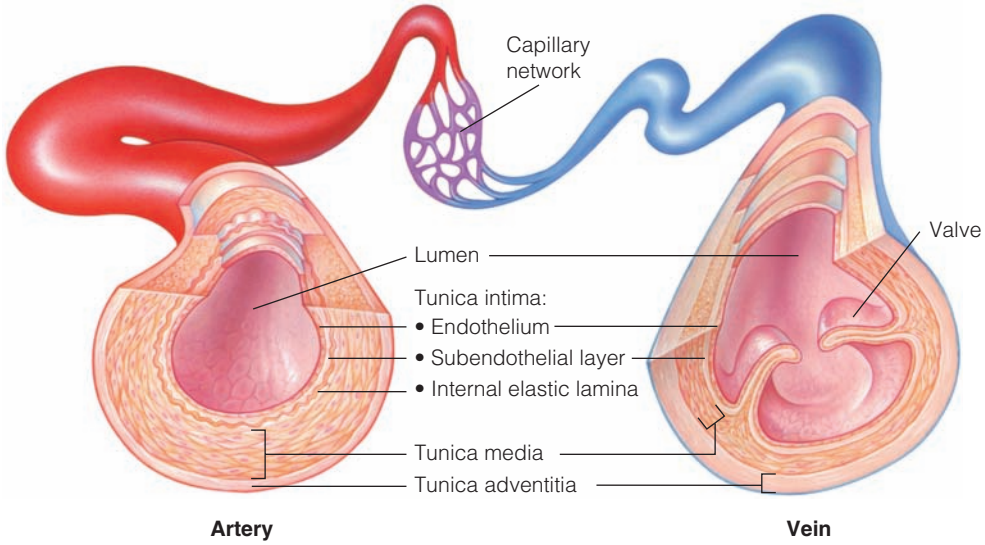


Figure 33–10 ■ Structure of arteries, veins, and capillaries. Capillaries are composed of only a fine tunica intima. Notice that the tunica media is thicker in arteries than in veins.

- *Diameter of the vessel:* The smaller the diameter of a vessel, the greater the friction against the walls of the vessel and, thus, the greater the impedance to blood flow.

Blood pressure is the force exerted against the walls of the arteries by the blood as it is pumped from the heart. It is most accurately referred to as **mean arterial pressure (MAP)**. The highest pressure exerted against the arterial walls at the peak of ventricular contraction (systole) is called the systolic blood pressure. The lowest pressure exerted during ventricular relaxation (diastole) is the diastolic blood pressure.

Mean arterial blood pressure is regulated mainly by cardiac output (CO) and peripheral vascular resistance (PVR), as represented in this formula: MAP = CO × PVR. For clinical use, the MAP may be estimated by calculating the diastolic blood pressure plus one-third of the pulse pressure (the difference between the systolic and diastolic blood pressure).

Factors Influencing Arterial Blood Pressure

Blood flow, peripheral vascular resistance, and blood pressure, which influence arterial circulation, are in turn influenced by various factors, as follows:

- The sympathetic and parasympathetic nervous systems are the primary mechanisms that regulate blood pressure. Stimulation of the sympathetic nervous system exerts a major effect on peripheral resistance by causing vasoconstriction of the arterioles, thereby increasing blood pressure. Parasympathetic stimulation causes vasodilation of the arterioles, lowering blood pressure.
- Baroreceptors and chemoreceptors in the aortic arch, carotid sinus, and other large vessels are sensitive to pressure and chemical changes and cause reflex sympathetic stimulation, resulting in vasoconstriction, increased heart rate, and increased blood pressure.
- The kidneys help maintain blood pressure by excreting or conserving sodium and water. When blood pressure decreases, the kidneys initiate the renin–angiotensin mechanism. This stimulates vasoconstriction, resulting in the release of the hormone aldosterone from the adrenal cortex, increasing sodium ion reabsorption and water retention. In addition, pituitary release of antidiuretic hormone (ADH) promotes renal reabsorption of water. The net result is an increase in blood volume and a consequent increase in cardiac output and blood pressure.
- Temperatures may also affect peripheral resistance: Cold causes vasoconstriction, whereas warmth produces vasodilation. Many chemicals, hormones, and drugs influence blood pressure by affecting CO and/or PVR. For example, epinephrine causes vasoconstriction and increased heart rate; prostaglandins dilate blood vessel diameter (by relaxing vascular smooth muscle); endothelin, a chemical released by the inner lining of vessels, is a potent vasoconstrictor; nicotine causes vasoconstriction; and alcohol and histamine cause vasodilation.
- Dietary factors, such as intake of salt, saturated fats, and cholesterol elevate blood pressure by affecting blood volume and vessel diameter.
- Race, gender, age, weight, time of day, position, exercise, and emotional state may also affect blood pressure. These factors influence the arterial pressure. Systemic venous pressure, though it is much lower, is also influenced by such factors as blood volume, venous tone, and right atrial pressure.

MEDIALINK ■ Case Study: Arterial Blood Pressure

ANATOMY, PHYSIOLOGY, AND FUNCTIONS OF THE LYMPHATIC SYSTEM

The structures of the lymphatic system include the lymphatic vessels and several lymphoid organs (Figure 33–11 ■). The organs of the lymphatic system are the lymph nodes, the spleen, the thymus, the tonsils, and the Peyer's patches of the small intestine. Lymph nodes are small aggregates of specialized cells that assist the immune system by removing foreign

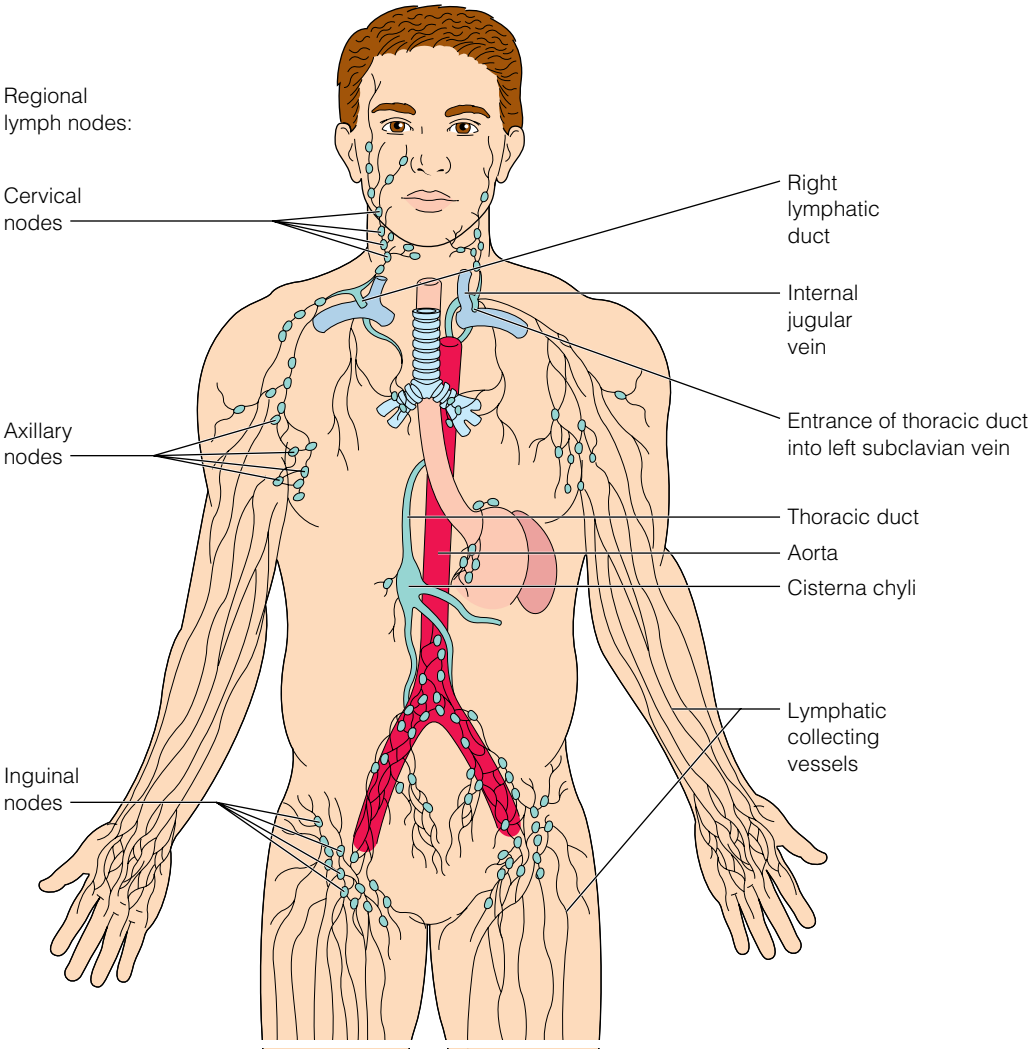


Figure 33–11 ■ The lymphatic system.

material, infectious organisms, and tumor cells from lymph. Lymph nodes are distributed along the lymphatic vessels, forming clusters in certain body regions such as the neck, axilla, and groin (see Figure 33–11). The spleen, the largest lymphoid organ, is in the upper left quadrant of the abdomen under the thorax. The main function of the spleen is to filter the blood by breaking down old red blood cells and storing or releasing to the liver their by-products (such as iron). The spleen also synthesizes lymphocytes, stores platelets for blood clotting, and serves as a reservoir of blood. The thymus gland is in the lower throat and is most active in childhood, producing hormones (such as thymosin) that facilitate the immune action of lymphocytes. The tonsils of the pharynx and Peyer's patches of the small intestine are lymphoid organs that protect the upper respiratory and digestive tracts from foreign pathogens.

The lymphatic vessels, or lymphatics, form a network around the arterial and venous channels and interweave at the capillary beds. They collect and drain excess tissue fluid, called *lymph*, that "leaks" from the cardiovascular system and accumulates at the venous end of the capillary bed. The lymphatics return this fluid to the heart through a one-way system of lymphatic venules and veins that eventually drain into the right lymphatic duct and left thoracic duct, both of which empty into their respective subclavian veins. Lymphatics are a low-pressure system without a pump; their fluid transport depends on the rhythmic contraction of their smooth muscle and the muscular and respiratory pumps that assist venous circulation.

ASSESSING HEMATOLOGIC, PERIPHERAL VASCULAR, AND LYMPHATIC FUNCTION

Hematologic, peripheral vascular, and lymphatic function are assessed by findings from diagnostic tests, a health assessment interview to collect subjective data, and a physical assessment to collect objective data. Sample documentation of an assessment for peripheral vascular function is included in the box on the next page.

SAMPLE DOCUMENTATION

Assessment of the Peripheral Vascular System

57-year-old male with medical history of type 1 diabetes for 15 years. Client states he has smoked cigars for 20 years (1/day), but "knows he shouldn't." Reports he can't walk more than 20 steps without pain in his legs and sometimes has pain in his feet at night. Pulses in lower extremities (dorsalis pedis, posterior tibial, and popliteal): regular but weak. No bruits auscultated over femoral arteries. When legs elevated and then lowered, the skin was pale on elevation and dusky red when dependent in the sitting position with lower legs dangling. Skin on both lower extremities from knees to toes is cool, shiny, and hairless. Capillary refill of toenails (which are thickened) on great toe is 6 seconds bilaterally. No ankle or tibial edema assessed.

Diagnostic Tests

The results of diagnostic tests of hematologic, peripheral vascular, and lymphatic function are used to support the diagnosis of a specific disease, to provide information to identify or modify the appropriate medications or therapy used to treat the disease, and to help nurses monitor the client's responses to treatment and nursing care interventions. Diagnostic tests to assess the structures and functions of the hematologic, peripheral vascular, and lymphatic systems are described in the Diagnostic Tests table below and summarized in the bulleted list that follows. More information is included in the discussion of specific disorders in Chapters 34 and 35.

- Tests to evaluate the structure, function, and adequacy of the blood and blood-forming organs include a complete blood count (CBC), erythrocyte sedimentation rate (ESR), and a bone marrow examination.

DIAGNOSTIC TESTS of Hematologic, Peripheral Vascular, and Lymphatic Disorders

HEMATOLOGIC DISORDERS

NAME OF TEST Complete blood count (CBC)

PURPOSE AND DESCRIPTION This is a blood test involving several measurements of blood components. See Table 33–1.

RELATED NURSING CARE None

NAME OF TEST Erythrocyte sedimentation rate (ESR)

PURPOSE AND DESCRIPTION This blood test is done as a measure of inflammation, and is increased in many illnesses, including cancer, heart disease, and kidney disease.

Normal values:
Women: 1–20 mm in 1 hour
Men: 1–15 mm in 1 hour

RELATED NURSING CARE None

NAME OF TEST Bone marrow

PURPOSE AND DESCRIPTION Conducted to evaluate blood-forming tissue; to diagnose multiple myeloma, leukemia, and some lymphomas; and to assess effectiveness of therapy for leukemia. Bone marrow is removed from a site such as the posterior iliac crest with needle aspiration.

NURSING CARE: BONE MARROW STUDIES

Bone marrow specimens are obtained by either aspiration or biopsy. The preferred site for bone marrow aspiration is the posterior iliac crest; the sternum may also be used. The procedure is performed by inserting a needle into the bone and drawing out a sample of the blood in the marrow. A bone marrow biopsy is performed by making a small incision over the bone and screwing a core biopsy instrument into the bone to obtain a specimen. Bone marrow studies are used to diagnose leukemias, metastatic cancer, lymphoma, aplastic anemia, and Hodgkin's disease.

Preparation of the Client

- Explain the purpose and procedure of the test.
- Record vital signs. Assure presence of a signed consent for the procedure.
- Ask the client to void.
- Place in supine position if the specimen will be obtained from the sternum or anterior iliac crest; prone position if the posterior iliac crest will be used.
- Assist in remaining still during the procedure.

After the Procedure

- Apply pressure to the puncture site for 5 to 10 minutes.
- Assess vital signs, and compare results to preprocedure readings.
- Apply a dressing to the puncture site, and monitor for bleeding and infection for 24 hours.

Health Education for the Client and Family

- The procedure (either aspiration or biopsy) takes about 20 minutes.
- A sedative may be given prior to the procedure.
- It is important to remain very still during the procedure to prevent accidental injury.
- Although the area will be anesthetized with a local anesthetic, insertion of the needle will be painful for a short time. Taking deep breaths may make this part of the procedure less painful.
- The aspiration site may ache for 1 or 2 days.
- Report any unusual bleeding immediately.

(continued)

DIAGNOSTIC TESTS of Hematologic, Peripheral Vascular, and Lymphatic Disorders (continued)

NAME OF TEST Magnetic resonance angiography (MRA)
PURPOSE AND DESCRIPTION Used to visualize vascular occlusive disease and aneurysms of the abdominal aorta. The procedure is done by using a non-iodine-based contrast medium injected IV.
RELATED NURSING CARE Assess for any metallic implants, such as a pacemaker or body piercings (if present, test is not performed).

NAME OF TEST Magnetic resonance imaging (MRI)
PURPOSE AND DESCRIPTION A radiologic study used to visualize liver, spleen, and lymph nodes. Does not require injection of contrast medium.
RELATED NURSING CARE Assess for any metallic implants, such as a pacemaker or body piercings. If present, the test will not be performed.

NAME OF TEST CT scan
PURPOSE AND DESCRIPTION A radiologic study used to evaluate the lymph nodes. Contrast medium may be used when assessing the nodes of the abdomen.
RELATED NURSING CARE Assess for allergy to iodine (such as shellfish).

NAME OF TEST Liver and/or spleen scan
PURPOSE AND DESCRIPTION A radiologic study used to assess the liver and/or spleen. A radioisotope is injected IV prior to the scan.

NAME OF TEST Lymphangiography (lymphangiogram)
PURPOSE AND DESCRIPTION This is an x-ray examination of the lymphatic vessels and lymph nodes, used to assess metastasis of the lymph nodes, to identify malignant lymphoma, and to identify the cause of lymphedema. An iodine contrast substance is injected at various sites and fluoroscopy is used to visualize lymphatic filling.
RELATED NURSING CARE Ask the client about allergies to seafood, iodine, or contrast medium used in a previous x-ray test. Tell the client that the blue contrast dye discolors the urine and possibly the skin for a few days.

NAME OF TEST Lymph node biopsy
PURPOSE AND DESCRIPTION Done to obtain tissue for histologic examination for diagnosis and treatment. May be open (performed in the operating room) or closed (needle) by needle aspiration of tissue from a lymph node.
RELATED NURSING CARE Use sterile technique when changing dressings.

- Disorders of the arteries and veins are diagnosed by various noninvasive examinations, including several discussed in Chapter 30 (transesophageal echocardiography [TEE], ultrasound, and Doppler studies). A magnetic resonance angiography (MRA) may be done to visualize vascular occlusive disease and abdominal aorta aneurysms.
- Tests of the lymphatic system, including a lymphangiogram and a lymph node biopsy, may be done to identify malignancies, assess metastasis of cancer to lymph nodes, identify the causes of lymphedema, and obtain tissue for diagnosis and treatment.

Regardless of the type of diagnostic test, the nurse is responsible for explaining the procedure and any special preparation needed, assessing for medication use that may affect the outcome of the tests, supporting the client during the examination as necessary, documenting the procedures as appropriate, and monitoring the results of the tests.

Genetic Considerations

When conducting a health assessment interview and a physical assessment, it is important for the nurse to consider genetic influences on the health of the adult. During the health assessment interview, ask about family members with health problems affecting hematologic, peripheral vascular, or lymphatic function. In addition, ask about a family history of high blood pressure, hemophilia, chronic myeloid leukemia, porphyria, and/or atherosclerosis. Depending on the racial and ethnic background of the client, ask about any family members with sickle cell anemia or thalassemia. During the physical assessment, assess for any manifestations that might indicate a genetic disorder (see the Genetics box on the next page). If data are found to indicate genetic risk factors or alterations, ask about genetic testing and refer for appropriate genetic counseling and evaluation. Chapter 8 provides further information about genetics in medical-surgical nursing.

Health Assessment Interview

A health assessment interview to determine problems with the structure and functions of the hematologic, peripheral vascular, and/or lymphatic systems may be conducted during a health screening, may focus on a chief complaint (such as fatigue and bleeding), or may be part of a total health assess-

GENETIC CONSIDERATIONS

Hematologic, Peripheral Vascular, and Lymphatic Disorders

- There is a genetic link in 30% to 40% of clients with primary hypertension.
- Sickle cell anemia is the most common inherited blood disorder in the United States, affecting 1 in 500 African Americans. It is characterized by episodes of pain, chronic hemolytic anemia, and severe infections.
- Gaucher disease, more common in descendants of Eastern European Jewish people, is an inherited illness caused by a gene mutation. The gene is responsible for an enzyme that breaks down a specific fat. When the fat is not broken down, it accumulates in the liver, spleen, and bone marrow, causing pain, fatigue, jaundice, bone damage, anemia, and even death.
- Hemophilia A is a hereditary blood disorder, primarily affecting males, characterized by a deficiency of the blood clotting factor named Factor VIII. Abnormal bleeding results.
- Chronic myeloid leukemia (CML), a cancer of blood cells, is characterized by replacement of bone marrow with malignant, leukemic cells. Leukemic cells also circulate in the blood, causing enlargement of the spleen, liver, and other organs. This leukemia is the result of chromosomal abnormality called the Philadelphia chromosome.
- Porphyria is a group of genetic blood diseases in which heme production is disrupted. When heme production is disrupted, porphyrins (a part of heme) are overproduced and cause illnesses; they also give urine a reddish-purple color.
- Thalassemia, an inherited disease of faulty hemoglobin synthesis, is more often found in descendants of people living near the Mediterranean Sea, Africa, the Middle East, and Asia. It comprises a group of disorders that range from very mild blood abnormalities to severe or fatal anemia.
- Atherosclerosis is characterized by narrowing of arteries by cholesterol-rich plaques of immune system cells. Risk factors may be genetic and/or environmental. Although it may affect people at any age, it usually does not cause health problems until people are in their 40s and 50s.

ment. Interview questions categorized by functional health patterns are listed in the Functional Health Pattern Interview on the next page.

Peripheral Vascular System

If the client has problems involving the peripheral vascular system, analyze its onset, characteristics and course, severity, precipitating and relieving factors, and any associated symptoms, noting the timing and circumstances. For example, ask the client the following:

- Does the leg pain occur only with activities such as walking, or also during rest?
- Do your ankles swell at the end of the day, after sitting for prolonged periods, or after sleeping all night?
- Does temperature or the position of your body affect the symptoms?

Explore the client's medical and family history for any cardiovascular disorders, such as heart disease, arteriosclerosis, peripheral vascular disease (PVD), stroke, hypertension (HTN), hyperlipidemia (elevated fat in blood) and blood clots, or other chronic illnesses (e.g., diabetes). Ask about past surgery of the heart or blood vessels or tests to evaluate their function and about any medications that affect circulation or blood pressure.

Ask the client about past or present pain, burning, numbness, or tingling in the limbs or digits; leg fatigue or cramps; changes in skin color or temperature, texture of hair, ulcers or skin irritation, varicose veins, phlebitis (inflamed veins) or edema (swelling). Explore the client's nutritional history for intake of protein, vitamins and minerals, salt, fats, and fluid. Quantify any consumption of caffeine and alcohol and history of smoking (packs per day for how many years) or other tobacco use. Assess the client's activity level for exercise habits and tolerance.

It is important to consider socioeconomic factors that may precipitate or aggravate circulatory problems (e.g., inadequate clothing, shoes, or shelter) and occupational factors, such as prolonged standing or sitting or exposure to temperature extremes. Also assess psychosocial factors that may affect the client's stress level and emotional state.

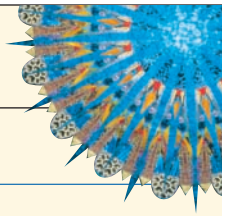
Lymphatic System

The health assessment of the lymphatic system includes a review of specific problems, such as lymph node enlargement or swollen glands, as well as other more general complaints about infection or impaired immunity, such as fever, fatigue, or weight loss. If a health problem exists, analyze its onset, characteristics, severity, and precipitating and relieving factors, noting the timing and circumstances. For example, ask the client the following:

- Did you notice that the glands in your neck became swollen after an infection?
- Have you noticed increased fatigue or weakness?
- Have you ever been exposed to radiation?

Explore the client's history for chronic illnesses (e.g., cardiovascular disease, renal disease, cancer, tuberculosis, HIV infection), predisposing factors (e.g., surgery, trauma, infection, blood transfusions, intravenous drug use), and environmental exposure (e.g., radiation, toxic chemicals, travel-related infectious disease). Review the family history for any incidence of cancer, anemia, or blood dyscrasias. Ask the client about past or present bleeding (e.g., from the nose, gums, or mouth; from vomiting; from the rectum; bruising) and associated symptoms (e.g., pallor, dizziness, fatigue, difficulty breathing); lymph node changes (e.g., enlargement, pain or tenderness, itching, warmth); swelling of extremities; and recurrent irritations or infections. Lastly, an assessment

FUNCTIONAL HEALTH PATTERN INTERVIEW **Hematologic, Peripheral Vascular, and Lymphatic Systems**



Functional Health Pattern	Interview Questions and Leading Statements
Health Perception-Health Management	■ Describe any problems you have had with bleeding, bruising, swollen glands, and circulation (for example, heart disease, hardening of the arteries, high blood pressure, stroke, clots, high cholesterol). ■ Have you ever been diagnosed with a health problem involving the blood, heart, blood vessels, or lymph glands? If so, what were they and how were they treated? ■ Is there a family history of bleeding, cancer, or anemia? Explain. ■ What medications, vitamins, dietary supplements, or over-the-counter drugs do you take now? ■ Do you or have you ever smoked? If so, what, for how long, and how many a day?
Nutritional-Metabolic	■ Describe your usual intake of food and fluids in a 24-hour period. ■ Do you drink liquids with caffeine? If so, how much? ■ Do you drink alcohol? If so, what type, how much, and how often? ■ Describe how much salt you use on your food. ■ Describe what type of fatty foods you eat. How often? ■ Have you noticed any change in the color, temperature, or appearance of the skin on your arms, hands, legs, or feet? If so, what were they? ■ Have you noticed any glands that are sore and swollen? What do you think causes this? ■ Have you noticed an increase in the time it takes your blood to clot or how easily you bruise? ■ Have you noticed loss of hair, bulging veins, sores that will not heal on your legs, or thicker toenails? Have you ever worn support stockings? ■ Do your feet ever swell or your shoes feel tight? If so, when does this happen and what do you do to decrease the swelling?
Elimination	■ Have you noticed any blood in your urine or bowel movements? ■ Have your bowel movements been a dark black color?
Activity-Exercise	■ Describe your activities in a typical day. ■ Do you exercise regularly? Describe what you do when you exercise. ■ Have your activities or exercise abilities changed? If so, explain. ■ Do you have leg pain when you walk? If so, where is it located? How far do you walk before you have pain? Describe the pain. What do you do to relieve it? ■ Do you feel tired even after sleep and rest? Describe the feeling.
Sleep-Rest	■ How much rest and sleep do you get each day? ■ Do leg cramps ever wake you at night? If so, describe the pain and what you do to relieve it.
Cognitive-Perceptual	■ Do you have any of these sensations in your legs or feet: pain, cramps, burning, numbness, tingling? ■ If you have these sensations, when do they occur, how long do they last, and what do you do to relieve them?
Self-Perception-Self-Concept	■ How does having this condition make you feel about yourself?
Role-Relationships	■ How has having this condition affected your relationships with others? ■ Has having this condition interfered with your ability to work? Explain. ■ Does your work environment bring you into contact with any chemicals? Describe them.
Sexuality-Reproductive	■ Has this condition interfered with your usual sexual activity? ■ *For women*: Have you noticed any changes in your menstrual flow? If so, describe them.
Coping-Stress-Tolerance	■ Has having this condition created stress for you? ■ Have you experienced any kind of stress that makes the condition worse? Explain. ■ Describe what you do when you feel stressed.
Value-Belief	■ Describe how specific relationships or activities help you cope with this problem. ■ Describe specific cultural beliefs or practices that affect how you care for and feel about this problem. ■ Are there any specific treatments (such as blood transfusions) that you would not use to treat this problem?

of the client's socioeconomic status, lifestyle, intravenous drug use, and sexual practices may be significant in determining risk for diseases associated with impaired lymphatic function.

Physical Assessment

Physical assessment of the hematologic, peripheral vascular, and lymphatic systems can be performed either as part of a total assessment or alone for clients with suspected or known problems with function of these systems, either from disease or from surgery or immobility. The techniques used to assess these systems include inspection of the skin for such changes as edema, ulcerations, or alterations in color and temperature; auscultation of blood pressure; and palpation of the major pulse points of the body (Figure 33–12 ■) and lymph nodes. The client may be assessed in the supine, sitting, and standing positions. Normal age-related findings for the older adult are summarized in Table 33–3.

Physical assessment of the lymphatic system is usually integrated into the assessment of other body systems. For example, the tonsils are inspected with the pharynx during the head and neck assessment; the regional lymph nodes are evaluated with corresponding body regions (e.g., occipital, auricular, and cervical nodes are evaluated with assessment of the head and neck, axillary nodes with assessment of the breast or thorax, epitrochlear node with assessment of the peripheral vascular exam of the arms, and inguinal nodes with assessment of the abdomen); the spleen can be palpated during the abdominal assessment. The techniques of inspection and palpation are used for the lymphatic examination.

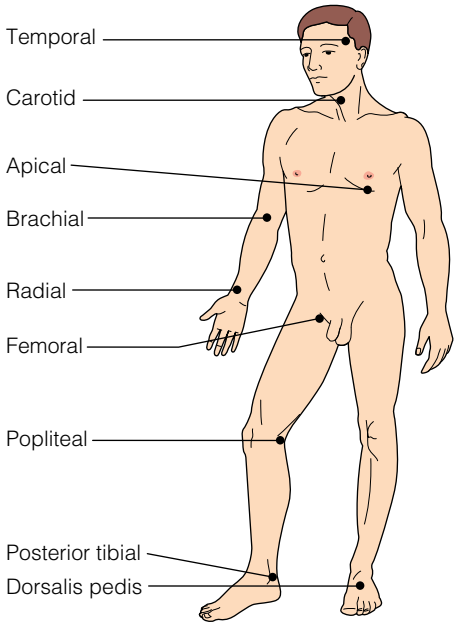
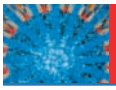


Figure 33–12 ■ Body sites at which peripheral pulses are most easily palpated.

TABLE 33–3 **Age-Related Changes in the Hematologic, Peripheral Vascular, and Lymphatic Systems**

AGE-RELATED CHANGE	SIGNIFICANCE
Bone marrow: ↓ ability of bone marrow to respond to need for increased RBCs, WBCs, and platelets.	■ Anemia may result.
Blood vessels:	
■ *Tunica intima*: fibrosis, calcium and lipid accumulation, cellular proliferation. ■ *Tunica media*: thins, elastin fibers calcify; increase in calcium results in stiffening. Baroreceptor function is impaired and peripheral resistance increases. ■ *Tunica adventicia*: no change.	■ As a result of age-related changes, the systolic blood pressure rises. Decreased arterial elasticity results in vascular changes in the heart, kidneys, and pituitary gland. Decreased baroreceptor function results in postural hypotension. Vessels in the head, neck, and extremities are more prominent. ■ Inefficient vasoconstriction, decreased cardiac output, and reduced muscle mass and subcutaneous tissue lead to a reduced ability to respond to cold temperatures. ■ With a decrease in blood pressure and changes in blood vessel walls, tissue perfusion may be inadequate, leading to edema, inflammation, pressure ulcers, and changes in effects of medications.
Immune system: ■ Impaired function of B and T lymphocytes. ■ ↓ production of antibodies. ■ Unable to distinguish "self" from "non-self." ■ Phagocytic immune response delayed.	■ Increased risk for infection, with decreased manifestations of an actual infection. ■ Increased incidence of cancers. ■ Altered response to antigens (such as PPD test). ■ May have reactivation of TB.



HEMATOLOGIC, PERIPHERAL VASCULAR, AND LYMPHATIC ASSESSMENTS

Blood Pressure and Pulse Pressure Assessment

See Box 33–1 for blood pressure measurement guidelines.

BOX 33–1 Guidelines for Blood Pressure Assessment

Review of Korotkoff's Sounds

The first sound heard is the systolic pressure; at least two consecutive sounds should be clear. If the sound disappears and then is heard again 10 to 15 mm later, an auscultatory gap is present; this may be a normal variant, or it may be associated with hypertension. The first diastolic sound is heard as a muffling of the Korotkoff's sound and is considered the best approximation of the true diastolic pressure. The second diastolic sound is the level at which sounds are no longer heard.

The American Heart Association recommends documenting all three readings when measuring blood pressure, for example, 120/72/64. If only two readings are documented, the systolic and the second diastolic pressure are taken, for example, 120/64.

Technique Reminders

- Choose a cuff of an appropriate size: The cuff should snugly cover two-thirds of the upper arm, and the bladder should completely encircle the arm. The bladder should be centered over the brachial artery, with the lower edge 2 to 3 cm above the antecubital space.
- The client's arm should be slightly flexed and supported (on a table or by the examiner) at heart level.
- To determine how high to inflate the cuff, palpate the brachial pulse, and inflate the cuff to the point on the manometer at which the pulse is no longer felt; then, add 30 mmHg to this reading, and use the sum as the target for inflation. Wait 15 seconds before reinflating the cuff to auscultate the BP.
- To recheck a BP, wait at least 30 seconds before attempting another inflation.
- Always inflate the cuff completely, then deflate it. Once deflation begins, allow it to continue; do not try to reinflate the cuff if the first systolic sound is not heard or if the cuff inadvertently deflates.
- The bell of the stethoscope more effectively transmits the low-pitched sounds of BP.

Sources of Error

- Falsely high readings can occur if the cuff is too small, too loose, or if the client supports his or her own arm.
- Falsely low readings can occur if a standard cuff is used on a client with thin arms.
- Inadequate inflation may result in underestimation of the systolic pressure or overestimation of the diastolic pressure if an auscultatory gap is present.
- Rapid deflation and repeated or slow inflations (causing venous congestion) can lead to underestimation of the systolic BP and overestimation of the diastolic BP.

Factors Altering Blood Pressure

- A change from the horizontal to upright position causes a slight decrease (5 to 10 mm) in systolic BP; the diastolic BP remains unchanged or rises slightly.
- BP taken in the arm is lower when the client is standing.
- If the BP is taken with the client in the lateral recumbent position, a lower BP reading may be obtained in both arms; this is especially apparent in the right arm with the client in the left lateral position.
- Factors that increase BP include exercise, caffeine, cold environment, eating a large meal, painful stimuli, and emotions.
- Factors that lower BP include sleep (by 20 mmHg) and very fast, slow, or irregular heart rates.
- BP tends to be higher in taller or heavier clients.

Alternative Methods of Blood Pressure Measurement

- The palpatory method may be necessary if severe hypotension is present and the BP is inaudible. Palpate the brachial pulse, and inflate the cuff 30 mm above the point where the pulse disappears; deflate the cuff, and note the point on the manometer where the pulse becomes palpable again. Record this as the palpatory systolic BP.
- Leg BP measurement may be needed when there is injury of the arms or to rule out coarctation of the aorta or aortic insufficiency when arm diastolic BP is over 90 mmHg. Place the client in the prone or supine position with the leg slightly flexed. Place a large leg cuff on the thigh with the bladder centered over the popliteal artery. Place the bell of the stethoscope over the popliteal space. Normal leg systolic BP is higher than arm BP; diastolic BP should be equal to or lower than arm BP. Abnormally low leg BP occurs with aortic insufficiency and coarctation of the aorta.

Technique/Normal Findings	Abnormal Findings
Auscultate blood pressure in each arm with the client seated. *The normal blood pressure is considered to be <120/<80, with readings of 120–139/80–89 diagnosed as prehypertension.*	■ Consistent BP readings over 140/90 in adults under age 40 is considered hypertension. ■ BP under 90/60 is considered hypotension. ■ An **auscultatory gap**—a temporary disappearance of sound between the systolic and diastolic BP—may be a normal variation, or it may be associated with systolic HTN or a drop in diastolic BP due to aortic stenosis. ■ **Korotkoff's sounds** (see Box 33–1) may be heard down to zero with cardiac valve replacements, hyperkinetic states, thyrotoxicosis, and severe anemia, as well as after vigorous exercise. ■ The sounds of aortic regurgitation may obscure the diastolic BP. ■ A difference of over 10 mmHg between arms suggests arterial compression on the side of the lower reading, aortic dissection, or coarctation of the aorta.

Technique/Normal Findings	Abnormal Findings
Auscultate blood pressure in each arm with the client standing. If orthostatic changes occur, measure the BP with the client supine, legs dangling, and again with the client standing, 1 to 3 minutes apart. *A decrease of systolic BP is expected, but should be <10 mmHg; diastolic BP should not drop on standing.*	■ A decrease in systolic BP of over 10 to 15 mmHg and a drop in diastolic BP on standing is called **orthostatic hypotension**. Causes include antihypertensive medications, volume depletion, PVD, prolonged bed rest, and aging.
Observe the pulse pressure. The pulse pressure is the difference between the systolic and diastolic BP. For example, if the BP is 140/80, the pulse pressure is 60. *A normal pulse pressure is one-third the systolic measurement.*	■ A widened pulse pressure with an elevated systolic BP occurs with exercise, arteriosclerosis, severe anemia, thyrotoxicosis, and increased intracranial pressure. ■ A narrowed pulse pressure with a decreased systolic BP occurs with shock, cardiac failure, and pulmonary embolus.

PRACTICE ALERT
If unable to auscultate blood pressure or palpate pulses, a Doppler ultrasound device may be used to evaluate blood flow. Apply a dime-sized amount of gel over the blood vessel to be assessed and lightly place the probe over the gel. Listen for a whooshing (artery) or rushing (vein) sound.

Skin Assessment

Inspect the color of the skin. *The skin color should be appropriate to the client's age and race.*	■ Pallor reflects constriction of peripheral blood flow (e.g., due to syncope or shock) or decreased circulating oxyhemoglobin (e.g., due to hemorrhage or anemia). ■ Central cyanosis of the lips, earlobes, oral mucosa, and tongue suggests chronic cardiopulmonary disease. (See Box 33–2 for abnormal findings associated with peripheral vascular and lymphatic assessment.)
Inspect the skin of the extremities and over the regional lymph nodes, noting any edema, erythema, red streaks, or skin lesions. *There should be no edema, redness, or lesions over the regional lymph nodes.*	■ Lymphangitis (inflammation of a lymphatic vessel) may produce a red streak with induration (hardness) following the course of the lymphatic collecting duct; infected skin lesions may be present, particularly between the digits. ■ **Lymphedema** (swelling due to lymphatic obstruction) occurs with congenital lymphatic anomaly (Milroy's disease) or with trauma to the regional lymphatic ducts from surgery or metastasis (e.g., arm lymphedema after radical mastectomy with axillary node removal). ■ Edema of lymphatic origin is usually not pitting, and the skin may be thickened; one example is the taut swelling of the face and body that occurs with myxedema, associated with hypothyroidism.

BOX 33–2 Abnormal Findings Associated with Peripheral Vascular and Lymphatic Assessment

- *Pallor* is an absence of color of the skin. The degree of pallor depends on the client's normal skin color and health status. Dark skin may appear ashen or have a yellowish tinge.
- *Cyanosis* is a bluish discoloration of the skin and mucous membranes in people with light skin. In people with dark skin, cyanosis may be difficult to observe. Inspect the nail beds and conjunctiva.
- *Edema* is an abnormal accumulation of fluid in the interstitial spaces of body tissues. It is often most apparent in the lower extremities.
- *Varicose veins* are tortuous and dilated veins that have incompetent valves. The saphenous veins of the legs are most commonly affected.
- *Enlarged lymph nodes* result from infection or malignancy.
- *Atrophic changes* are changes in size or activity of body tissues as the result of pathology or injury. Decreased blood flow and oxygenation of the lower extremities often cause atrophic changes of loss of hair, thickened toe nails, changes in pigmentation, and ulcerations.
- *Gangrene* is the necrosis (or death) of tissue, most often the result of loss of blood supply and infection. Gangrene often begins in the most distal of the tissues of the extremities.
- *Pressure ulcers*, also called decubitus ulcers or bed sores, are the result of ischemia and hypoxia of tissue following prolonged pressure. These ulcers often are located over bony prominences. If untreated, the tissue changes proceed from red skin to deep, crater-like ulcers.

Technique/Normal Findings	Abnormal Findings

Artery and Vein Assessment

Palpate the temporal arteries. *There should be no redness, swelling, nodules, or variations in pulse amplitude.*

- Redness, swelling, nodularity, and variations in pulse amplitude may occur with temporal arteritis.

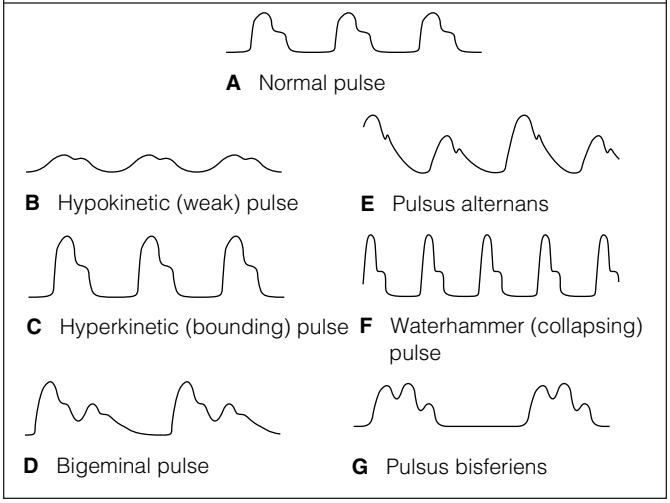
Inspect and palpate the carotid arteries. Note symmetry, the pulse rate, rhythm, volume, and amplitude. ***Note any variation with respiration. Describe all pulses as increased, normal, diminished, or absent. Scales ranging from 0 to 4+ are sometimes used as follows:***

0 = Absent
1+ = Diminished
2+ = Normal
3+ = Increased
4+ = Bounding

Pulse waveforms are shown in Box 33–3. *The carotid pulses should be bilaterally equal in rate, rhythm, volume, and amplitude.*

- A unilateral pulsating bulge is seen with a tortuous or kinked carotid artery.
- Alterations in pulse rate or rhythm are due to cardiac dysrhythmias.
- An absent pulse indicates arterial occlusion.
- A hypokinetic (weak) pulse is associated with decreased stroke volume (Box 33–3B). This may be due to congestive heart failure (CHF), aortic stenosis, or hypovolemia; to increased peripheral resistance, which may result from cold temperatures; or to arterial narrowing, commonly found with atherosclerosis.
- A hyperkinetic (bounding) pulse occurs with increased stroke volume and/or decreased peripheral resistance (Box 33–3C). This may result from states in which cardiac output is high or from aortic regurgitation. It also may occur with anemia, hyperthyroidism, bradycardia, or reduced compliance, as with atherosclerosis.
- A bigeminal pulse is marked by decreased amplitude of every second beat (Box 33–3D). This may be due to premature contractions (usually ventricular).
- Pulsus alternans is a regular pulse with alternating strong and weak beats (Box 33–3E). This may be due to left ventricular failure and severe HTN.

BOX 33–3 Types of Pulse Patterns



Auscultate the carotid arteries, using the bell of the stethoscope. *No bruits should be heard.*

- A murmuring or blowing sound heard over stenosed peripheral vessels is known as a *bruit*. A bruit heard over the middle to upper carotid artery suggests atherosclerosis.

Inspect and palpate the internal and external jugular veins for venous pressure. *See Box 33–4 for guidelines for assessing jugular venous pressure (JVP).*

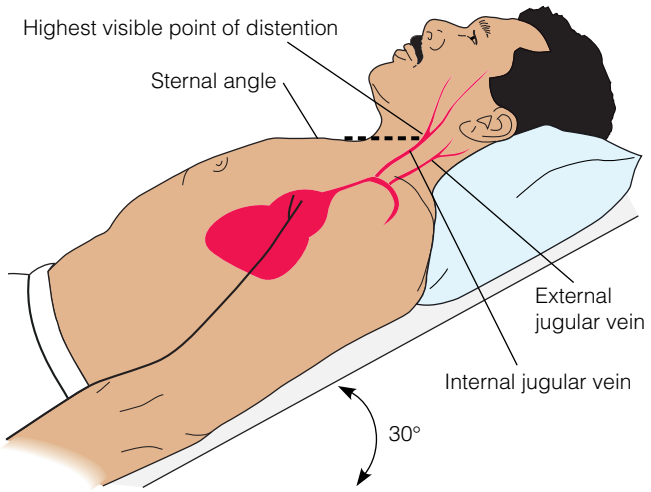
- An increase in jugular venous pressure (JVP) over 3 cm and located above the sternal angle reflects increased right atrial pressure. This occurs with right ventricular failure or, less commonly, with constrictive pericarditis, tricuspid stenosis, and superior venae cavae obstruction.

Technique/Normal Findings **Abnormal Findings**

BOX 33–4 Assessing Jugular Venous Pressure

When a client with normal venous pressure lies in the supine position, full neck veins are normally visible, but as the head of the bed is elevated, the pulsations disappear. In the client with greatly elevated venous pressure, visible pulsations of the jugular vein are present even in the upright position. To conduct the inspection:

1. Remove clothing from the client's neck and chest. Elevate the head of the bed 30 to 45 degrees, and turn the client's head to the opposite side. Shine a light tangentially across the neck to increase shadows. If the external jugular veins are distended, they will be visible vertically between the mandible and outer clavicle.
2. If jugular distention is present, assess the JVP by measuring from the highest point of visible distention to the sternal angle (the point at which the clavicles meet) on both sides of the neck (see the accompanying figure). Bilateral measurements above 3 cm are considered elevated and indicate increased venous pressure; distention on only one side may indicate obstruction.



Assessment of the highest point of jugular vein distention.

If venous pressure is elevated, assess the hepatojugular reflex. (Compress the liver in the right upper abdominal quadrant with the palm of the hand for 30 to 60 seconds while observing the jugular veins.)

- A decrease in venous pressure reflects reduced left ventricular output or blood volume.
- Unilateral neck vein distention suggests local compression or anatomic anomaly.
- A rise in the column of neck vein distention over 1 cm with liver compression indicates right heart failure.

Upper Extremity Assessment

Inspect and palpate the arms and hands, noting size and symmetry, skin color, and temperature. *Arms and hands should be symmetrical in size and shape, warm, and of appropriate skin color.*

- Unilateral swelling with venous prominence occurs with venous obstruction.
- Extreme localized pallor of the fingers is seen with Raynaud's disease.
- Cyanosis of the nail beds reflects chronic cardiopulmonary disease.
- Cold temperature of the hands and fingers occurs with vasoconstriction.

Palpate the nail beds for capillary refill. (Apply pressure to the client's fingertips. Watch for blanching of the nail beds. Release the pressure. Note the time it takes for capillary refill, indicated by the return of pink color on release of the pressure.) *Capillary refill should be less than 2 seconds (i.e., immediate).*

- Capillary refill that takes more than 2 seconds reflects circulatory compromise, such as hypovolemia or anemia.

Assess venous pattern and pressure. (Elevate one of the client's arms over the head for a few seconds. Slowly lower the arm. Observe the filling of the client's hand veins.) *Hand veins should fill equally and immediately.*

- Distention of hand veins at elevations over 9 cm above heart level reflects an increase in systemic venous pressure.

Technique/Normal Findings	Abnormal Findings
Palpate the radial and brachial pulses. Note rate, rhythm, volume amplitude, symmetry, variations with respiration. (See Box 33–3 for pulse patterns.) *Radial and brachial pulses should have equal and normal rate, be strong, and not vary with respirations.*	■ Alterations in pulse rate or rhythm are due to cardiac dysrhythmias (such as atrial fibrillation, atrial flutter, and premature ventricular contractions). A pulse rate over 100 bpm is tachycardia; a pulse rate below 60 bpm is bradycardia. ■ A pulse deficit (slower radial rate than apical rate) occurs with dysrhythmias and CHF. ■ Irregularities of rhythm produce early beats and pauses (skipped beats) in the pulse, which may be regular in pattern, sporadic, or grossly irregular. ■ Diminished or absent radial pulses may be due to thromboangiitis obliterans (Buerger's disease) or acute arterial occlusion. ■ A weak and thready pulse, often with tachycardia, reflects decreased cardiac output. ■ A bounding pulse occurs with hyperkinetic states and atherosclerosis. ■ Unequal pulses between extremities suggest arterial narrowing or obstruction on one side. ■ In sinus dysrhythmia (a normal variant, especially in young adults), the pulse rate increases with inspiration and decreases with expiration.
If arterial insufficiency is suspected, palpate the ulnar pulse and perform the Allen test: ■ **Have the client make a tight fist.** ■ **Compress both the radial and ulnar arteries.** ■ **Have the client open the hand to a slightly flexed position.** ■ **Observe for pallor and manifestations of pain.** ■ **Release the ulnar artery and observe for the return of pink color within 3 to 5 seconds.** ■ **Repeat the procedure on the radial artery.** *Color should return within 3 to 5 seconds in both the ulnar and the radial arteries.*	■ The normal ulnar artery may or may not have a palpable pulse. ■ Persistent pallor with the Allen test suggests ulnar artery occlusion.
Inspect and palpate each leg, noting size, shape, and symmetry; arterial pattern; skin color, temperature, and texture; hair pattern; pigmentation; rashes; ulcers, sensation; and capillary refill. *Legs should be symmetric in size and shape, arterial pattern, appropriate color, warm, without lesions. Capillary refill on toenails should be immediate.*	■ Chronic arterial insufficiency may be due to arteriosclerosis or autonomic dysfunction, or to acute occlusion resulting from thrombosis, embolus, or aneurysm. ■ Signs of arterial disruption include pallor, dependent rubor (dusky redness); cool to cold temperature; and atrophic changes, such as hair loss with shiny and smooth texture, thickened nails, sensory loss, slow capillary refill, and muscle atrophy. ■ Ulcers with symmetric margins, a deep base, black or necrotic tissue, and absence of bleeding may occur at pressure points on or between the toes, on the heel, on the lateral malleolar or tibial area, over the metatarsal heads, or along the side or sole of the foot. ■ Gangrene due to complete arterial occlusion presents as black, dry, hard skin; pregangrenous color changes include deep cyanosis and purple-black discoloration.

Lower Extremity Assessment

With the client supine, assess the venous pattern of the legs. Repeat with the client standing. *Venous pattern on both legs should be symmetric, and there should be no edema, cyanosis, or lesions.*	■ Signs of venous insufficiency include swelling, thickened skin, cyanosis, stasis dermatitis (brown pigmentation, erythema, and scaling), and superficial ankle ulcers located predominantly at the medial malleolus with uneven margins, ruddy granulation tissue, and bleeding. ■ Varicose veins appear as dilated, tortuous, and thickened veins, which are more prominent in a dependent position.

Technique/Normal Findings	Abnormal Findings
Palpate the femoral, popliteal, posterior tibial, and dorsalis pedis pulses for volume, amplitude, and symmetry (see Figure 33–12). *All lower extremity pulses should be strong and equal in amplitude.*	■ Diminished or absent leg pulses suggest partial or complete arterial occlusion of the proximal vessel and are often due to arteriosclerosis obliterans. ■ Increased and widened femoral and popliteal pulsations suggest aneurysm. ■ Absence of a posterior tibial pulse with signs and symptoms of arterial insufficiency is usually due to acute occlusion by thrombosis or embolus. ■ Diminished or absent pedal pulses are often due to popliteal occlusion associated with diabetes mellitus.
If pulses are diminished, observe for postural color changes. Elevate both legs 60 degrees, and observe the color of the soles of the feet. Have the client sit and dangle the legs; note the return of color to the feet.	■ Extensive pallor on elevation is suggestive of arterial insufficiency. ■ Rubor (dusky redness) of the toes and feet along with delayed venous return (over 45 seconds) suggests arterial insufficiency.
If arterial insufficiency is suspected, auscultate the femoral arteries. *No bruits should be heard.*	■ Femoral bruits suggest arterial narrowing due to arteriosclerosis.
Inspect and gently palpate the calves. *There should be no redness or swelling, heat, or pain in the calves of the legs.*	■ Redness, warmth, swelling, tenderness, and cords along a superficial vein suggest thrombophlebitis or deep venous thrombosis.
Inspect and palpate for edema. Use your thumb to compress the dorsum of the client's foot, around the ankles, and along the tibia (Figure 33–13A ■). A depression in the skin that does not immediately refill is called pitting edema. *Normally, there is no edema.*	Edema can be graded on a scale from 1+ to 4+ (Figure 33–13B): 1+ (–2 mm depression) No visible change in the leg; slight pitting 2+ (–4 mm depression) No marked change in the shape of the leg; pitting slightly deeper 3+ (–6 mm depression) Leg visibly swollen; pitting deep 4+ (–8 mm depression) Leg very swollen; pitting very deep ■ Edema may be caused by disease of the cardiovascular system such as CHF; by renal, hepatic, or lymphatic problems; or by infection. ■ Venous distention suggests venous insufficiency or incompetence.

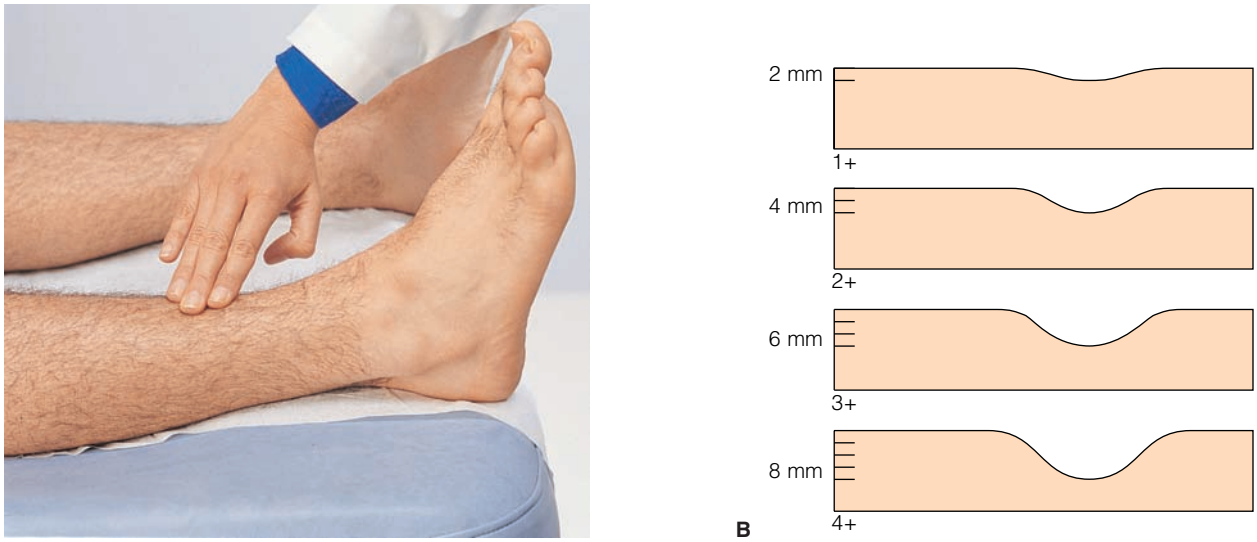


Figure 33–13 ■ Evaluation of edema. *A,* Palpating for edema over the tibia. *B,* Four-point scale for grading edema.

Technique/Normal Findings	Abnormal Findings

Abdominal Assessment

Inspect and palpate the abdominal aorta. Note size, width, and any visible pulsations or bulging.
Abdominal aorta should be of appropriate size without visible pulsations or bulging.

- A pulsating mass in the upper abdomen suggests an aortic aneurysm, particularly in the older adult.
- An aorta greater than 2.5 to 3 cm in width reflects pathologic dilation, most likely due to arteriosclerosis.

Auscultate the epigastrium and each abdominal quadrant, using the bell of the stethoscope (Figure 33–14 ■).
No bruits should be heard over the abdominal aorta.

- Abdominal bruits reflect turbulent blood flow associated with partial arterial occlusion.
- A bruit heard over the aorta suggests an aneurysm.
- A bruit heard over the epigastrium and radiating laterally, especially with HTN, suggests renal artery stenosis.
- Bruits heard in the lower abdominal quadrants suggest partial occlusion of the iliac arteries.

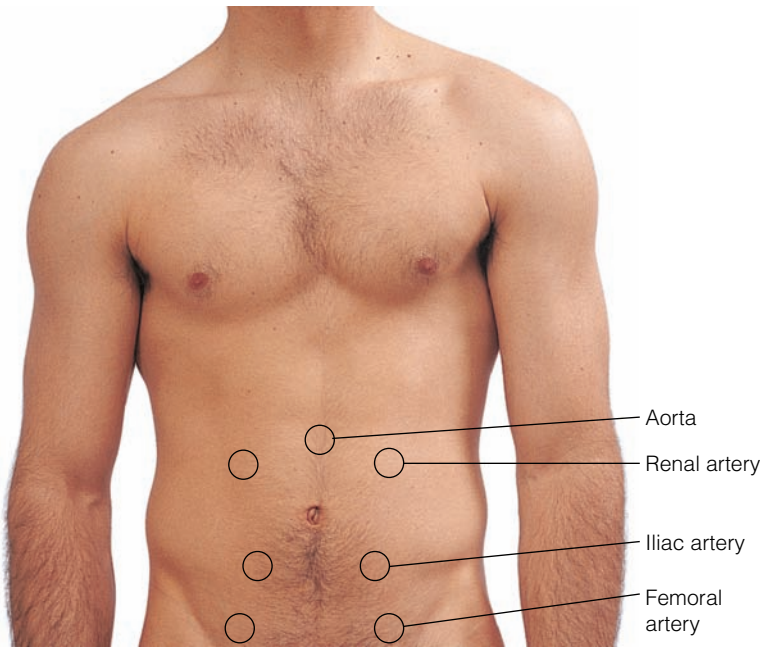


Figure 33–14 ■ Auscultation sites of the abdominal aorta and its branches.

Lymph Node Assessment

Palpate the regional lymph nodes of the head and neck, axillae, arms, and groin. Use firm, circular movements of the finger pads and note size, shape, symmetry, consistency, delineation, mobility, tenderness, sensation, and condition of overlying skin.
Nodes should not be enlarged or painful.

- **Lymphadenopathy** refers to the enlargement of lymph nodes (over 1 cm) with or without tenderness. It may be caused by inflammation, infection, or malignancy of the nodes or the regions drained by the nodes.
- Lymph node enlargement with tenderness suggests inflammation (*lymphadenitis*). With bacterial infection, the nodes may be warm and matted with localized swelling.
- Malignant or metastatic nodes may be hard, indicating lymphoma; rubbery, indicating Hodgkin's disease; or fixed to adjacent structures. Usually they are not tender.
- Ear infections and scalp and facial lesions, such as acne, may cause enlargement of the preauricular and cervical nodes.
- Anterior cervical nodes are enlarged and infected with streptococcal pharyngitis and mononucleosis.
- Lymphadenitis of the cervical and submandibular nodes occurs with herpes simplex lesions.
- Enlargement of supraclavicular nodes, especially the left, is highly suggestive of metastatic disease from abdominal and thoracic cancer.
- Axillary lymphadenopathy is associated with breast cancer.
- Lesions of the genitals may produce enlargement of the inguinal nodes.
- Persistent generalized lymphadenopathy is associated with acquired immune deficiency syndrome (AIDS) and AIDS-related complex.

Technique/Normal Findings	Abnormal Findings
Spleen Assessment	
Palpate for the spleen, in the upper left quadrant of the abdomen. *The spleen is normally not palpable.*	■ A palpable spleen in the left upper abdominal quadrant of an adult may indicate abnormal enlargement (splenomegaly) and may be associated with cancer, blood dyscrasias, and viral infection, such as mononucleosis.
Percuss for splenic dullness in the lowest left intercostal space (ICS) at the anterior axillary line or in the ninth to tenth ICS at the midaxillary line (Figure 33–15 ■). *Normally, tympany is heard.*	■ A dull percussion note in the lowest left ICS at the anterior axillary line or below the tenth rib at the midaxillary line suggests splenic enlargement.

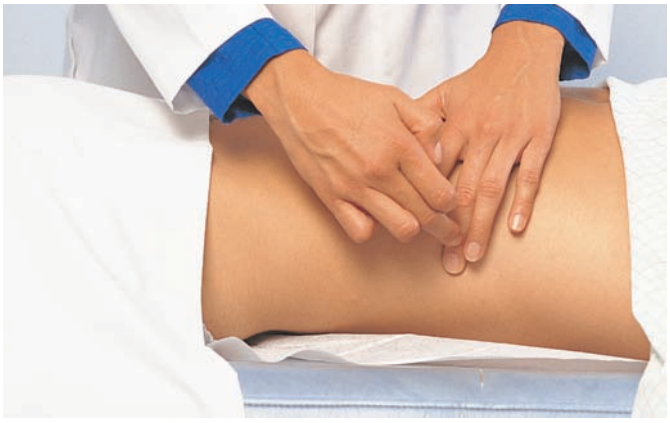


Figure 33–15 ■ Percussing the spleen.

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TEST YOURSELF NCLEX-RN® REVIEW

1 What part of the peripheral vascular system has the major control of blood pressure?
1. veins
2. capillaries
3. arteries
4. arterioles

2 Your client has a very low RBC count. What subjective manifestation would you expect to find during a health history?
1. sore throat
2. chest pain
3. fatigue
4. nausea

3 A client has a low platelet count. What would you likely find on physical assessment?
1. enlarged lymph nodes
2. excessive bruising
3. varicose veins
4. changes in pulse pressure

4 What physiologic difference from the veins accounts for the ability of the arteries to dilate and constrict?
1. veins have smooth muscle
2. veins are larger in diameter
3. arteries are more distensible
4. arteries have smooth muscle

5 An older client is severely dehydrated and, as a result, has increased blood viscosity. How will this affect the peripheral vascular resistance (PVR)?
1. increased PVR
2. decreased PVR
3. no change
4. depends on gender

6 What is the source of lymph?
1. the respiratory system
2. the cardiovascular system
3. the central nervous system
4. the integumentary system

7 What method would be most appropriate to assess the carotid arteries?
1. Inspect for absence of movement.
2. Auscultate with the bell of the stethoscope.
3. Palpate with firm pressure.
4. Percuss lightly over each artery.

8 When auscultating the abdominal aorta, you hear a murmuring or blowing sound. You would document this sound as a:
1. hypokinetic pulse.
2. bigeminal pulse.
3. bruit.
4. dysrhythmia.

9 Swelling of a body part as a result of lymphatic obstruction is labeled:
1. lymphedema.
2. lymphadenopathy.
3. atrophic change.
4. central cyanosis.

10 You are assessing a man who has severe leg pain. The leg is cool and cyanotic. You are unable to palpate a femoral pulse. What would be your priority intervention based on these assessments?
1. Document your findings.
2. Ask the family about this problem.
3. Teach the man relaxation techniques.
4. Notify the physician immediately.

See Test Yourself answers in Appendix C.

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